



Print ISSN : 2393-8234
Online ISSN : 2454-6011

Frontiers in Crop Improvement

VOLUME 9 SPECIAL ISSUE-III AUGUST 2021

Website : www.asthafoundation.in



ASTHA FOUNDATION

MEERUT (U.P.) INDIA

ASTHA FOUNDATION®

Website : www.asthafoundation.in

EXECUTIVE COUNCIL FOR FRONTIERS IN CROP IMPROVEMENT JOURNAL (2021)

President	–	Dr. S.P. Singh, Aligarh
Vice President	–	Dr. Pooran Chand, Meerut Dr. Yogendra Kumar Singh, Kanpur
Secretary	–	Smt. S. Rani, Meerut
Joint Secretary	–	Dr. Shobhana Gupta, Gwalior
Treasurer	–	Dr. Rajendra Kumar, Saharanpur
Members	–	Dr. Pradip Kumar, Meerut Dr. Mukesh Kumar, Pillibhit

ADVISORY BOARD

Dr. Ashok Kumar Singh, Deputy Director General (Agriculture Extension), ICAR, New Delhi, India
Dr. J.S. Sandhu, Vice Chancellor, S.K.N. Agriculture University, Jobner, Rajasthan, India
Dr. A.K. Singh, Ex-Vice Chancellor, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) India
Dr. Ajoy Kumar Singh, Vice Chancellor, Bihar Agricultural University, Sabour, Bhagalpur (Bihar) India
Dr. S.K. Patil, Vice Chancellor, Indra Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) India
Dr. P.K. Agrawal, Odisha, University of Agriculture and Technology, Bhubaneswar, Odisha, India
Dr. R.P. Singh, Vice Chancellor, Swami Keshwanand Rajasthan Agriculture University, Bikaner, Rajasthan, India
Dr. M.K. Naik, Vice Chancellor, University of Agriculture & Horticulture Sciences, Shivamogga (Karnataka) India
Dr. H.G. Prakash, Director Research, C.S.A. University of Agricultural & Technology, Kanpur (U.P.) India
Dr. S.K. Chaturvedi, Dean, Rani Laxmibai Central Agricultural University, Jhansi (U.P.) India
Dr. John Farrington, Overseas Development Institute, 111, Westminster Bridge Road, London SE1, 7JD, UK

EDITORIAL BOARD

Chief Editor

Dr. S.P. Singh
ARS-CSAUAT, Kalai, Aligarh

Executive Editors

Dr. B.V. Tamburne, UAS, Raichur
Dr. S.C. Gaur, BRD (PG) College, Deoria
Dr. Brajendra, ICAR-IIRR, Hyderabad
Dr. A.S. Jeena, GBPUAT, Pantnagar

EDITORS

Dr. Bijendra Pal, Hyderabad
Dr. R. Lokesh, Raichur
Dr. Balwinder Kumar, Tarn Taran
Dr. Shweta, Kanpur
Dr. Pradip Kumar, Meerut
Dr. Rohit Rana, Shamli
Dr. Laxmikant Sharma, Junagadh
Dr. M.K. Tripathi, Gwalior
Dr. Sourabh Gupta, Khandwa
Dr. Harish Pal Bhati, Meerut
Dr. Pankaj Sharma, Shimla

Dr. Shailendra S. Gaurav, Meerut
Dr. Ganesh U. Kulkarni, Junagadh
Dr. Vivek Yadav, Nagina
Dr. U.K. Tripathi, Kanpur
Dr. Rajendar Kumar Yadav, Kanpur
Dr. Anil Kumar, Sabour
Dr. M. Vignesh, New Delhi
Dr. Nand Kumar, Kanpur
Dr. Bilal Ahmed Lone, Srinagar
Dr. Amit Kumar, Srinagar
Dr. Hiranmayee Nayak, Bhubaneswar

Dr. Brijendra Singh, East Garo Hill
Dr. Mahender Singh, Shimla
Dr. Raj Mohan Sharma, Ganj Basoda
Dr. S.B. Singh, Begusarai
Dr. P.B. Singh, Udaipur
Dr. H.C. Nanda, Raipur
Dr. A.K. Chaudhary, Darbhanga
Dr. Prabha Rani Chaudhari, Raipur
Dr. Omkar Singh, Shamli
Dr. Nirupma Singh, New Delhi
Dr. Vijay Kr. Kurmaliker, Raichur

JOURNAL SUBSCRIPTION

Individual Fee	Inland	Foreign	Institutional Fee	Inland	Foreign
Ordinary (Annual) Membership	– Rs. 1000/-	\$ 500	Institutional (Annual) Membership	– Rs. 3000/-	\$ 2000
Life membership	– Rs. 4000/-	\$ 2000	Institutional (10 Years) Membership	– Rs. 15000/-	\$ 7000

The life membership fee may be paid by Bank Draft/Cheque/Bank Transfer in favour of **Frontiers in Crop Improvement** and payable at Meerut. Payment by out station cheques must include **Rs. 100/-** extra towards bank charges. Correspondence regarding membership subscription and any other matters on the journal should be addressed to **Dr. S.P. Singh, President, ASTHA FOUNDATION**, Suman Villa, 85, Phool Bagh Colony, Main Road, Meerut-250002 (U.P.), Cell : 09450068438, 08273775051, E-mail : dr.sp.singh24@gmail.com | Website: www.asthafoundation.in

MEMBERSHIP FORM
FRONTIERS IN CROP IMPROVEMENT JOURNAL
Astha Foundation, Meerut, (U.P.) INDIA
Website : www.asthafoundation.in

To,

Dr. S.P. SINGH

Scientist (Plant Breeding), A.R.S., Kalai, Aligarh (C.S.A. University of Agriculture and Technology, Kanpur)

Chief Managing Director, Astha Foundation, Meerut (U.P.), INDIA

Chief Editor, Frontiers in Crop Improvement Journal, Meerut (U.P.), INDIA

Correspondence to : Dr. S.P. Singh, Suman Villa, 85, Phool Bagh Colony, Main Road, Meerut-250 002 (U.P.), INDIA

Cell : **09450068438, 08273775051**, E-mail : **dr.sp.singh24@gmail.com**

Dear Sir,

Please enrol me as a Life/Annual Member of (Biodata enclosed). I am enclosing herewith a draft of Rs..... (in words.....), having Draft No..... Dated..... for Life/Annual Subscription and it enrolled, agree to abide by its rules and regulations.

1. Full Name (In capital Letters).....

2. Designation.....

3. Academic and professional qualification.....

4. Specialization.....

5. Institute / Organisation where employed.....

6. Address for correspondence.....

City..... State.....

Pin Code Telephone No. (STD Code).....

Office Residence.....

Mobile No..... E-mail.....

7. Permanent Home Address.....

City..... State.....

Pin Code..... Telephone No. (STD Code)

Office..... Residence

Mobile No..... E-mail

Dated.....

Signature.....

JOURNAL SUBSCRIPTION

Individual Fee			Institutional Fee		
	Inland	Foreign		Inland	Foreign
Ordinary (Annual) Membership	– Rs. 1000/-	\$ 500	Institutional (Annual) Membership	– Rs. 3000/-	\$ 2000
Life membership	– Rs. 4000/-	\$ 2000	Institutional (10 Years) Membership	– Rs. 15000/-	\$ 7000

The life membership fee may be paid by Bank Draft/Cheque/Bank Transfer in favour of **Frontiers in Crop Improvement** and **payable at Meerut**. Payment by out station cheques must include **Rs. 100/-** extra towards bank charges. Correspondence regarding membership subscription and any other matters on the journal should be addressed to **Dr. S.P. Singh, President, ASTHA FOUNDATION**, Suman Villa, 85, Phool Bagh Colony, Main Road, Meerut-250002 (U.P.), Cell : **09450068438, 08273775051**, E-mail : **dr.sp.singh24@gmail.com** | Website: **www.asthafoundation.in**

GUIDELINES TO THE CONTRIBUTORS

The journal publishes original research papers, review articles and short communications in plant genetic resources, plant breeding, plant biotechnology, genetics, cytogenetics and seed research. The manuscripts will be accepted for publication from members of the executive body of journal. All the manuscripts will be referred. The responsibility for any statement in the article rests entirely with the concerning authors. The manuscripts should be submitted, in duplicate, to Chief Editor of the Journal. A paper will not be accepted for publication unless all the authors are member of the Frontiers in Crop Improvement Journal. A paper will not be published without printing/processing formalities. The authors are advised to prepare their manuscripts according to the following guidelines:

Preparation of the Text : Each full length research paper must not exceed 8-10 typed pages including tables and illustrations. However, the review articles may contain 15-20 typed pages. Short communication should not exceed 3-5 typed pages in which no separate abstract and other sections are needed. Manuscripts should be typed on one side of bond paper of 22x28 cm. double space and thoroughly revised before submission. Numerical data and calculations should be carefully checked. No editing or material changes at the proof stage will be permitted unless the extra cost is paid by the authors involved.

Short Title : A short title not exceeding 45 letters, should be typed at the top of the first page in First letters capital and underlined.

Title : Title should be brief, specific and informative, typed in all capitals, scientific name in italics/underlined.

Authors : Names of authors to be typed, in all capitals unaccompanied by their degrees, titles etc.

Address : Address of the institution where the work was carried out be given below the name(s) of author(s). Present address of correspondence should be given as footnote indicating by asterisk the author to whom the correspondence are to be addressed.

Abstract : A brief abstract, not exceeding 250 words, of the principal points and important conclusions should be typed.

Key words : The Abstract should be followed by not exceeding ten key words indicating the contents of the research article.

Introduction : This should be brief and without headings related to the aim of the study. The review of the literature should be pertinent to the theme of the paper. Extensive review and unnecessary detail of earlier work should be avoided.

Materials and Methods : It should inform the reader about appropriate methodology etc. but if known methods have been adopted, only references be cited. It should comprise the experimental design and techniques.

Results and Discussion : It should be combined to avoid repetition. The results should not be repeated in both tables and figures. The discussion should relate to the significance of the observations.

Tables and Figures : Tables should be typed on separate sheet with first letter capital, table numbers followed by the title of the table. For each figure, a glossy print or original drawing should be submitted. The size of the figure should not exceed 8.5 cm. x 15.0 cm. Captions and legends to illustrations should be typed on separate sheet of paper. Line drawings and photographs should contain figure number and authors name on the back with soft lead pencils. Colour photographs will be printed on special request and on payment of extra printing charges which will be communicated after receiving the specific request.

Acknowledgments : It should be mentioned only assistance received in real terms, and financial grant provided by an agency.

References : References should be cited in text by numbers in brackets (for review articles with author name will be cited in text). Listing of references by S. No. in accordance with their order of text citation. Author's names to be written in normal sequence, with surname first, followed by initials (in double space), year in bracket.

Journal name/book name, volume number (underlined/italic) and page number. The following style of the references should be followed as :

1. Johnson, H. W.; Robinson, H. E. and Comstock, R. E. (1955). Estimate of genetic and environmental variability in soybean. *Agron. J.* 47: 314-318
2. Allard, R. W. (1960). Principles of Plant Breeding, *John. Wiley and Sons, Inc.* New York.
3. Palmer, J. D. (1992). In : *Cell Organelles* (R. G. Herman, Editor) Springer Verlag, Vienna. 99-133.
4. Weber, D. R (1967). On the Interaction of Nonhomologous Segments of Chromosomes in *Zea mays*. *Unpubl. Ph.D. Thesis, Indiana University*, Bloomington, Indiana, USA. (For Indian Universities, Country name not to be indicated).
5. Chandola, R. P.; Bhatnagar, C. P. and Sah Sudha (1971). Nature of variability induced by radiations. In : *Proc. Int. Symp on use of Isotopes, Radiations in Agriculture and Animal Husbandry Research*, New Delhi 46-50.

Print ISSN : 2393-8234
Online ISSN : 2454-6011



Frontiers in Crop Improvement

Chief Editor : Dr. S.P. Singh

Volume 9

Special Issue-III

August 2021

NAAS Rating - 4.67

Peer Reviewed, Refereed and Indexed Journal



ASTHA FOUNDATION
MEERUT (U.P.) INDIA

Website : www.asthafoundation.in

Frontiers in Crop Improvement, Volume 9 (Special Issue-III) August 2021

Contents

Research Papers/Articles	Page No.
1. Characterization of morphological characters of Karpooram Mango : An Indigenous Mango (<i>Mangifera indica</i> L.) variety of Southern Kerala Bindu B.	741-743
2. Influence of long-term application of farmyard manure and fertilizer nitrogen on total nutrient status in sandy loam soil under pearl millet-wheat cropping Sunita Sheoran, Dhram Prakash, Dev Raj and K.S. Grewal	444-449
3. Soil available phosphorus as influenced by manures and levels of phosphorus in calcareous soil Dipti Waghdhare, Dhanashree Desai, Sunita Waghmare, Tai Deokate and Pramod Jagtap	750-753
4. Influence of slow releasing nitrogenous fertilizers on hrowth, yield and economics of paddy in Coastal Karnataka H.R. Bhanuprakash, M. Hanumanthappa, P. Athaulla, M. Dinesh Kumar and K.V. Sudhir Kamath	754-757
5. Identification of resistant sources to <i>Fusarium wilt</i> caused by <i>Fusarium udum</i> in pigeonpea Bindhu K.G., Yenjerappa S.T., Ajithkumar K., Gururaj Sunkad, Sreenivasa A.G. and Mahadevaswamy	758-762
6. Nutrient system (IPNS) in laterite soils B. Aparna, Gladis R., Biju Joseph and Neethu R.S	763-770
7. Study of various plant growth enhancers on propagation in betel leaf utting (<i>Piper betle</i> L.) Bhagwat Saran Asati	771-775
8. Effect of phenotypes and levels of nitrogen on yield of kakrol (<i>Momordica dioica</i> Roxb.) Ch. Bindhu, M.B. Nageswara Rao, K. Umajothi and K. Umakrishna	776-780
9. Documentation and validation of indigenous technical knowledge of dairy farming in Gwalior division of M.P. Reena Rawat, O.P. Daipuria, Prashant Sharma, Prabhakar Sharma and Mona Raghuvanshi	781-783
10. Suitable ingredients for preparation of chats supplemented with jackfruit-seed paste Akkamahadevi D. Agasimani, Roopa S. Patil, Annapurna Neeralgi and Shivashenkaramurthy M.	784-786
11. Study on rooting ability of <i>Pseuderanthemum carruthersii</i> var. <i>reticulatum</i> (Seem.) guillaumin under the influence of rooting hormone A.D. Ashok	787-789
12. Physico-chemical properties of green peas (<i>Pisum sativum</i> L.) A.K. Senapati, A.K. Varshney, V.K. Shrama, S. Patel, M. Varma, P.R. Pandey	799-794
13. Farmers' coping mechanism for mitigating adverse effect of flood-A study in flood affected districts of Assam A. Rahman, S. Barman and P. Saikia	795-798
14. Influence of lime and organic manures on yield performance of baby corn (<i>Zea mays</i> L.) under rainfed condition Abdul Rahman Munib and K. Pathak	799-801
15. Constraints perceived by the growers in adoption of recommended jute production technology Amit Kumar, M.N. Ansari and A.K. Paswan	802-804
16. Production of kachri (<i>Cucumis callosus</i>) (AHK-119) with saline water irrigation in hot arid region Anita Meena, P.L. Saroj, M.K. Jatav and B.D. Sharma	805-808
17. Evaluation of soil fertility, correlation and nutrient indexing of available macro and micro nutrients in arid vegetable growing pockets of Rajasthan Anita Meena, M.K. Jatav, P.L. Saroj, R.C. Balai, B.D. Sharma and S.R. Meena	809-814
18. Comparative economics of sprinkler and surface irrigation in Raipur district of Chhattisgarh Ashwin Anthony and V.K. Choudhary	815-819
19. Fuel quality assessment of biodiesel produced through transesterification process from different plant oils Atul Kumar Shrivastava, D.M. Kadam, R.K. Rathod and R.K. Dubey	820-825
20. Drying of fenugreek leaves using continuous microwave dryer B.C. Khodifad, N.K. Dhamsaniya and P.J. Rathod	826-833
21. Assessment of green manuring and STV based nutrient management in Mustard (<i>Brassica</i> Spp.) Debesh Singh, B.S. Kasana, Reena Sharma, S.P. Singh and S.V.S. Chauhan	834-836

22.	Influence of microbial inoculants on biological properties in the <i>Rhizosphere of Capsicum</i> (<i>Capsicum annuum</i> L.) B.S. Nalini, L. Krishna Naik and R. Muthuraju	837-843
23.	Impact of pusa hydrogel and different growing media on growth and flowering of pot chrysanthemum (<i>Dendranthema grandiflora</i> Ramat.) B.V. Thumar, Trupti Dodiya, N.S. Joshi, Prof. P.V. Maheta and N.V. Chovatiya	844-849
24.	Problem faced by mushroom growers in adoption of mushroom production technology in Chhattisgarh Bharti Shriwas, K.K. Srivastava and M.A. Khan	850-852
25.	Insect Pollination Viji C.P., Phani Kumar K., Sudha Vani V. and Divya Bharathi V.	853-857
26.	Cost and return of mango fruit in Kanker district of Chhattisgarh Chanchal and B.C. Jain	858-860
27.	Growth and foliage production of kasuri methi (<i>Trigonella corniculata</i>) under the influence of different types and doses of organic manures at temperate region of Bharsar, Uttarakhand Chand P., Singh K.C. and Chauhan R.S.	861-865
28.	Linkage map construction using ssr markers and qtl mapping for some productivity and fiber quality traits in desi cotton Chetankumar N. Banakar, Rajendragouda Patil B. M, Khadi and I.S. Katageri	866-870
29.	Economic analysis of production and marketing of milk in Raipur district of Chhattisgarh Chiranjeet Malakar, B.C. Jain and V.K. Choudhary	871-875
30.	<i>In-vitro</i> evaluation of bio control agents against <i>Fusarium oxysporum</i> f. sp. <i>Ciceri</i> D.H. Sarnobat, Y.S. Balgude, R.S. Bhoge and B.T. Shete	876-879
31.	Effect of sowing windows on newly released varieties for seed yield and economics of sunnhemp (<i>Crotalaria juncea</i> L.) D.P. Pacharne, P.H. Deshmukh and N.K. Bhute	880-882
32.	Perception of rural agricultural extension officers on climate change in balod district of Chhattisgarh State Damini Ishda, H.K. Awasthi and K.K. Shrivastava	883-885
33.	The study about socio-economical profile of the respondents of direct seeded rice cultivation practices of paddy of Chhattisgarh State Deeksha Baghel, P.K. Pandey, M.A. Khan and M.L. Sharma	886-889
34.	Seasonal incidence of sweet potato weevil, <i>Cylas formicarius</i> (fab.) (<i>Brentidae, coleoptera</i>) and its correlation with weather parameters A. Deepthy, C.P. Viji, N. Emmanuel and V. Sudha Vani	890-893
35.	Influence of cluster frontline demonstration of blackgram var. WBU-109 in Giridih district of Jharkhand Devkant Prasad and Srikant Singh	894-897
36.	Performance evaluation of cluster frontline demonstration on sesame (<i>Sesamum Indicum</i> L.) in Giridih district of Jharkhand Devkant Prasad and Srikant Singh	898-901
37.	Changes in physico-chemical and biological properties of soil under conservation agriculture based pearl millet-wheat cropping system Dhinu Yadav, Rohit Rana, Leela Wati and Prashun Sachan	902-906
38.	Characterization of soil available nutrients using multivariate statistics in Northeastern Karnataka, India J.B. Kambale and Shashidhar K.K.	907-910
39.	Impact of front line demonstration on productivity of brinjal cv. kashi uttam through drip and fertigation in tribal belt of Korea district (C.G.) K.C. Rajhansa, Ranjeet Singh Rajpoot, Harishankar, Vijay Kumar, Kamlesh Singh, P.R. Bobdae, Doman Singh Tekam and P.C. Kanwar	911-914
40.	Role and application of nanotechnology in the modern agriculture practice Mamta Rathore, Pooja Singh and H.G. Prakash	915-917
41.	Stability analysis for selecting promising greengram (<i>Vigna radiata</i> L. Wilczek) genotypes over the seasons through AMMI analysis Nitesh S.D., Manoj Katiyar, Sarvendra Kumar, Mahak Singh, Lokendra Singh, Bajpai V.P., Anjani Kumar Singh, Amar and Yashwanth R.D.	918-921
42.	Piper Betle-The golden leaves P. Geetha	922-925
43.	Critical period of crop weed competition in rice (<i>Oryza sativa</i> L.) N.S. Kular and U.S. Tiwana	926-928
44.	Effect of drought stress on germination of sesame germplasm under laboratory conditions Roshni Sahu, Rajani Bisen, Anand Pandey and Surabhi Jain	929-933

45.	Evaluation of reproduction traits in halfbred and three breed crosses of Gir S.R. Garudkar, S.D. Mandakmale and C.A. Nimbalkar	934-940
46.	Studies of adoption technology of trained and untrained farm women's of different villages of district Chandauli Satya Pal Singh, Abhay Deep Gautam, Ritesh Singh, S.K. Pandey, Krishna Murari, Manoj Mishra and Y.K. Singh	941-948
47.	Pattern of calf mortality in gangatiri cattle at araziline organized dairy farm of district, Varanasi Shiv Bachan, K.B. Anand, R.K. Pal and Aditya Kumar	948-950
48.	Adoption of dairy technology by Indian dairy farmers Thorat Dinesh D., Sonwane Rajkumar S. and Naik Arvind P.	951-954
49.	Correlation and path analysis in Indian Mustard [(<i>Brassica juncea</i> L. (Czern and Coss))] Jyotsana Rathore, Hemlata Sharma, Natwar Singh Dodiya, Abhay Dashora and Nitu Yadav	955-959
50.	Extent of knowledge, adoption and existing gap Regarding recommended pigeonpea production practices among the farmers of Raipur District in Chhattisgarh Pooja Yadav, P.K. Pandey, M.A. Khan and M.L. Sharma	960-963
51.	Population dynamics of the fall armyworm, <i>Spodoptera frugiperda</i> (J.E. Smith) in Rabi Maize Rohit Kumar, S. Ramesh Babu, N.L. Dangi, M.K. Mahla and Beerendra Singh	964-970
52.	Genetic Variability and Correlation Studies of Bread Wheat Genotypes under Late Sown Irrigated Conditions V. Gupta, M. Kumar, V. Singh and L. Chaudhary	971-975
53.	Heritability and genetic advance studies in single cross hybrids of maize (<i>Zea mays</i> L.) N. Chamundeswari, K. Phani Kumar and K. Mohana Rao	976-979
54.	Heterosis studies for yield and its components in sorghum H.L. Barupal, N.S. Dodiya, Sandeep Kumar Bangarwa and Ravi Kumawat	980-983
55.	Sustainable membrane filtration technology for wastewater treatment for agriculture production Mohd. Ayub Ansari, Anuradha Singh, Afren Ansari and Ramesh Kumar Prajapati	984-987
56.	Genetic Diversity Studies through D ² Analysis in Chickpea (<i>Cicer arietinum</i> L.) Germplasm Mayuri Megha Taidalwar and Gaibriyal M. Lal	988-994
57.	Effect of foliar spray of nutrients and plant growth regulator on vegetative, reproductive growth, physical character and leaf chlorophyll content of acid lime (<i>Citrus aurantifolia</i> Swingle) Naresh Meena, R.N. Kanpure, R.P. Patel, B.K. Kachouli and B.K. Patidar	995-999
58.	Guni cultivation of finger millet : An indigenous practice for sustained productivity and scientific evaluation Sukanya T.S., Chaithra C. and Pratima Ningaraddi Morab	1000-1004
59.	Effect of GA ₃ with and without boron on fruiting, yield, quality of guava (<i>Psidium guajava</i> L.) cv. Sardar Ankit Verma, J.P. Singh, Swatantra Yadav and Siddhartha Gautam	1005-1008
60.	Estimation of combining ability in sorghum [<i>Sorghum bicolor</i> (L.) Moench] B.L. Meena, P.B. Singh, B.R. Ranwah, S.P. Das and Prashun Sachan	1009-1021
61.	Characterization of wheat (<i>Triticum</i> Spp.) varieties on the basis of seed morphology N.M. Magar, S.S. Dodake, R.D. Lokhande and U.G. Kachole	1022-1025
62.	Impact of pre-harvest application of plant bio-regulators and micronutrient on fruit retention, yield and quality of mango (<i>Mangifera Indica</i> L.) Anushi, V.K. Tripathi, Vineet Awasthi and G. Naga Yashasvi	1026-1030
63.	Per se performance in dual purpose sorghum [<i>Sorghum bicolor</i> (L.) Moench] B.L. Meena, P.B. Singh, B.R. Ranwah, S.P. Das and Prashun Sachan	1031-1040
64.	Identification of statistical weights for the components of the hunger index Arshi Khan and P.V. Ubale	1041-1045
65.	Impact of <i>Azotobacter</i> and vermicompost on growth, flowering, yield and quality traits of strawberry Vineet Awasthi, V.K. Tripathi, G. Naga Yashasvi and Anushi	1046-1050
66.	Production potential and economics of rice (<i>Oryza sativa</i>) based cropping systems under organic nutrient management Ratan Deep Soni, S.B. Agrawal, R.P. Sahu, S.K. Singh and Poornima Malviya	1051-1054
67.	Triple test cross analysis in three sorghum crosses B.L. Meena, P.B. Singh, B.R. Ranwah and S.P. Das	1055-1063
68.	Influence of foliar application of plant bio-regulators and micronutrient on fruit retention, yield and quality attributes of mango Jitendra Singh Yadav, R.K.S. Gautam, Ankit Singh Bhadauria and Prakash Pandey	1064-1068
69.	Bio-efficacy of spinetoram 12% SC (11.70% w/w) against fall armyworm, <i>Spodoptera frugiperda</i> (J.E. Smith) in maize C.S. Chaudhari, A.S. Totre, V.S. Shinde, S.B. Latake and S.R. Dhonde	1069-1072

70.	Effect of foliar application of naa and boron on growth, yield and quality of phalsa Sangam Kumar, A.K. Dwivedi, Akash Shukla and Satya Veer	1073-1076
71.	Assessment of yield and quality attributes of basmati rice-based cropping system under organic nutrient management practices Ratan Deep Soni, S.B. Agrawal, R.P. Sahu, Poornima Malviya and S.K. Singh	1077-1080
72.	Evaluation of salt tolerant rice, wheat and mustard varieties under sodic soil conditions Devendra Singh and Ravindra Kumar	1081-1083
73.	Evaluation of local landraces and released varieties of mungbean (<i>Vigna radiata</i> L. Wilczek) in eastern plain zones of U.P. Mayank and G.M. Lal	1084-1089
74.	Diversity and phytosociological analysis of weed species : An important tool for crop management Thejanguzo T.R., Himshikha, A.K. Negi, J.S. Butola, L.S. Kandari and C.S. Dhanai	1090-1098
75.	Effect of integrated nutrient management on growth, yield and quality of tissue cultured banana cv. grand naine Satya Veer, A.K. Dwivedi, Akash Shukla, Shubham Gupta and Sangam Kumar	1099-1102
76.	Breeding for white rust resistance in Indian mustard (<i>Brassica juncea</i> L.) B.L. Meena, H.S. Meena and H.K. Sharma	1103-1108
77.	Impact of modern agro-techniques on growth and yield of wheat B.L. Meena, R.S. Meena, Prashun Sachan, M.L. Meena and Y.K. Sharma	1109-1112
78.	Problems faced by the households in existing crop production in Dausa District of Rajasthan B.L. Meena, Nisha Meena, M.L. Meena and Y.K. Sharma	1113-1115
79.	Proteolytic activity of ginger extract, Kachri (<i>Cucumis melo</i> var. <i>agrestis</i>) extract, kiwi fruit extract and papaya peel extract against casein as substrate Praneeta Singh and P. Prabhakaran	1116-1120
80.	Survey of soft rot causing bacterium <i>Pectobacterium carotovorum</i> sp. <i>carotovorum</i> from Daurala Block of Meerut District Ajay Kumar Mishra	1121-1126
81.	Management of weeds in rice (<i>Oryza sativa</i> L.) K.V. Singh and U.S. Tiwana	1127-1130
82.	Assessment of genetic variability among muskmelon (<i>Cucumis melo</i>) genotypes in the hot arid regions Priyanka, Santosh Choudhary and S.K. Moond	1131-1135
83.	Crop weed competition in late sown wheat (<i>Triticum aestivum</i> L.) central Punjab Hidam Roji Devi and Udham Singh Tiwana	1136-1138
84.	An economics analysis of tomato crop in Bilaspur District of Chhattisgarh State, India Yogeshwari Marko¹, B.C. Jain¹ and V.K. Choudhary	1139-1142
85.	Response of late sown wheat (<i>Triticum aestivum</i> L.) to nitrogen levels under different sowing methods Amandeep Kaur and Udham Singh Tiwana	1143-1146
86.	Integrated nutrient management in late sown wheat (<i>Triticum aestivum</i> L.) in central Punjab Athokpam Sushma Luwang and Udham Singh Tiwana	1147-1150
87.	Influence of boron and NAA on fruiting, yield and quality attributes of Litchi (<i>Litchi chinensis</i> Sonn.) cv. Rose Scented Prakash Pandey, R.K.S. Gautam, Shubham Gupta and Jitendra Singh Yadav	1151-1156
88.	Knowledge level of chickpea growers regarding pradhan mantri fasal bima yojna with reference to chickpea growers in Raipur District of Chhattisgarh Vijay Singh Thakur and K.K. Shrivastava	1157-1159
89.	Study on growing degree days, heat use efficiency and weather indices of timely sown wheat (<i>Triticum aestivum</i> L.) varieties Prashun Sachan, V.K. Verma, C.B. Singh, A.K. Sachan, Ram Pyare and Dhananjai Singh	1160-1163
90.	Screening of timely sown wheat (<i>Triticum aestivum</i> L.) varieties in relation to climate change in central plain zone of Uttar Pradesh Prashun Sachan, V.K. Verma, A.K. Sachan and Ram Pyare	1164-1166
91.	Productivity of rice (<i>Oryza sativa</i> L.) in relation to nitrogen levels and time of application P.D. Singh and U.S. Tiwana	1167-1170
92.	Weed management in basmati rice (<i>Oryza sativa</i> L.) Soibam Priya Devi and Udham Singh Tiwana	1171-1173
93.	Effect of incorporating chicken skin blend on quality attributes of chicken patties Chirag Singh, Praneeta Singh and P. Prabhakaran	1174-1177
94.	Effect of EFS (Enzymes feed supplementation) on growth and development of broiler chicks Ashok Kumar Singh	1178-1181
95.	Influence of different combination of organic, inorganic and foliar grade fertilizer on growth and yield of groundnut P.V. Mahatale, G.D. Chandankar, M.D. Yenppreddiwar, M.M. Raut and N.R. Palaspagar	1182-1185

96.	Yield and nitrogen use efficiency of maize (<i>Zea mays</i> L.) as influenced by green seeker based nitrogen management practices Prakasha G., Mudalagiriappa, Hanumanthappa D.C. and Somashekar K.S.	1186-1190
97.	Growth, multiplication efficiency of composting earth worms (<i>Eisenia fetida</i>) as influenced by substrata and seasons Jagdish Prajapati, Sadhana Chaurasia and Ravindra Singh	1191-1194
98.	Assessment of different sesame (<i>Sesamum indicum</i> L.) varieties under different agro ecological environments for higher yield Varsha Thakur, Seema Paroha, S.B. Agrawal Archana Pandey and S.K. Singh	1195-1198
99.	Effect of foliar application of plant growth regulators on growth and yield attributes of linseed (<i>Linum usitatissimum</i> L.) Harshit Kumar, Dhananjai Singh, V.K. Verma, Ram Pyare, Arvind Kumar Singh, Mandeep Kumar and Jaykar Singh	1199-1201
100.	Effect of foliar application of plant growth regulators on oil content, yield and economics of linseed (<i>Linum usitatissimum</i> L.) Harshit Kumar, Dhananjai Singh, V.K. Verma, Ram Pyare, Arvind Kumar Singh, Mandeep Kumar and Jaykar Singh	1202-1204
101.	Assessment of weed management practices on seed yield and economics of irrigated linseed (<i>Linum usitatissimum</i> L.) Jaykar Singh, Dhananjai Singh, Ram Pyare, V.K. Verma, Arvind Kumar Singh, Ashish Kumar Yadav, Harshit Kumar	1205-1208
102.	Effect of weed management practices on weed density, weed dry weight and yield of irrigated linseed (<i>Linum usitatissimum</i> L.) Jaykar Singh, Dhananjai Singh, Ram Pyare, V.K. Verma, Arvind Kumar Singh, Ashish Kumar Yadav, Harshit Kumar	1209-1212
103.	Effect of nitrogen levels and its application methods in late sown wheat (<i>Triticum aestivum</i> L.) Rahul Yadav and Udham Singh Tiwana	1213-1215
104.	Effect of sowing methods and seed rates on the grain yield of late sown wheat (<i>Triticum aestivum</i> L.) Ravinder Kumar and Udham Singh Tiwana	1216-1218
105.	Appication of Nitrogen in Late Sown Wheat (<i>Triticum Aestivum</i> L.) Through Leaf Colour Chart Ankur Gaba and Udham Singh Tiwana	1219-1222
106.	Power and functions, board and revenue officers under U.P. revenue code 2006 and U.P. revenue code rules 2016 Youdh Vir Singh	1223-1225
107.	Correlation and path analysis for yield contributing parameters for grain yield of maize (<i>Zea mays</i> L.) genotypes Vipin Kumar and Ashvani Panwar	1226-1231
108.	Heritability and genetic advance estimates from F ₁ lines of maize (<i>Zea mays</i> L.) Vipin Kumar and Ashvani Panwar	1232-1236
109.	Nitrogen management in late sown wheat (<i>Triticum aestivum</i> L.) varieties Komal Sharma and Udham Singh Tiwana	1237-1239
110.	Response of wheat (<i>Triticum aestivum</i> L.) varieties to phosphorous levels under late sown conditions Pritpal Singh and Udham Singh Tiwana	1240-1242



Characterization of Morphological Characters of Karpooram Mango : An Indigenous Mango (*Mangifera indica* L.) Variety of Southern Kerala

Bindu B.

Farming Systems Research Station, Sadanandapuram, Kerala Agricultural University

Email : bindu.b@kau.in

Abstract

'Karpooram', the traditional mango variety was found mainly in the homesteads of southern Kerala. The fruit of this variety has a characteristic flavor of 'Karpooram' or camphor. This is a table variety with medium to large fruit size, high pulp content, less fibrous flesh. The study was conducted at the Farming Systems Research Station, Sadanandapuram, Kerala Agricultural University during 2018–2020, to evaluate the various accessions of traditional mango variety 'Karpooram' in Southern Kerala. During the survey, a good number of Karpooram mango trees were located in Kollam district. Fruit weight varies from 250g to 675g. The tree is moderately vigorous with spreading habit. Inflorescence length varies from 12.6 cm - 38.6 cm, inflorescence width varies from 7.4cm - 31.2cm, petiole length varies from 1.7cm - 6.5cm, leaf length varies from 13.5cm - 27.9 cm, leaf width varies from 3.2cm - 7.2cm, tree height varies from tall to medium (6.2 m - 12.4 m). Fruit bearing type is solitary. Highest TSS (20° brix) was reported from accession KLM-35 and KLM-36, lowest acidity of 0.32 % was reported from KLM-21, KLM 22, KLM-32, KLM-33 and PTA-2. Highest carotenoid content of 4.89 mg 100g⁻¹ was reported from KLM-26, highest ascorbic acid content of 30 mg 100g⁻¹ was reported from KLM-32. Highest total sugar content of 18.6 % was reported from KLM-21. Reducing sugar content (3.6%) was highest from KLM-33. Highest fruit number of 800 was reported from accession KLM-21.

Key words : Traditional mango, karpooram, characterisation, fruit quality, yield

Introduction

Mango is the most important commercially grown fruit of our country (Bhalekar *et al*, 2016). The major mango producing countries include India, China, Thailand, Indonesia, Philippines, Pakistan, Brazil, Bangladesh, USA, Africa and Mexico (Adikshita *et al*, 2018). 'Karpooram' is a native or indigenous mango variety found in the homesteads of south and central Kerala. This is a table variety with medium to large fruit size, high pulp, low peel and stone percent, high TSS and reducing sugar, low acidity and fibre content with characteristic flavor of 'Karpooram' (camphor) and high overall consumer acceptability. The tree is moderately vigorous with spreading habit and regular bearer. It normally flowers during January-February (mid season flowering) and rarely off season flowering (secondary flowering) is also reported by Borel *et al* (2017). Fruits are medium to large (280-750g) in size, high pulp- stone ratio and high rind thickness. The skin colour is dark green with red shade and brown spots. Oil glands are present in the rind. Ripened fruit has high TSS, reducing sugar and carotenoid content, low fibre and acidity. Fruit has the distinct flavor of camphor and also has high keeping quality. High variability is observed with respect to colour, size, shape and quality of fruit and fruit yield. Poly embryonic character is also seen in this variety. The variety is becoming extinct from our homesteads as in the case of other traditional or native varieties of Kerala.

Considering the high quality attributes and export potential of this variety, there is an urgent need to conserve the available genetic resources in situ which are on the verge of extinction.

Urbanization and industrialization paved way to large scale destruction of native varieties of mango. Moreover, the introduction of new varieties from other states and changed preference of people towards these varieties and use of grafts instead of seedlings led to the extinction of native cultivars. This also led to the irreversible genetic erosion leading to extinction of many of our traditional varieties. However a few varieties are still existing in some homesteads and as avenue plants. So it is necessary to conserve the available traditional genetic resources, which are on the verge of extinction.

Traditional mango varieties are poorly investigated and promoted. Evaluation of these varieties will be useful for developing high yielding varieties with desirable characters through breeding approaches. However, the efforts taken to conserve the traditional mango germplasm of southern Kerala and its utilization in genetic improvement programmes is not much appreciable. Hence this work is envisaged with an objective of identification, conservation and maintenance of superior lines of the traditional mango variety "Karpooram" in Southern Kerala from existing germplasm in the farmer's field.

Table-1 : Fruit characters of traditional mango Karpooram.

Acc no.	Fruit Weight (g)	Fruit Length (cm)	Fruit width (cm)	Fruit diameter (cm)	Fruit volume (cc)	Pulp weight (g)	Peel weight (g)
KLM 4	486.00	11.00	10.00	29.33	520.00	350.00	69.00
KLM 9	419.00	13.00	8.80	25.50	350.00	256.33	38.07
KLM 14	399.00	11.00	7.80	25.00	322.00	260.00	30.00
KLM 16	484.67	13.50	9.00	26.00	420.00	330.00	40.00
KLM 20	393.33	11.00	9.00	27.00	309.00	218.00	27.00
KLM 21	284.00	10.50	8.60	25.67	400.00	307.00	46.00
KLM 22	410.00	12.00	10.00	26.80	375.00	284.00	44.00
KLM 26	638.00	14.20	11.00	30.00	610.00	553.33	37.67
KLM 32	336.00	10.30	9.27	23.00	435.00	363.00	50.00
KLM 33	484.67	12.00	12.00	29.50	500.00	393.00	53.00
KLM 35	387.00	11.50	8.00	33.00	345.00	242.00	51.00
KLM 36	320.00	11.00	9.17	26.30	385.33	291.67	46.00
KLM 41	325.67	10.30	9.07	25.63	351.00	271.00	44.00
TVM-1	317.00	10.50	9.50	28.10	420.00	289.00	51.00
TVM-6	336.00	11.00	7.00	24.00	318.00	197.00	55.00
TVM 8	433.00	13.00	9.50	27.00	400.00	208.00	29.00
TVM 9	430.00	12.00	8.00	24.00	385.00	210.00	37.00
TVM 11	317.33	10.00	10.00	25.00	310.00	186.00	30.00
TVM13	480.00	12.00	10.50	28.00	432.00	340.00	61.00
PTA2	303.00	9.00	8.00	24.00	300.00	205.00	35.00
CD	27.85	1.44	1.75	2.18	20.81	15.23	5.76

Materials and Methods

Random survey was conducted to locate the indigenous/native mango variety 'Karpooram' in different parts of central and south Kerala. The elite mango trees of this variety which are superior with respect to the important economic characters like yield, fruit size, organoleptic qualities, regularity in bearing and offseason bearing was selected and germplasm was established at FSRs, Sadanandapuram using grafts. The grafts will be prepared by pre-curing of scions in the mother plants identified. Pre-cured scions will be separated from the mother tree and grafts will be prepared. The grafts was maintained at the farm and established grafts were planted and maintained in the orchard. For the study descriptive characters of leaf, inflorescence, fruit and stone were recorded as per IPGRI descriptor. Quantitative characters like leaf length, leaf width, petiole length, inflorescence length, inflorescence width, fruit length, fruit width, fruit weight, fruit volume were noted. Quality characters like acidity, ascorbic acid content, total carotenoids, total soluble solids, total sugar and reducing sugar and crude fibre content were studied.

Results and Discussion

The study revealed that (Table-1) fruit weight ranges from 284g (KLM-21) to 638g (KLM-26) also reported by Asif *et al* (2002), fruit length varied from 10.0 cm (TVM-11) to 14.2 cm (KLM-26), fruit width varied from 7cm (TVM-6) to

Table-2 : Yield characters of traditional mango Karpooram.

Acc no.	Number of fruits	Yield per tree (Kg)	Shelf life (days)
KLM 4	500	242.35	7.00
KLM 9	350	146.65	6.00
KLM 14	620	247.38	6.66
KLM 16	370	151.55	7.00
KLM 20	550	166.65	7.33
KLM 21	600	307.20	7.33
KLM 22	525	275.25	7.00
KLM 26	850	542.30	7.33
KLM 32	600	275.40	6.66
KLM 33	730	353.00	7.00
KLM 35	500	170.00	7.33
1KLM 36	550	209.00	7.00
KLM 41	500	180.50	7.00
TVM-1	480	152.16	5.00
TVM-6	550	165.00	6.33
TVM 8	700	188.30	7.33
TVM 9	550	221.60	7.66
TVM 11	490	155.33	6.33
TVM13	500	221.00	6.60
PTA2	500	135.50	7.00
CD	30.23	24.62	1.05

12cm (KLM-33), fruit diameter varied from 23cm (KLM-32) to 33cm (KLM-35), fruit volume varied from 300cc (PTA-2) to 610cc KLM-26), pulp weight varied from 186 g (TVM-11) to 553.33g (KLM-26), peel weight varied from 27g (KLM-20) to 69.0 g (KLM-4).

Results of the experiment showed that (Table-2)

Table-3 : Fruit quality characters of different accessions of traditional mango Karpooram.

Acc no.	TSS (°brix)	Acidity (%)	Carotenoid (mg 100 g ⁻¹)	Ascorbic Acid (mg 100 g ⁻¹)	Total Sugar (%)	Reducing Sugar (%)	Non Reducing Sugar (%)
KLM 4	15.00	0.640	4.20	15.00	9.22	3.00	6.22
KLM 9	16.80	0.640	3.15	17.01	8.29	3.00	5.29
KLM 14	14.00	0.320	2.23	15.00	9.06	1.66	7.40
KLM 16	16.00	1.900	2.89	17.05	8.43	2.63	5.80
KLM 20	15.50	1.280	2.02	30.27	11.62	2.38	9.24
KLM 21	14.00	0.320	3.62	15.00	12.60	2.08	10.52
KLM 22	14.60	0.320	2.18	13.30	8.60	2.92	5.68
KLM 26	22.00	0.317	5.22	28.50	15.00	5.00	10.00
KLM 32	15.00	0.820	2.05	20.00	7.52	1.99	5.53
KLM 33	20.00	0.320	4.82	30.27	15.64	4.20	11.44
KLM 35	16.00	0.320	4.49	17.23	8.90	3.27	5.63
KLM 36	15.00	0.953	3.38	13.33	13.31	4.20	9.11
KLM 41	18.00	0.323	2.50	12.00	8.33	2.03	6.30
TVM-1	16.00	0.937	2.40	20.67	8.91	1.62	7.29
TVM-6	20.00	0.319	5.25	20.00	14.00	4.16	9.84
TVM 8	18.00	0.633	3.00	15.00	7.22	2.40	4.82
TVM 9	19.00	0.960	4.00	20.33	13.12	2.60	10.52
TVM 11	16.00	0.923	5.78	14.93	10.40	2.50	7.90
TVM13	18.00	0.630	4.48	18.00	13.12	2.93	10.19
PTA2	19.00	0.320	2.65	13.32	12.91	3.57	9.34
CD	1.114	0.189	0.242	2.340	0.471	0.294	0.593

number of fruits from different accessions of Karpooram varies from 350 (KLM-9) to 800 (KLM-26), yield per tree varies from 146.65 Kg (KLM-9) to 542.3kg (KLM-26). Prakashkumar and Suresh (2018) observed similar results in mango, shelf life at ambient conditions varies from 5 days (TVM-1) to 7.66 days (TVM-9).

Fruit quality characters showed significant difference among different accessions studied (Table-3). TSS value varied from 14⁰ Brix (KLM-21) to (KLM-26) 22⁰ Brix, acidity varied from 0.317% (KLM-26) to 1.9 % (KLM-16). Das *et al* (2020) showed similar result. Carotenoid content varied from 2.02 mg 100 g⁻¹ (KLM-20) to 5.78 mg 100 g⁻¹ (TVM-11), ascorbic acid varied from 12.0 mg 100 g⁻¹ (KLM-41) to 30.27 mg 100 g⁻¹ (KLM-33), total sugar content varied from 7.22 % (TVM-8) to 15.64% (KLM-33), reducing sugar content varied from 1.62 % (TVM-1) to 5.0% (KLM-26), non reducing sugar content varied from 4.82 % (TVM-8) to 11.44% (KLM-33), crude fibre content varied from 2.80 % (KLM-26) to 16.5 % (KLM-41).

Thus Karpooram' is a indigenous mango variety found in the homesteads of south and central Kerala. Evaluation of various accessions of traditional mango variety 'Karpooram' in Southern Kerala revealed that a good number of Karpooram mango trees were located in Kollam district of Kerala. Fruit weight varies from 250g to 675g. The tree is moderately vigorous with spreading habit. Fruit bearing type is solitary. Highest TSS (20⁰ brix) was reported from accession KLM 35 and KLM 36, lowest acidity of 0.32 % was reported from KLM 21, KLM 22,

KLM 32, KLM-33 and PTA -2. Highest carotenoid content of 4.89 mg 100g⁻¹ was reported from KLM 26, highest ascorbic acid content of 30 mg 100g⁻¹ was reported from KLM-32. The work revealed that Karpooram mango accessions KLM-26 and KLM-33 were promising ones with respect to the morphological characters studied under Kerala conditions.

References

- Adikshita, I.M.; Sharma, M. and Kishore, S. (2018). Use of plant water extracts and bio-control agents for post harvest management of mango anthracnose caused by *Colletotrichum gloeosporioides*. *J Krishi Vigyan*, 7 (Special Issue) : 163-168.
- Asif, M.; Usman, M.; Jaskani, M.J. and Khan, M.M. (2002). Comparative study of flower sex ratio in different cultivars of mango (*Mangifera indica* L.). *Int J Agric Biol* 4 : 220-222.
- Bhalekar, S.G.; Chalak, S.U. and Badgugar, C.D. (2016). Performance of exotic mango cultivars under Pune conditions. *J Krishi Vigyan* 5: 88-91.
- Bora, L.; Singh, A.K. and Singh, C.P. (2017). Characterization of mango (*Mangifera indica* L.) genotypes based on physico-chemical quality attributes. *J Appl Nat Sci* 9 : 2199-2204.
- Das, B.; Singh, D. and Yadav, V.B. (2020). Path coefficient analysis for some quantitative characters in mango. *Env Ecol* 19: 885-887.
- Prakashkumar, R. and Suresh, S. (2018). A note on the pollen wall ornamentation of *Mangifera indica* hybrid and its varieties. *S. Indian Hort.* 50: 515-516.



Influence of Long-Term Application of Farmyard Manure and Fertilizer Nitrogen on Total Nutrient Status in Sandy Loam Soil under Pearl Millet-Wheat Cropping

Sunita Sheoran*, Dhram Prakash, Dev Raj and K.S. Grewal

Department of Soil Science, CCS Haryana Agricultural University Hisar-125004

*Email : sheoransunita27@gmail.com

Abstract

Pearl millet-wheat is one of the major cropping systems in semi-arid region of Haryana. Understanding the nutrient status in soil make sense to decide the adoption of best nutrient management practices for crop production. In present study, the soil samples were collected after completion of 51 cycles of pearl millet-wheat cropping from an ongoing long-term field experiment established in 1967 at Soil Research Farm, CCS Haryana Agricultural University, Hisar. Lowest total N content was recorded in absolute control and application of 120 kg N ha⁻¹ increased total N by 17.0% over control. Application of FYM in rabi, kharif and both season increased the total N content by 133.6, 123.3 and 162.6%, respectively over control. Incorporation of FYM along with fertilizer N in rabi, kharif and both season increased the total N content by 6.0, 8.9 and 4.9%, respectively as compared to plots FYM applied alone. Regardless of mode of application, total phosphorus (P) content in soil was significantly increased with increasing application rate of FYM from 5 to 15 Mg ha⁻¹. Application of FYM in rabi, kharif and both season increased the total P content by 49.2, 41.7 and 67.7%, respectively over control. Incorporation of FYM along with 120 kg N ha⁻¹ in rabi, kharif and both season increased total P content by 15.5, 11.7 and 13.0%, respectively over FYM sole application. Application of FYM in rabi, kharif and both season increased the total potassium (K) content by 18.1, 12.8 and 25.8%, respectively over control. Among the different modes of FYM application, total sulphur (S) content in soil followed the order: both season > rabi > kharif. Incorporation of FYM along with 120 kg N ha⁻¹ in rabi, kharif and both season increased total S content by 14.9, 13.7 and 13.5%, respectively over the sole application of FYM. Conjoint application of FYM and fertilizers N was found superior for enhancing the soil total N, P, K and S content under pearl millet-wheat cropping system.

Key words : Long-term, FYM levels and modes, total nitrogen, total sulphur, wheat

Introduction

In exhaustive cropping systems like pearl millet-wheat, it is suggested that nutrient mining should be replenished by adding manures and/or fertilizers for sustaining soil fertility and productivity. Soils of semi-arid and arid eco-regions generally retain low organic matter content. This emphasized the addition of suitable organic amendments along with fertilizers to achieve the soil recuperation in these conditions, where soil biological activity and microbial biomass are relatively low (Antil *et al.* 2011). In India, farmyard manure (FYM) is the major organic nutrient source as soil amendment. In addition to manures, chemical fertilizers especially NPK are added to improve soil fertility, but their application directly or indirectly changes soil physico-chemical and biological properties (Saha *et al.* 2008, Benbi and Brar 2009). Long term experiments help in evaluating a range of treatments and also act as a tool to identify the treatment that is maintaining the agricultural sustainability. Complex processes occurring in field can be understood and evaluated by conducting the long term field experiments as it provides sufficient time to crops, crop rotation, fertilizers and manures to have a measurable effect or changes in soil properties, fertility and productivity (Johnston and Poulton, 2018).

Long-term experiments estimate nutrient dynamics and help to identify the current changes and also predict future changes to be occurred in soil properties. With the adoption of modern agricultural techniques the soil has been extensively exploited. Because of continuous nutrient depletion by the crops without adequate replenishment may causes threat to food security. Maintenance and importance of soil organic matter (SOM) in soil is considered as an important objective for any sustainable system of cropping (Benbi and Brar, 2009; Dhram Prakash *et al.*, 2017). In order to maintain SOM in soil, nutrients removed by the field crops must be replenished. Incorporation of organic amendments is considered as a desirable strategy to achieve soil recuperation especially in semi-arid eco-regions (Bastida *et al.*, 2008). The SOM plays an important role in the maintaining the fertility and productivity of soil, especially, through the cycling, retention, and release of essential plant nutrients, total nutrients and also in maintaining the soil physical health (Benbi *et al.*, 2015). Incorporation of the organic matter stimulates the natural soil microbes, especially the micro flora and also reactivates bio-chemical processes in soil (Watts *et al.*, 2010). Inorganic fertilizers especially nitrogen, phosphorus and potassium, not only help to maintain soil fertility, but also directly or

Table-1 : Physico-chemical properties of soil at the start of experiment-1967.

Property	Value
Texture	Sandy loam
pH (1:2)	8.2
Organic carbon (%)	0.47
CaCO ₃ (%)	1.1
Available N (kg ha ⁻¹)	200.0
Available P (kg ha ⁻¹)	26.0
Available K (kg ha ⁻¹)	498.0

indirectly changes the soil chemical, physical and biological properties. On long-term basis, these changes in soil properties are believed to cause significant differences in soil health and quality which in turn influences productivity of soils (Saha *et al.*, 2008). Combined rather than imbalanced use of organic manures and fertilizers improves the microbial population and diversity in soil rather than sole application (Meena *et al.*, 2016). The combined use of chemical fertilizers and organic manures has been found more beneficial than using either of the alone for sustainable agriculture on long-term basis (Henryson *et al.*, 2018).

Continuous application of FYM on long-term basis can lead to increase the content of N, P, K, Ca, Mg and other soluble ions in soil (Watts *et al.*, 2010), hereby creating a reservoir of nutrients in soil. However, integrated use of organic manures and fertilizers could be the most logical way for maintaining the soil fertility, productivity and sustaining the soil health and quality on long term basis (Kumara *et al.*, 2013; Sheoran *et al.*, 2018). Studies on long-term effect of FYM and fertilizer nitrogen on total nutrient status (N,P,K and S) in soil under pearl millet-wheat cropping system are rare. Keeping in view the above mentioned facts, the present investigation was planned to study the long term effect of different modes and levels of FYM and fertilizer N on: total N,P,K and S status in soil under pearl millet-wheat cropping system.

Materials and Methods

Description of the Experimental Site and Field Experiment : An ongoing long-term field experiment established in October 1967 on 'compensation of fertilizer nitrogen through use of FYM under pearl millet-wheat cropping system' at Research Farm, Department of Soil Science, CCSHAU, Hisar (India) was selected to conduct the present study. The experimental site is located at 29°16'N latitude and 75°75'E longitude in North-Western part of India. The soil was sandy loam, *Typic Ustochrept* and physico-chemical properties of surface soil (0-15 cm) analyzed at the start of experiment (1967) are presented in Table-1 (Gupta *et al.*, 1992).

The treatments of present study consist of 3 levels (15, 30 and 45 Mg ha⁻¹ yr⁻¹ till 2007-08 and 5, 10 and 15 Mg ha⁻¹ yr⁻¹ from 2008-09 onwards, on dry weight basis) and 3 modes of FYM application *i.e.* applying to *Kharif* crop (summer season), to *Rabi* crop (winter season) and to both the crops (*Rabi* and *Kharif* season). One treatment of FYM control was also maintained. These 10 treatments (3 FYM modes × 3 FYM levels +1 FYM control) were allocated in the main plots. Each main plot was divided into two sub-plots receiving 0 and 120 kg N ha⁻¹ in the respective plots through urea. Since 2007-08, the following treatments are being maintained on the permanent plots :

Main plot :

FYM levels : 0, 5, 10 and 15 Mg ha⁻¹

Mode of application : *Rabi*, *Kharif* and both *Rabi* and *Kharif* season.

Sub plot :

N levels : 0 and 120 kg ha⁻¹, Plot size: 10m x 5m, Replications : 3, Design: Split plot

Cropping sequence : Pearl millet-wheat

The FYM was incorporated on dry weight basis in the plough layer (15 cm) before sowing of the crops. The FYM used in the experiment was analyzed every year and average nutrient composition of FYM applied during 2017-18 is given in Figure-1. Nitrogen was applied in two splits *i.e.* half at sowing time and remaining half after 25-30 days of sowing to both the crops in respective treatments. Since the start of experiment, no chemical fertilizers other than urea have been applied to any treatment.

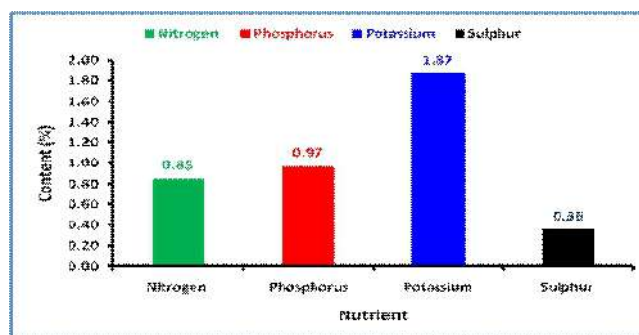


Fig-1 : Average nutrient composition of FYM used (oven dry basis).

After completion of 51 years of pearl millet-wheat cropping the surface soil samples (0-15 cm) were collected. The soil samples were air dried, ground and sieved through 2 mm sieve. The details of the methods used for soil analysis are given below :

Table-2 : Effect of different modes, levels of FYM and fertilizer N application on total N and P content (kg ha^{-1}) in soil after wheat harvest.

Mode of application	FYM level (Mg ha^{-1})	Total N (kg ha^{-1})			Total P (kg ha^{-1})		
		N (kg ha^{-1})			N (kg ha^{-1})		
		0	120	Mean	0	120	Mean
Rabi	0	852.0	996.7	924.3	685.7	825.3	755.5
	5	1876.0	2007.3	1941.7	778.0	907.7	842.9
	10	2114.0	2221.3	2167.7	982.4	1228.3	1105.3
	15	2300.7	2437.7	2369.2	1378.0	1488.0	1433.0
	Mean	2096.9	2222.1	2159.5	1046.1	1208.0	1127.1
Kharif	5	1806.0	1953.3	1879.7	746.0	889.3	817.6
	10	1998.0	2111.7	2054.8	958.7	1186.0	1072.3
	15	2123.3	2391.7	2257.5	1330.1	1313.7	1321.9
	Mean	1975.8	2152.2	2064.0	1011.6	1129.7	1070.6
Both	5	2144.7	2226.7	2185.7	881.0	1031.7	956.3
	10	2366.0	2487.3	2426.7	1180.1	1355.8	1267.9
	15	2596.7	2739.3	2668.0	1508.0	1644.4	1576.2
	Mean	2369.1	2484.4	2426.8	1189.7	1344.0	1266.8
CD (0.05)		Mode=45.4, FYM level=52.5 N level=23.7, Mode $\times$ FYM=90.9 FYM $\times$ N= NS, Mode $\times$ N= NS Mode $\times$ FYM $\times$ N= NS			Mode=28.0, FYM level=32.3 N level=20.8, Mode $\times$ FYM=55.9 FYM $\times$ N=41.5, Mode $\times$ N= NS Mode $\times$ FYM $\times$ N= NS		

Total Nitrogen : Soil (1g) was digested with sulfuric-salicyclic acid mixture in presence of certain catalysts (Cu or Se) and salts (K_2SO_4), which raised the digestion temperature (Bremner and Mulvaney, 1982).

Total Phosphorus : Two g soil sample was taken in 250 ml flask and digested in 30 ml of 60% HClO_4 (Bray and Kurtz, 1945).

Total Potassium : Total K in soil sample was analysed by digestion in diacid mixture (5 ml $\text{HF}+0.5$ ml HClO_4) as described by Jackson (1958).

Total Sulphur : Total S in soil samples was determined by digesting in a mixture of HClO_4 and HNO_3 (Chapman and Prat, 1961).

Statistical Analysis : Statistical analysis was accomplished using the program STATISTICA 6.0 Stat Soft, Inc. (2001).

Results and Discussion

Total Nutrients : Data related to effect of long term application of FYM and fertilizer N on total nutrient contents in soil after 51 years of continuous cropping of pearl millet-wheat is presented in Table-2. Total N content in soil after wheat harvest was found varied from 852.0 to 2739.3 kg ha^{-1} among different treatments. Among different mode of FYM application, highest amount of total N was observed in the plots receiving FYM in both seasons followed by rabi season application of FYM. Lowest total N content (852.0 kg ha^{-1}) was recorded in

absolute control and application of 120 kg N ha^{-1} increased total N by 17.0% over control.

Irrespective of mode of application, total N content in soil was significantly increased with increasing application rate of FYM. Addition of fertilizer N significantly increased the total N content in soil. Application of FYM in rabi, kharif and both season increased the total N content by 133.6, 123.3 and 162.6%, respectively over control. Incorporation of FYM along with fertilizer N in rabi, kharif and both season increased total N content by 6.0, 8.9 and 4.9%, respectively over the total N content when only FYM was applied. Under the influence of long term application of FYM and fertilizer N, total P content in soil after wheat harvest was found varied from 685.7 to 1644.4 kg ha^{-1} among different treatments (Table-2). The highest amount of total P was observed in the plots receiving 15 Mg ha^{-1} FYM along with 120 kg N ha^{-1} in both seasons. Lowest total P content (685.7 kg ha^{-1}) was recorded in absolute control and application of 120 kg N ha^{-1} increased total N by 20.4% over control. Regardless of mode of application, total P content in soil was significantly increased with increasing application rate of FYM from 5 to 15 Mg ha^{-1} . Addition of fertilizer N significantly increased the total P content in soil. Application of FYM in rabi, kharif and both season increased the total P content by 49.2, 41.7 and 67.7%, respectively over control. Incorporation of FYM along with 120 kg N ha^{-1} in rabi, kharif and both season increased total P content by 15.5, 11.7 and 13.0%, respectively over the total P content when only FYM was applied. Data pertaining to the total K content in soil after wheat harvest

Table-3 : Effect of different modes, levels of FYM and fertilizer N application on total K and S content (kg ha⁻¹) in soil after wheat harvest.

Mode of application	FYM level (Mg ha ⁻¹)	Total K (kg ha ⁻¹)			Total S (kg ha ⁻¹)		
		N (kg ha ⁻¹)			N (kg ha ⁻¹)		
		0	120	Mean	0	120	Mean
Rabi	0	23079.4	20424.7	21752.0	353.3	493.2	423.3
	5	25068.9	23288.6	24178.8	882.3	1064.3	973.3
	10	25752.4	23877.3	24814.9	1287.0	1568.6	1427.8
	15	29722.2	26383.7	28052.9	2085.5	2256.3	2170.9
	Mean	26847.8	24516.5	25682.2	1418.3	1629.7	1524.0
Kharif	5	24257.7	22467.1	23362.4	902.9	1098.8	1000.8
	10	24365.9	23303.3	23834.6	1239.1	1466.0	1352.6
	15	27121.8	25752.9	26437.3	2013.3	2161.5	2087.4
	Mean	25248.5	23841.1	24544.8	1385.1	1575.4	1480.3
Both	5	27342.0	25342.0	26342.0	1272.9	1416.3	1344.6
	10	28204.2	26414.4	27309.3	1715.2	2023.2	1869.2
	15	29038.9	27855.1	28447.0	2382.1	2654.4	2518.3
	Mean	28195.0	26537.1	27366.1	1790.1	2031.3	1910.7

is represented in Table 3 and was found varied from 20424.7 to 29038.9 kg ha⁻¹ among different treatments. The highest and lowest content of total K was observed in the plots receiving 15 Mg ha⁻¹ FYM in both seasons and 120 kg N ha⁻¹, respectively. Among the different modes of FYM application, total K content in soil followed the order: both season > rabi > kharif. Irrespective of mode of application, total K content in soil was significantly increased with increasing application rate and highest was obtained with 15 Mg ha⁻¹ FYM. Addition of fertilizer N significantly decreased the total K content in soil. Application of FYM in rabi, kharif and both season increased the total K content by 18.1, 12.8 and 25.8%, respectively over control. Incorporation of FYM along with 120 kg N ha⁻¹ in rabi, kharif and both season decreased total

K content by 8.7, 5.6 and 5.9%, respectively over the total K content when only FYM was applied. Data related to the total S content in soil after wheat harvest is represented in Table 3 and was found varied from 353.3 to 2654.4 kg ha⁻¹ among different treatments. The highest and lowest content of total S was observed in the plots receiving 15 Mg ha⁻¹ FYM along with 120 kg N ha⁻¹ in both seasons and absolute control, respectively.

Among the different modes of FYM application, total S content in soil followed the order: both season>rabi>kharif. Irrespective of mode of application, total S content in soil was significantly increased with increasing application rate and highest was obtained with 15 Mg ha⁻¹ FYM. Addition of fertilizer N significantly increased the total S content in soil. Application of FYM in rabi, kharif and both season increased the total S content by 260.0, 249.7 and 351.4%, respectively over control. Incorporation of FYM along with 120 kg N ha⁻¹ in rabi, kharif and both season increased total S content by 14.9,

13.7 and 13.5%, respectively over the total S content when only FYM was applied.

After 51 years of continuous FYM and fertilizer applications under pearl millet-wheat system, the lowest total nutrients content was observed in control plots. Irrespective of modes, application of FYM enhanced the total nutrients content in soil. Piotrowska and Koper (2010) observed that total N content in soil was significantly increased with increasing FYM application rate, however no significant influence of N fertilization on total N concentration of soil was seen under winter wheat crop. Addition of crop residues/organic manures under agro forestry, rice-wheat and maize-wheat led to significant build-up in total P in soil and chemical fertilizer applications showed increase in total P in alluvial soils either under alternate wetting-drying moisture regime (Dhram Prakash *et al.*, 2018). Venugopal *et al.* (2016) and Pathariya (2017) concluded that application of FYM along with N fertilizer resulted in higher total K content in soil than fertilizer applied alone. Kumar and Narwal (2016) observed that application of FYM alone increased the total K content in soil by about 40 %. Brar *et al.* (2004) observed higher total K content in soil with fertilizer application as compared to no fertilizer addition. Lowest total S content in soil was obtained when no organic manures was applied in the soil (Reddy 2005). Irrespective of mode of FYM application, total S content was found increased with increasing FYM application rate, however, effect of increasing N fertilizer doses was non-significant. Singh *et al.* (2014) noticed that application of FYM and fertilizer significantly resulted in build-up of total S in soil.

Long term application of FYM increased organic matter content that also results in greater nutrient accumulation in soil (Kaur *et al.*, 2005; Luo *et al.*, 2015).

The higher total N, P and K content in soil in the plots receiving organic manure as compared to plots receiving chemical fertilizer was also reported by Chang *et al.* (2007); Liang *et al.* (2014); Maharjana *et al.* (2017); Jia *et al.* (2018). Total nutrients content in soil was increased with increasing application rate of FYM similar to the findings of Reddy (2005); Chang *et al.* (2007). The highest total nutrients content was observed in the plots receiving FYM in both seasons followed by rabi application. These results are in line with the outcomes of Reddy (2005). Application of FYM in combination with fertilizer N significantly improved the total nutrients (N, P, K and S) status in soil as compared to FYM applied alone. This increase might be due to increased underground biomass due to the adoption of high yielding varieties of both the crops as well as increased nutrient inputs through FYM and fertilizer N (Zhang *et al.*, 2009; Arif *et al.*, 2017). Increment in total nutrients with the integrated use of FYM and fertilizer N was also reported by Zhang *et al.* (2009); Stehlikova *et al.* (2016); Tana and Woldeesenbet (2017); Jia *et al.* (2018).

Conclusions

After 51 years of continuous manure and fertilizer application under pearl millet-wheat cropping system, total N, P, K and S content in soil after wheat harvest varied from 852.0 to 2739.3; 685.7 to 1644.4; 20424.7 to 29038.9 and 353.3 to 2654.4 kg ha⁻¹, respectively among different treatments. Among the different modes of FYM application, total nutrients content in soil followed the order: both season>rabi>kharif. The higher doses of FYM cause build-up of organic matter in soil resulting into higher amount of total nutrients in soil. Influence of fertilizer N was also found significant in increasing the total nutrient content. Considering the results of present study, it was concluded that application of FYM in conjunction with fertilizers N may lead to accrual of total nutrients in these sandy loam soils.

References

- Antil, R.S., Narwal, R.P., Singh, B. and Singh, J.P. (2011). Integrated nutrient management for sustainable soil health and crop productivity. *Indian Journal of Fertilisers*. 7(7): 14-32.
- Arif, M., Ilyasa, M., Riaz, M., Alic, K., Shahd, K., Haqd, I.U. and Fahad, S. (2017). Biochar improves phosphorus use efficiency of organic-inorganic fertilizers, maize-wheat productivity and soil quality in a low fertility alkaline soil. *Field Crops Research*. 214: 25-37.
- Bastida, F., Kandeler, E., Moreno, J.L., Ros, M., Garcia, C. and Hernandez, T. (2008). Application of fresh and composted organic wastes modifies structure, size and activity of soil microbial community under semi arid climate. *Applied Soil Ecology*. 40: 318-329.
- Benbi, D.K. and Brar, J.S. (2009). A 25-year record of carbon sequestration and soil properties in intensive agriculture. *Agronomy for Sustainable Development*. 29: 257-265.
- Benbi, D.K., Brar, K., Toor, A.S. and Sharma, S. (2015). Sensitivity of labile soil organic carbon pools to long-term fertilizer, straw and manure management in rice-wheat system. *Pedosphere*. 25(4): 534-545.
- Brar, B.S., Singh, M.V., Dhillon, N.S. and Benipal, D.S. (2004). Soil quality, crop productivity and sustainability expenses under long term Maize-Wheat-Cowpea cropping sequence in Inceptisol. *Research Bulletins*. pp. 66.
- Bray, R.H. and Kurtz, L.T. (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Science*. 59: 39-45.
- Bremner, J.M. and Mulvaney, C.S. (1982). Total Nitrogen. In A.L. Page, R.H. Miller and D.R. Keeney (Eds.), *Methods of Soil Analysis*. American Society of Agronomy and Soil Science Society of America. pp. 1119-1123.
- Chang E.H., Chung, R.S. and Tsai, Y.H. (2007). Effect of different application rates of organic fertilizer on soil enzyme activity and microbial population. *Soil Science and Plant Nutrition*. 53: 132-140.
- Chapman, H.D. and Pratt, P.F. (1961). *Methods of Analysis of Soils, Plants and Water*. University of California, USA.
- Dharam Prakash, Benbi, D.K. and Saroa, G.S. (2017). Clay, organic carbon, available P and calcium carbonate effects on phosphorus release and sorption-desorption kinetics in alluvial soils. *Communications in Soil Science and Plant Analysis*. 48(1): 92-106.
- Dharam Prakash, Benbi, D.K. and Saroa, G.S. (2018). Land-use effects on phosphorus fractions in Indo-Gangetic alluvial soils. *Agroforestry Systems*. 92: 437-448.
- Gupta, A.P., Narwal, R.P., Antil, R.S. and Dev, S. (1992). Sustaining soil fertility with organic C, N, P and K by using farmyard manure and fertilizer N in a semi arid zone: A long term study. *Arid Soil Research and Rehabilitation*. 6: 243-251.
- Henryson, K., Sundberg, C., Katterer, T. and Hansson, P.A. (2018). Accounting for long-term soil fertility effects when assessing the climate impact of crop cultivation. *Agricultural systems*. 164: 185-192.
- Jackson, M.L. (1958). *Soil Chemical Analysis*. Prentice-Hall, Inc., Englewood.
- Jia, Q., Kamran, M., Ali, S., Sun, L., Zhang, P., Ren, X. and Jia, Z. (2018). Deficit irrigation and fertilization strategies to improve soil quality and alfalfa yield in arid and semi-arid areas of northern China. *Peer Journal*. 6: 4410.
- Johnston, A.E. and Poulton, P.R. (2018). The importance of long-term experiments in agriculture: their management to ensure continued crop production and soil fertility; the Rothamsted experience. *European Journal of Soil Science*. 69(1): 113-125.
- Kaur K., Kapoor K.K. and Gupta A.P. (2005). Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *Journal of Plant Nutrition and Soil Science*. 168: 117-122.

19. Kumar, R. and Narwal, R.P. (2016). Long-term effect of FYM and nitrogen fertilizer on the distribution of K fraction in soil under pearl millet-wheat cropping system. *Forage Research*. 42(2): 131-134.
20. Kumara, B.H., Antil, R.S. and Raj, D. (2013). Long term effect of nutrient management on soil health and crop productivity under pearl millet-wheat cropping system. *Indian Journal of Fertilisers*. 9(12): 86-97.
21. Liang, Q., Chen, H., Gong, Y., Yang, H., Fan, M. and Kuzyakov, Y. (2014). Effects of 15 years of manure and mineral fertilizers on enzyme activities in particle-size fractions in a North China Plain soil. *European Journal of Soil Biology*. 60: 112-119.
22. Luo, P., Han, X., Wang, Y., Han, M., Shi, H., Liu, N. and Bai, H. (2015). Influence of long-term fertilization on soil microbial biomass, dehydrogenase activity, and bacterial and fungal community structure in a brown soil of northeast China. *Annals of Microbiology*. 65: 533-542.
23. Maharjana, M., Sanaulaha, M., Bahar, S. Razavid and Kuzyakova, Y. (2017). Effect of land use and management practices on microbial biomass and enzyme activities in subtropical top-and sub-soils. *Applied Soil Ecology*. 113: 22-28.
24. Meena, M.D., Joshi, P.K., Jat, H.S., Chinchmalatpure, A.R., Narjary, B., Sheoran, P. and Sharma, D.K. (2016). Changes in biological and chemical properties of saline soil amended with municipal solid waste compost and chemical fertilizers in a mustard-pearl millet cropping system. *Catena*. 140:1-8.
25. Pathariya, P. (2017). Effect of continuous application of fertilizers and manure on distribution of potassium pools in a vertisol. Thesis submitted to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.
26. Piotrowska, A. and Koper, J. (2010). Soil α -glucosidase activity under winter wheat cultivated in crop rotation systems depleting and enriching the soil in organic matter. *Journal of Elementology*. 15(3): 593-600.
27. Sheoran S., Antil, R.S., Raj, D., Deepika and Grewal, K.S. (2018). Yield trends and changes in soil fertility in a long term pearl millet (*Pennisetum glaucum*)-wheat (*Triticum aestivum*) cropping system managed with organic, inorganic and integrated sources of nutrients. *Indian Journal of Agricultural Sciences*. 88(10): 1521-1531.
28. Singh, M., Shriram, Wanjari, R.H. and Sharma, P. (2014). Balance and forms of potassium under rice-wheat system in a 40-year-old long- term experiment on Mollisols of Pantnagar. *Journal of Indian Society of Soil Science*. 62(1): 38-44.
29. Stehlikova, I., Madaras, M., Lipavsky, J. and Simon, T. (2016). Study on some soil quality changes obtained from long-term experiments. *Plant Soil and Environment*. 62(2): 74-79.
30. Tana, T. and Woldesenbet, M. (2017). Effect of combined application of organic and mineral nitrogen and phosphorus fertilizer on soil physico-chemical properties and grain yield of food barley (*Hordeum vulgare* L.) in Kaffa Zone, South-western Ethiopia. *Momona Ethiopian Journal of Science*. 9(2): 242-261.
31. Venugopal, G., Sharma, S.H.K., Qureshi, A.A., Sudhakar, S.N. and Vidyasagar, G.E. (2016). Potassium uptake by sorghum and potassium fractions in soil under long term fertilization and manuring. *The Bioscan*. 11(2): 1159-1162.
32. Watts, D.B., Allen, T.H., Feng, Y. and Prior, S.A. (2010). Soil microbial community dynamics as influenced by composted dairy manure, soil properties, and landscape position. *Soil Science*. 175: 474-486.
33. Zhang, J., Qin, J., Yao, W., Bi, L., Lai, T. and Yu, X. (2009). Effect of long-term application of manure and mineral fertilizers on nitrogen mineralization and microbial biomass in paddy soil during rice growth stages. *Plant Soil and Environment*. 55(3): 101-109.



Soil Available Phosphorus as Influenced by Manures and Levels of Phosphorus in Calcareous Soil

Dipti Waghdhare^{1*}, Dhanashree Desai¹, Sunita Waghmare², Tai Deokate³ and Pramod Jagtap⁴

¹Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Maharashtra

²Plant Pathology Section, RSCM College of Agriculture, Kolhapur, Maharashtra

³Division of Agricultural Economics, College of Agriculture, Pune, Maharashtra

⁴Division of Soil Science and Agricultural Chemistry, RSCM College of Agriculture, Kolhapur, Maharashtra

*Email : dip_981@rediffmail.com

Abstract

Incubation study was carried out to study the effect of manures and levels of phosphorus on availability of phosphorus in calcareous soil at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, during *kharif* 2019. The experiment consists of eleven treatments as control, RDF and combination of three organic manures (FYM, Vermicompost and PMC) and three levels of phosphorus (25, 50 and 75 kg P₂O₅ ha⁻¹) through DAP replicated thrice in Factorial Completely Randomized Design. In incubation study the soil samples were collected at 15 days interval i.e. 0, 15, 30, 45 and 55 days after incubation and analyzed for available phosphorus in soil. The soil available phosphorus was significantly increased due to different treatments up to 30 days incubation except in control and recommended dose of fertilizer treatments. Among the organic manures, the application of vermicompost @ 2.5 t ha⁻¹ to soil significantly increased soil available phosphorus over rest of organic manures. As regard phosphorus levels, the application of 75 kg P₂O₅ ha⁻¹ significantly increased the soil available phosphorus than that of 25 and 50 kg P₂O₅ ha⁻¹. The application of vermicompost along with 75 kg P₂O₅ ha⁻¹ significantly increased maximum available phosphorus (20.94 kg ha⁻¹) at 30 days incubation and there after it was declined.

Key words : Manures, available phosphorus, calcareous soil.

Introduction

Phosphorus plays a major role in existence of all living creatures. It is an essential constituent of nucleic acid. Among other things it ensures the transfer and storage of energy and permits the conservation and transmission of genetic characteristics in plants as well as in men and animals. Nothing at all happens within living things without energy. Living creatures have an absolute need with this indispensable element. Phosphorus therefore plays a leading role in living things and it is not without reason that it is said to be the key element in metabolism.

The phosphorus availability is drastically influenced by pH of the soil. In alkaline soil applied phosphorus get fixed either with clay in clayey soil or with calcium in calcareous soils. Further, availability of soil phosphorus is decreasing consistently due to black clay soil, calcareous soil having alkaline pH. The low availability of phosphorus is one of the reasons to decrease crop yield in calcareous soils. Low use efficiency (UE) is the major drawback of phosphorus in all soils particularly in calcareous soils. In calcareous soils, calcite acts as an adsorbent site for phosphorus. The amount and reactivity of calcium carbonate influence P-sorption. In these soils, applied inorganic phosphorus immediately precipitated with Ca²⁺ and Mg²⁺ (Pradhan and Sukla, 2005; Aziz *et al.*, 2016) and thus lead to low productivity of crops. The cost of crop

production in India is very high due to low phosphorus available through indigenous rock phosphate and import of phosphatic fertilizers.

Calcareous soils are common in arid and semiarid climate and occur as inclusions in more humid regions, affecting over 1.5 billion acres of soils worldwide and comprising more than 13 per cent of soil. Calcareous soils are identified for presence of mineral calcium carbonate in parent material. The pH of this soil is above 7 and may be as high as 8.5. In some soils, CaCO₃ can concentrate into very hard layers that are impermeable to water and plant roots. The calcareousness is unique properties of soil, which affects the physico-chemical properties of soil, phosphorus, zinc and iron availability in soil and plant growth. Such soils are difficult to manage from fertility point of view. Calcareous soils are extremely productive for agricultural use when they are managed properly.

Organic matter (OM) is commonly applied to reduce phosphorus fixation, as also improving other nutrient content and water availability in the soil. Application of soil with organic materials like FYM, manure, vermicompost and plant residues can increase the soil phosphorus availability directly by the phosphorus containing in them and indirectly by release and production of organic acids, stimulation of microbial activity or blocking of phosphorus fixing sites which can increase phosphorus mobilization

Table-1 : Characterization of Organic manures.

Sr. No.	Manures	FYM	Vermicompost	Press mud cake
1.	pH (1:10)	8.15	7.45	7.9
2.	EC (dS m ⁻¹)	2.27	2.53	1.5
3.	O.C. (%)	18.75	24.46	12.89
4.	Total Nitrogen (%)	0.98	1.82	1.12
1.	Total Phosphorus (%)	0.29	1.42	0.60
2.	Total Potassium (%)	0.48	1.25	0.32
3.	Total Fe (mg kg ⁻¹)	2567	2726	2318
4.	Total Mn (mg kg ⁻¹)	241	418	298
5.	Total Zn (mg kg ⁻¹)	261.7	475.5	309.8
6.	Total Cu (mg kg ⁻¹)	96.8	189.3	108.9
7.	C: N Ratio	19.13	13.44	11.51

Table-2 : Total quantity of manures and fertilizers applied during incubation study.

Sr. No.	Nutrient		Quantity
1.	Farm yard manure (g bowl ⁻¹)		1.12
2.	Vermicompost (g bowl ⁻¹)		0.28
3.	Press mud cake (g bowl ⁻¹)		0.56
4.	Urea (mg bowl ⁻¹) -		
	For T ₃ , T ₆ and T ₉ -	Basal	11
		Split	12.2
	For T ₄ , T ₇ and T ₁₀ -	Basal	10
		Split	12.2
	For T ₅ , T ₈ and T ₁₁ -	Basal	8.5
		Split	12.2
5.	Di-ammonium phosphate (mg bowl ⁻¹) -	For 25 kg P ₂ O ₅ ha ⁻¹	6.2
		For 50 kg P ₂ O ₅ ha ⁻¹	12.3
		For 75 kg P ₂ O ₅ ha ⁻¹	18.5
6.	Muriate of potash (mg bowl ⁻¹)		9.3
7.	Zinc sulphate (mg bowl ⁻¹)		2.23
8.	Ferrous sulphate (mg bowl ⁻¹)		2.79

and decrease phosphorus fixation (Suman Lata Varma, 2013).

Materials and Methods

The present investigation was undertaken in kharif 2019 at Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune-411005, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Highly calcareous soil sample (0-22.5 cm depth) was obtained from Agronomy Farm, Division of Agronomy, College of Agriculture Pune.

Incubation study was carried out by discard method. Bowls having capacity to contain 300 g soil per bowl were used for study. The manure sources and phosphorus were applied (Table-2) as per the treatment details for incubation study experiment. The soil samples were analyzed at an interval of 15 days up to 55 days (i.e. at 0, 15, 30, 45 & 55 days after incubation) for soil available phosphorus in soil (Olsen *et al.* 1965). The soil moisture

was maintained at field capacity during incubation. Chemical properties of organic manures are mentioned in Table-1.

The experimental soil was clay in texture and having field capacity 36.69%, pH 8.3, EC 0.18 dS m⁻¹, organic carbon 0.45%, CaCO₃ equivalent 13.5%, available nitrogen 132.5 kg ha⁻¹, available phosphorus 6.36 kg ha⁻¹, available potassium 470.88 kg ha⁻¹, DTPA extractable Zn, Fe, Mn, Cu was 0.54 mg kg⁻¹, 3.3 mg kg⁻¹, 10.59 mg kg⁻¹, 6.48 mg kg⁻¹ respectively.

The experiment consisted of 11 treatments with 3 replications. The experiment was designed in factorial completely randomized design (FCRD).

Treatment Details

Factor A : Sources of organic manures

1. FYM @ 10 t ha⁻¹
2. Vermicompost @ 2.5 t ha⁻¹
3. PMC @ 5 t ha⁻¹

Table-3 : Effect of organic manures and levels of phosphorus on soil available phosphorus throughout the incubation period.

Tr. No.	Treatments	Day of incubation					Cumulative soil available phosphorus (kg ha ⁻¹)
		0	15	30	45	55	
1.	Absolute control	6.40	6.60	6.47	6.13	5.14	31.17
2.	Recommended dose of fertilizer (100:50:50 N: P ₂ O ₅ : K ₂ O kg ha ⁻¹)	12.91	14.9	14.07	10.12	8.71	60.71
3.	FYM @ 10 t ha ⁻¹ + 25 kg P ₂ O ₅ ha ⁻¹	11.03	13.78	13.97	9.89	8.04	56.71
4.	FYM @ 10 t ha ⁻¹ + 50 kg P ₂ O ₅ ha ⁻¹	14.41	16.04	17.55	11.32	10.98	70.3
5.	FYM @ 10 t ha ⁻¹ + 75 kg P ₂ O ₅ ha ⁻¹	16.31	16.97	18.68	14.77	11.79	78.52
6.	Vermicompost @ 2.5 t ha ⁻¹ + 25 kg P ₂ O ₅ ha ⁻¹	11.97	14	14.62	10.47	10	61.06
7.	Vermicompost @ 2.5 t ha ⁻¹ + 50 kg P ₂ O ₅ ha ⁻¹	15.21	17.91	18.81	14.9	13.22	80.05
8.	Vermicompost @ 2.5 t ha ⁻¹ + 75 kg P ₂ O ₅ ha ⁻¹	18.92	19.13	20.94	17.36	16.01	92.36
9.	PMC @ 5 t ha ⁻¹ + 25 kg P ₂ O ₅ ha ⁻¹	10.01	12.11	12.93	8.93	7.48	51.46
10.	PMC @ 5 t ha ⁻¹ + 50 kg P ₂ O ₅ ha ⁻¹	13.33	15.89	17.04	10.82	9.9	66.98
11.	PMC @ 5 t ha ⁻¹ + 75 kg P ₂ O ₅ ha ⁻¹	14.91	16.01	18.36	13.11	11.01	73.4
	SEm±	0.04	0.16	0.22	0.12	0.025	
	C.D.(0.05)	0.12	0.47	0.64	0.36	0.074	

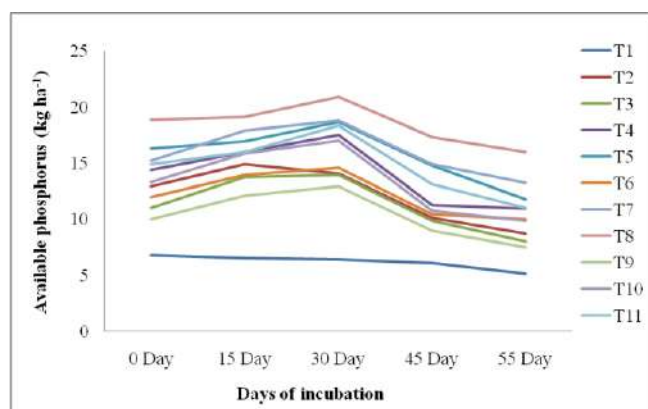


Fig.-1 : Influence of different organic manures and levels of phosphorus on soil available phosphorus throughout the incubation period.

Factor B: Levels of phosphorus

1. 25 kg P₂O₅ ha⁻¹
2. 50 kg P₂O₅ ha⁻¹
3. 75 kg P₂O₅ ha⁻¹

Additional treatments :

1. Absolute control
2. Recommended dose of fertilizer (100:50:50 N: P₂O₅: K₂O kg ha⁻¹)

The results were statistically analyzed and appropriately interpreted as per the method given by Panse and Sukhatme (1985).

Results and Discussion

Effect of Soil Available Phosphorus as influenced by Organic Manures and Levels of Phosphorus in Calcareous Soil during Incubation Study : The organic

manures viz., FYM @ 10 t ha⁻¹, vermicompost @ 2.5 t ha⁻¹ and PMC @ 5 t ha⁻¹ along with 25, 50, 75 kg ha⁻¹ P₂O₅ levels were incubated for 55 days in calcareous soil. The mineralization of phosphorus at different intervals was studied and presented in Table-3.

(a) Effect of organic manures : The data on influence of different organic manures on available phosphorus in calcareous soil clearly indicated that there was significant difference in available phosphorus in soil due to application of different organic manures. Among different organic manures, application of vermicompost registered significantly higher available phosphorus (upto 55 days of incubation) in soil over FYM and press mud cake application to soil. The application of press mud cake might have certain limitations for growth of micro-organisms which had resulted in less release of available phosphorus in soil even though press mud cake contain higher amount of phosphorus compared with FYM.

Soil applied with vermicompost showed higher value for available phosphorus than FYM and PMC applied soil, it could be seen that vermicompost is rich manure in releasing available phosphorus. Many studies showed that vermicompost is rich in nutrients especially phosphorus and phosphorus is in the form that is easily taken up by plants (Kale *et al.*, 1987, Nethra *et al.*, 1999, Lazcano *et al.*, 2008).

(b) Effect of phosphorus levels : The data indicated that levels of phosphorus showed significant effect on availability of phosphorus. Among different levels of phosphorus, application of 75 kg P₂O₅ ha⁻¹ registered significantly higher available phosphorus (16.71 kg ha⁻¹) over application of 25 kg P₂O₅ ha⁻¹ (11.01 kg ha⁻¹) and

application of 50 kg P₂O₅ ha⁻¹ (14.38 kg ha⁻¹) to soil. There was increase in available phosphorus as the levels of applied phosphorus increased from 25 kg P₂O₅ ha⁻¹ to 75 kg P₂O₅ ha⁻¹.

In general, the application of 50 kg P₂O₅ ha⁻¹ along with either vermicompost, FYM or PMC recorded significantly higher available phosphorus over recommended dose of fertilizer (12.91 kg ha⁻¹) i.e. 50 kg P₂O₅ ha⁻¹ without organic manures.

(c) Effect of interactions : It was observed from interaction of organic manures and levels of phosphorus that there was significant increase in available phosphorus content in soil. The data clearly indicated that the application of vermicompost @ 2.5 t ha⁻¹ along with 75 kg P₂O₅ ha⁻¹ showed significantly higher available phosphorus (18.92 kg ha⁻¹) in soil over all rest of the interactions. It might be due to greater growth of micro-organisms, improvement in physical health of the soil.

During incubation from 0 to 55th day availability of phosphorus was increased up to 15th day of incubation in RDF (14.90 kg ha⁻¹) then after the available phosphorus showed decreasing pattern. However it is interesting to know that, when phosphorus was applied along with different organic manures i.e. vermicompost @ 2.5 t ha⁻¹, FYM @ 10 t ha⁻¹, PMC @ 5 t ha⁻¹ showed increase in available phosphorus up to 30th day of incubation. It is due to additive effect of organic manures for release of phosphorus. Further the result revealed that increasing carbon in soil whether from manures or other sources can also increase phosphorus availability. Organic matter is made up of a variety of carbon compounds that can coat reactive surfaces that tie up phosphorus, such as soil particles and calcium carbonates, therefore making applied phosphorus more plant available. Adding humic and fulvic acids (organic matter compounds) with phosphorus fertilizers may help to improve phosphorus availability. (Leytem 2008 and Delgado *et al.*, 2002). Subbaiah (2019) reported that enzyme phosphatase breaks hemicellulose compounds of organic materials. By involving water, it breaks “humus – O – P (OH)₂” bond to produce “humus–OH” and H₃PO₄ making phosphorus available to plants.

Conclusions

Significant increase in soil available phosphorus was noticed due to different treatments over control up to 30 days and there after it was declined. Among the organic manures, application of vermicompost @ 2.5 t ha⁻¹

registered significantly higher soil available phosphorus than that of FYM and PMC sources. The application of phosphorus @ 75 kg P₂O₅ ha⁻¹ recorded significantly higher soil available phosphorus over 25 and 50 kg P₂O₅ ha⁻¹ treatments. The application of vermicompost @ 2.5 t ha⁻¹ along with 75 kg P₂O₅ ha⁻¹ recorded significantly higher soil available phosphorus.

References

1. Aziz, M.Z., Yaseen, M., Naveed, M. and Shahid, M. (2016) Promoting fertilizer use efficiency of wheat via controlled release of phosphorus by coating alginate loaded bacteria on diammonium phosphate. 3rd Conference of the *World Association of Soil and Water Conservation*, August 22-26, Belgrade, Republic of Serbia.
2. Delgado, A., Madrid, A., Kassem, S., Andreu, L. and Carmen del Campilo. (2002) Phosphorus fertilizer recovery from calcareous soils amended with humic and fulvic acids. *Plant and Soils* 245: 277-286.
3. Kale, R.D., Bano, K., Sreenivasa, M.N., Vinayak, K. and Bagyaraj, D.J. (1987) *In Incidence of cellulolytic and lignolytic organisms in the earthworm worked soils* (Eds.: G. K. Veeresh, D. Rajagopal and C.A. Viraktamath). Professor of Zoology College, Bangalore. 659-665.
4. Lazcano, C., Brandon-Gomez, M. and Dominguez, J. (2008) Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere* 1013–1019.
5. Leytem, A. (2008) Phosphorus Chemistry in Soils and Response to Fertilizers and Manures. USDA/ARS PowerPoint presented at *Idaho Nutrient Management Conference*.
6. Nethra, N. N., Jayaprasad, K.V. and Kale, R.D. (1999) China aster [*Callistephus chinensis* (L)] cultivation using vermicompost as organic amendment. *Crop Research, Hissar* 17, 209–215.
7. Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, C.A. (1965). Estimation of available phosphorus in soils by extraction with NaHCO₃. USDA Cir.939 C. A.Part II Chemical and microbiological properties. *American Society of Agronomy, Inc.*, Madison, Wisconsin, USA.
8. Panse, V.G. and Sukhatme, P.V. (1985) Statistical methods for agricultural workers. IV Ed. *Indian Council of Agricultural Research*, New Delhi, 157-165.
9. Pradhan, N. and Sukla, L. B. (2005) Solubilization of inorganic phosphate by fungi isolated from agriculture soil. *African Journal of Biotechnology* 5, 850–854.
10. Subbaiah, P.V. (2019) Effect of inorganic and organic sources of nutrients and their conjunctive use on soil health. *Journal of Pharmacognosy and Phytochemistry*, 8, 1352-1357.
11. Suman Lata Varma (2013) Thesis-Effect of compost on soil phosphorus availability. School of Agriculture, Food and Wine, *The University Of Adelaide*. 9-124.



Influence of Slow Releasing Nitrogenous Fertilizers on Growth, Yield and Economics of Paddy in Coastal Karnataka

H.R. Bhanuprakash, M. Hanumanthappa, P. Athaulla, M. Dinesh Kumar and K.V. Sudhir Kamath

College of Agriculture, Shivamogga, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka

Email : hr.bhanuprakash@gmail.com

Abstract

A field experiment was conducted during the kharif 2015 at Zonal Agricultural and Horticultural Research Station Brahmavara, UAHS, Shivamogga to study the efficiency of urea coated with different substances on growth and yield of transplanted paddy. The experiment was laid out in randomized complete block design with nine treatments replicated thrice. The treatments consisted of neem (*Azadirachta indica*) oil coated urea, mud coated urea, pongamia oil coated urea and cashew nut shell liquid coated urea at 100 per cent and 75 per cent recommended dose of nitrogen and only basal application of these fertilizers are coated. The results revealed that grain and straw yields of 100 per cent recommended dose of nitrogen (RDN) through neem oil coated urea produced the highest grain (5541 kg ha⁻¹) and straw yield (7995 kg ha⁻¹) which was significantly higher ($p < 0.05$) than all other treatments and it produced 24 % increase in grain yield and 15 % increase in straw yield over the recommended dose of fertilizers. Current study reveals that neem oil coated with urea has out yielded compare to other treatments.

Key words : cashew nut shell liquid, coated fertilizer, neem oil, pongamia oil, recommended dose of fertilizers.

Introduction

Rice is one of the important cereal crops of India and is cultivated in an area of 43.95 million hectare with a production of 102.36 million tonnes. The coastal region represents nearly all rice ecologies namely; irrigated, rainfed, shallow land, rainfed semi deep, deep water and upland. The productivity of paddy in coastal Karnataka is low due to heavy rainfall, inadequate and improper time of application of nutrients. The heavy rainfall results in leaching of nutrients like nitrogen and potassium which leads to poor fertility condition of soil, low pH, iron (Fe) and aluminium (Al) toxicity causing the main constraints for the low productivity of rice.

Nitrogen (N) occupies a conspicuous place in plant system. All vital processes in plants are associated with protein, of which nitrogen is an essential constituent. Nitrogen is very important and needed for plant growth. Nitrogen is a part of chlorophyll molecule which gives plants their green colour and is involved in creating food for plants through photo synthesis. Nitrogen is one of the most important nutrient elements for the productivity of cereal crops. Its production is hampered due to deficiency of soil nitrogen and poor use efficiency of applied fertilizers. Leaching losses of urea and nitrate nitrogen (NO₃⁻-N), volatilization losses of NH₃ from standing water and denitrification losses under reduced conditions are some of the losses occurring under waterlogged transplanted paddy cultivation. Since rice requires large amount of nitrogen for potential production, it is possible to increase rice production per unit area by increasing the

quantity of nitrogen application or by increasing the efficiency of the applied fertilizer nitrogen. In order to reduce N losses from the soil, various slow release fertilizers have been developed that would provide a continuous and regular supply of nitrogen during annual cycle. Nitrification inhibitor and slow release nitrogenous fertilizers may play a dual role by safe guarding environment and increasing fertilizer use efficiency.

Materials and Methods

Field experiment was conducted at Zonal Agricultural and Horticultural Research Station, Brahmavar, University of Agricultural and Horticultural Sciences, Shivamogga during kharif 2015 coming under Coastal zone of Karnataka (Zone-10). The experimental site is situated between 13° 24' North latitude and 74° 45' East longitude and an altitude of 10 meters above mean sea level. The soil was sandy loam in texture and acidic in nature (pH= 5.18). It has medium organic carbon content (0.60 %) and EC 0.048 dSm⁻¹. Medium availability of NPK (where, 302.16, 48.24 and 208.2 kg ha⁻¹ respectively). The experimental soil was sandy loam with an average particle content of 73.33 % sand, 10.2 % silt and 16.5 % clay. The total actual rainfall during crop growth period was 2983 mm. The mean monthly maximum temperature ranged between 28.5°C in July and 31.4°C in the month of October and minimum temperature ranged between 18.87 to 23.42, humidity ranged from 76.41 to 90.83 %. The experiment was laid out under randomized complete block design having three replications with the nine treatment combinations, N fertilizers were applied at 2 splits apart from basal. At the time of transplanting basal dose of N

Table-1 : Growth parameters of paddy as influenced by different slow releasing nitrogenous fertilizers.

Treatment Details	Plant height (cm)	No. of Tillers per hill	No. of leaves	Leaf area per hill (cm ²)	LAI	Dry matter accumulation in leaf (gram)	Dry matter accumulation in stem (gram)	Total dry matter production (gram)
T ₁	84.68	13.92	44.79	702.84	3.51	10.14	40.25	46.35
T ₂	97.09	19.60	66.90	1014.96	5.07	16.01	53.78	62.66
T ₃	88.19	15.56	55.31	848.83	4.24	12.94	46.23	53.10
T ₄	91.46	17.18	61.72	891.11	4.45	14.27	50.02	57.50
T ₅	94.87	18.38	62.57	915.78	4.57	15.03	51.41	59.64
T ₆	88.31	16.17	55.84	861.73	4.30	13.70	46.56	53.53
T ₇	84.30	14.25	49.43	725.29	3.62	11.32	42.92	49.20
T ₈	84.98	14.84	51.82	812.39	4.06	11.93	44.34	50.92
T ₉	85.67	15.06	55.04	826.24	4.13	12.16	45.43	52.14
S.Em.+	2.78	1.12	3.68	57.83	0.28	0.69	2.60	2.84
C.D. at 5%	8.35	3.38	11.05	173.40	0.86	2.09	7.82	8.52

Note : T₁= 100% RDF (60:30:60 NPK Kg ha⁻¹)

T₂= 100% RDN (30 kg N through NOCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₃= 100% RDN (30 kg N through MCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₄= 100% RDN (30 kg N through POCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₅= 100% RDN (30 kg N through CNSL coated urea as basal +15 kg N through urea at 30 and 55 DAT)

T₆= 75% RDN (22.5 kg N through NOCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₇= 75% RDN (22.5 kg N through MCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₈= 75% RDN (22.5 kg N through POCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₉= 75% RDN (22.5 kg N through CNSL coated urea as basal + 11.25 kg N through urea at 30 and 55 DAT)

Table-2 : Yield parameters of paddy as influenced by different slow releasing nitrogenous fertilizers.

Treatment Details	No. of productive tillers per hill	Panicle length (cm)	Panicle weight (g)	Filled grains per panicle	Un filled grains per panicle	Total grains per panicle	1000 grain weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest Index
T ₁	13.75	15.88	2.41	76.78	12.41	89.19	19.92	4209	6793	0.382
T ₂	19.48	23.73	3.67	110.29	8.22	118.52	23.64	5541	7995	0.409
T ₃	15.39	19.86	3.13	89.73	10.40	100.13	21.95	4829	7414	0.395
T ₄	17.02	21.00	3.36	95.45	9.54	104.99	22.74	5046	7677	0.396
T ₅	18.22	22.27	3.56	101.24	8.90	110.14	23.47	5226	7892	0.398
T ₆	16.05	19.98	3.16	91.06	9.12	100.19	22.10	4927	7486	0.397
T ₇	14.10	16.83	2.63	81.18	10.17	91.35	20.80	4357	6963	0.385
T ₈	14.71	18.91	2.78	83.04	9.72	92.76	21.15	4520	7223	0.386
T ₉	14.94	19.21	3.10	86.02	9.22	95.24	21.66	4701	7381	0.389
S.Em.+	1.12	1.26	0.24	3.33	0.65	3.63	0.75	232	234	0.013
C.D. at 5%	3.37	3.79	0.73	9.99	1.95	10.89	2.26	696	702	NS

Note : T₁= 100% RDF (60:30:60 NPK Kg ha⁻¹)

T₂= 100% RDN (30 kg N through NOCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₃= 100% RDN (30 kg N through MCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₄= 100% RDN (30 kg N through POCU as basal + 15 kg N through urea at 30 and 55 DAT)

T₅= 100% RDN (30 kg N through CNSL coated urea as basal +15 kg N through urea at 30 and 55 DAT)

T₆= 75% RDN (22.5 kg N through NOCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₇= 75% RDN (22.5 kg N through MCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₈= 75% RDN (22.5 kg N through POCU as basal + 11.25 kg N through urea at 30 and 55 DAT)

T₉= 75% RDN (22.5 kg N through CNSL coated urea as basal + 11.25 kg N through urea at 30 and 55 DAT)

fertilizers either with urea or coated forms of urea along with full dose of phosphorus and potash fertilizers were applied. The remaining half of nitrogen was top-dressed twice in equal quantities in the form of urea for all treatments, once during 30 DAT and other during 55 DAT.

Results and Discussion

The fertilizer treatment had significant effect on the plant height at different growth stages ($p < 0.05$). Plant height reveals the overall vegetative growth of the crop in response to various management practices. It was found

Table-3 : Economics of paddy as influenced by different slow releasing nitrogenous fertilizers.

Treatment	Gross returns (Rs. ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B : C ratio
T ₁	79315.10	63134.70	16180.4	1.26
T ₂	101562.22	63167.36	38394.86	1.61
T ₃	89861.88	63259.75	26602.13	1.42
T ₄	93684.01	63279.35	30404.66	1.48
T ₅	96846.29	63275.75	33570.54	1.53
T ₆	91440.36	62979.90	28460.46	1.45
T ₇	81900.05	63080.40	18819.65	1.30
T ₈	84960.49	63095.40	21865.09	1.35
T ₉	87958.58	63092.65	24865.93	1.39

Note : T₁= 100% RDF (60:30:60 NPK kg ha⁻¹)
 T₂= 100% RDN (30 kg N through NOCU as basal + 15 kg N through urea at 30 and 55 DAT)
 T₃= 100% RDN (30 kg N through MCU as basal + 15 kg N through urea at 30 and 55 DAT)
 T₄= 100% RDN (30 kg N through POCU as basal + 15 kg N through urea at 30 and 55 DAT)
 T₅= 100% RDN (30 kg N through CNSL coated urea as basal + 15 kg N through urea at 30 and 55 DAT)
 T₆= 75% RDN (22.5 kg N through NOCU as basal + 11.25 kg N through urea at 30 and 55 DAT)
 T₇= 75% RDN (22.5 kg N through MCU as basal + 11.25 kg N through urea at 30 and 55 DAT)
 T₈= 75% RDN (22.5 kg N through POCU as basal + 11.25 kg N through urea at 30 and 55 DAT)
 T₉= 75% RDN (22.5 kg N through CNSL coated urea as basal + 11.25 kg N through urea at 30 and 55 DAT)

that application of nitrogenous fertilizers increased the plant height significantly, but maximum plant height (97.09 cm) was obtained in plots where the 100 per cent neem oil coated urea were treated and the lowest plant height (84.68 cm) was recorded for 100 per cent RDN through recommended dose of fertilizers (Table-1). The increase in plant height in response to application of neem oil coated fertilizers is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. These results are supported by Kumar *et al.* (2007).

Nitrogenous fertilizer application increased significantly tillers per hill in paddy (90 days after transplanting) (Table 1). The use of neem oil coated urea (NOCU) and cashew nut shell liquid coated urea (CNSL) produced maximum number of tillers per hill (19.60 and 18.38, respectively) than all other treatments. Number of tillers per hill is the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield. More number of tillers per hill in experiment might be due to the more availability of nitrogen that played a vital role in crop growth and cell division, as the amount of nitrogen absorbed by the crop increases, there is an increase in the number of tillers per hill.

The data on number of leaves and leaf area at 90 DAT was significantly increased with application of neem oil coated urea, (66.90 and 1014.96 cm² hill⁻¹ respectively). This result was statistically at par with that of treatment T₅. Significantly lowest number of leaves and leaf area (44.79 and 702.84 cm² hill⁻¹), was obtained from 100 per cent RDN though recommended dose of

fertilizers. The increase in leaf count as well as leaf weight due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in well-fertilized plots.

The data regarding leaf area index is presented in Table 1. Data reveals that significantly higher leaf index (5.07) was observed with application of 100 per cent RDN through neem oil coated urea at 90 DAT closely followed by cashew nut shell liquid coated urea and pongamia oil coated which were on par and significantly superior over other treatments. The main effect of nitrogenous fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the canopy.

Dry matter accumulation in leaf and stem increased significantly with nitrogenous fertilizers application in paddy at all the growth stages of the crop (Table 2). Significantly highest dry-matter accumulation leaf (8.98 g hill⁻¹) and stem (53.78 g hill⁻¹) at harvest was obtained from 100 per cent RDN through neem coated urea. These results were statistically at par with that of treatment T₅, where cashew nut shell liquid is applied. It was as expected since vegetative growth resulting from higher photosynthetic activities is well known to be influenced by nitrogen. In general, dry matter accumulation increased at slow rate up to 30 days after transplanting and thereafter increased at faster rate up to harvest. Significantly lowest dry-matter accumulation in leaf (6.10 g hill⁻¹) and stem (4.25 g hill⁻¹) was obtained from application of 100 per cent RDN through recommended dose of fertilizers. The increase is probably due to the equal availability of N

throughout the plant life that enhanced leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Choudhury and Kennedy, 2005).

Yield attributes, viz., number of productive tillers per hill (19.48), panicle weight (3.67g), panicle length (23.73cm), 1000-grain weight (23.64g), total number of grains (118.52), filled grains per panicle (100.29) and unfilled grains panicle (8.22) (Table 3). These results were statistically at par with that of treatment T₅ i.e., cashew nut shell liquid coated urea. The maximum grain yield of 5541 kg ha⁻¹ and significantly lowest grain yield of 4209 kg ha⁻¹ was obtained from the plots where 100 per cent RDN through neem coated urea and recommended dose of fertilizers respectively. The other possible reason in yield enhancement might be due to continuous and steady supply of N into the soil by coated fertilizers to meet the required nutrient for physiological processes, which in turn improved grain yield (Reddy, 2006).

Among the different treatments, 100 per cent RDN through neem oil coated urea recorded higher gross returns (Rs. 1, 01,562.22) and higher net returns (Rs. 38,394.86) than other combination of treatments (Table-3). The higher gross and net return was mainly attributed to higher grain and straw yields. However, higher benefit cost ratio was registered in treatment T₂ (1.61) i.e. application of 100 per cent RDN through neem oil coated urea. This was mainly due to lower cost of cultivation. Similar findings were also observed by Kumar et al. (2015). On the other hand, lower benefit to cost ratio (1.26) was recorded in plots receiving 100 per cent RDN through recommended dose of fertilizer, resulting in lower

grain and straw yield obtained by the treatment. The results were in conformity with earlier findings of Hashim et al. (2015) and Gagnon et al. (2012).

Conclusion

Different coating materials of urea are source of N for basal application produced higher yield both in grain and straw compared to only recommend dose of fertilizers. Coating urea with neem for basal application was found best followed by cashew nut shell liquid coated urea, pongamia oil coated urea and mud coated urea in that order. The current study helps to improve the efficiency the applied nutrients in the coastal condition or high rainfall area to control fertilizers losses in different ways.

References

1. Kumar, N.; Prasad, R. and Zaman, F. U. (2007). Relative response of high yielding variety and a hybrid of rice to levels and sources of nitrogen. *Proceedings of Indian National Science Academy* 73 : 1-6.
2. Choudhury, A. and Kennedy, I. (2005). Nitrogen fertilizer losses from rice soils and control of environmental pollution problems. *Communication Soil Science and Plant Analysis journal* 36 : 1625-1639.
3. Reddy, S. R. (2016). *Agronomy of field crops*. Kalyani publishers, New Delhi, India. pp. 65.
4. Hashim, M.; Shiva Dhar,; Vyas, A.K.; Pramesh, V. and Kumar, B. (2015). Integrated nutrient management in maize-wheat cropping system. *Indian Journal Agronomy* 60 (3): 352-359.
5. Gagnon, B.; Ziadi, N. and Grant, C. (2012). Urea fertilizer forms affect grain corn yield and nitrogen use efficiency. *Canada Journal of Soil Science* 92 : 341-351.



Identification of Resistant Sources to Fusarium Wilt Caused by *Fusarium udum* in Pigeonpea

Bindhu K.G.^{1*}, Yenjerappa S.T.¹, Ajithkumar K.¹, Gururaj Sunkad¹, Sreenivasa A.G.² and Mahadevaswamy³

¹Department of Plant Pathology, UAS, Raichur-584102, Karnataka, India

²Department of Agriculture Entomology, UAS, Raichur-584102, Karnataka, India

³Department of Microbiology, UAS, Raichur-584102, Karnataka, India

*Corresponding Author Email : bindhukg77@gmail.com

Abstract

A field study was conducted to identify the sources of resistance against Fusarium wilt in pigeonpea. A total of 70 genotypes were evaluated under artificial epiphytotic conditions during Kharif 2017 & 2018 using randomized block design with two replications, with a spacing of 60 x 20cm using one susceptible check and one resistant check with recommended agronomic practices to establish good crop stand at Agricultural Research Station, College of Agriculture, Kalaburgi. Out of these genotypes, 44 genotypes were found to be resistant, 19 were moderately resistant, and 7 were Susceptible to the Fusarium wilt.

Introduction

Pigeonpea (*Cajanus cajan* (L) Mills.) is an important pulse crop grown in semi-arid, tropical and sub-tropical farming systems adopted by small and marginal farmers, it provides high quality vegetable protein to human beings and is one of the animal feed and fire wood (Rangaswamy *et al.*, 2016). It belongs to the family Leguminosae and is a short-lived perennial shrub, that's traditionally cultivated as an annual crop in developing countries. It is fast growing, hardy, widely adapted and drought resistant and often cross pollinated (20 - 70 %), which is alleged to be awfully old and one in every important leguminous crops of tropics and subtropics. It is potential to revive soil fertility by fixing atmospheric nitrogen and has the flexibility to solubilize fixed phosphorus (Ae *et al.*, 1990). In India, the crop area of 294.47 lakh ha with production of 231.31 lakh tonnes and productivity of 786 kg/ha. (Anonymous, 2018).

Several factors are known to affect the cultivation of pigeonpea, but the most important being the diseases. Some of the important diseases are Fusarium wilt, Phytophthora blight, Cercospora leaf spot, collar rot, dry root rot, Alternaria leaf spot, powdery mildew, sterility mosaic and phyllody. Incidentally, only a few of them causes economic losses in India (Kannaiyan *et al.*, 1984). Among the diseases Fusarium wilt caused by *Fusarium udum* is the most important soil borne disease and was first reported from Bihar state in India (Butler, 1906).

Pigeonpea causes yield loss at pre-pod, maturity and pre harvest stages, with an incidence of 100, 67 and 30 per cent respectively depends on the stage at which the plants wilt and it can approach when wilt occurs (Kannaiyan and Nene, 1981) and sometimes it causing up to 100% loss in grain yield (Okiror, 2002).

The disease incidence has been increasing year after year and most of the released cultivars became susceptible to the disease indicating the development of more virulent races of the pathogen in major pigeonpea growing areas of the state so there is a need to develop resistant varieties to build the innate resistance within the plant and to identify the hotspots for Fusarium wilt. Thus, investment in host plant resistance and identification of resistant sources and their utilization in breeding of disease resistant hybrids is the best option for sustainable production of pigeonpea. So, in the present study attempt has been made to identify resistant sources of pigeonpea against Fusarium wilt under artificial epiphytotic conditions.

Materials and Methods

A total of 70 pigeonpea genotypes were screened against *F. udum* in sick plot maintained at Agricultural Research Station, Kalaburagi during the year 2018-19 and 2019-20. The field experiment was laid out in a randomized complete block design with a spacing of 60 x 20 cm in two replications. Each genotype was sown in 2 rows of 5 m row length. Each of the test entry was alternated by susceptible check. Observations on wilt incidence was recorded at twenty days interval starting from 80 days after sowing up to 160 days. The disease reaction of each genotype was recorded on the basis of following ratings given by AICRP on pigeonpea. Based on the average wilt incidence, genotypes were grouped into different disease reaction category as follows :

Rating	Disease incidence (%)	Disease reaction
1	0-10	Resistant (R)
2	11-30	Moderately resistant (MR)
3	>30	Susceptible (S)

Table-1 : Reaction of promising genotypes of pigeonpea against *Fusarium* wilt.

Sl. No.	Genotypes	Wilt incidence (%)			Reaction
		2018-19	2019-20	Average incidence	
1.	GRG-152	4.06	4.15	4.11	R
2.	GRG-177	5.78	6.00	5.89	R
3.	GRG-222	7.57	6.70	7.14	R
4.	GRG-617	8.47	9.05	8.76	R
5.	KRG-224	7.73	7.40	7.57	R
6.	KRG-223	17.97	16.95	17.4	MR
7.	KRG-33	2.28	3.00	2.64	R
8.	KRG-221	8.86	8.95	8.91	R
9.	KRG-244	2.98	3.55	3.27	R
10.	KRG-155	5.78	6.60	6.19	R
11.	KRG-251	17.67	19.15	18.4	MR
12.	PUSA-2017-1	4.01	4.26	4.14	R
13.	PUSA-2018-2	3.77	5.70	4.74	R
14.	PUSA-2018-4	1.94	2.70	2.32	R
15.	PUSA-2018-5	0.00	0.00	0.00	R
16.	PUSA-151	13.60	14.25	13.9	MR
17.	PUSA-163	18.69	19.30	19.0	MR
18.	PUSA-171	4.94	5.50	5.22	R
19.	PUSA-172	2.41	27.90	15.1	MR
20.	AL-2211	5.40	6.35	5.88	R
21.	RKPV-705	5.72	6.75	6.24	R
22.	RKPV-704	5.45	6.00	5.73	R
23.	RVKT-314	8.70	9.60	9.15	R
24.	RKPV-807	12.75	14.35	13.5	MR
25.	RKPV-413-02	26.86	0.00	13.4	MR
26.	RKPV-527-01	13.86	0.00	6.93	R
27.	RVSA-16-1	3.04	4.35	3.70	R
28.	LRG-133-33	8.02	8.02	8.02	R
29.	PT-0723-1-2-3	0.00	0.00	0.00	R
30.	GJP-1606	2.16	3.60	2.88	R
31.	KRG-33	8.23	8.80	8.52	R
32.	MPV-106	0.00	4.50	2.25	R
33.	TDRG-58	7.62	8.90	8.26	R
34.	WRG-93	0.00	14.41	7.21	R
35.	DA-18-1	38.02	38.52	38.2	S
36.	DA-18-2	47.08	47.50	47.2	S
37.	PT-0012	13.71	19.60	16.6	MR
38.	IARI-IUTL	15.27	16.12	15.7	MR
39.	AGL-1603-2	15.30	15.90	15.6	MR
40.	WRP-R-29-2	32.50	34.85	33.6	S
41.	ISA-59-2	16.95	18.75	17.8	MR
42.	GPT-1	3.97	4.75	4.36	R
43.	ICPL-15017	9.01	9.10	9.06	R
44.	BRG-1	14.64	15.14	14.8	MR
45.	BRG-2	4.77	5.50	5.14	R
46.	BRG-3	9.54	7.50	8.52	R
47.	BRG-4	6.79	7.60	7.20	R
48.	BRG-5	7.40	7.85	7.63	R
49.	BSMR-736	11.88	12.70	12.2	MR
50.	ICP-8858	0.50	0.00	0.25	R
51.	ICP-8859	4.94	5.00	4.97	R
52.	ICP-8863	24.83	13.99	19.4	MR
53.	ICP-2376	4.84	7.06	5.95	R
54.	ICP-9174	17.57	18.20	17.8	MR
55.	ICPL-15048	52.06	53.15	52.6	S

Table-1 : Contd....

Sl. No.	Genotypes	Wilt incidence (%)			Reaction
		2018-19	2019-20	Average incidence	
56.	WRG-65	16.04	20.0	18.0	MR
57.	TJT-501	8.02	9.90	8.96	R
58.	ICP-7035	3.87	3.95	3.91	R
59.	C-11	23.20	24.45	23.8	MR
60.	BAHAR	14.00	15.40	14.7	MR
61.	BDN-2	7.57	8.50	8.04	R
62.	JKM-189	7.64	8.14	7.89	R
63.	MAL-51	9.18	9.85	9.52	R
64.	IPA-8F	16.34	16.50	16.4	MR
65.	IPA-15F	6.63	7.13	6.88	R
66.	ICPL-99048	0.00	0.00	0.00	R
67.	ICPL-20114	0.00	0.00	0.00	R
68.	KPL-44	5.90	6.15	6.03	R
69.	KA-17-1	25.95	26.40	26.1	MR
70.	KA-17-2	33.77	34.60	34.1	S
Check	TS-3R-(ch)	0.00	0.00	0.00	R
Check	GRG-811 (ch)	0.00	0.00	0.00	R

R-resistant; MR-Moderately resistant; S-Susceptible

0-10% - Resistant, 10.1% - 30% - Moderately resistant, 30.1% - 100% - Susceptible

Symptomatology : The typical wilt symptoms was observed when the plants were of 4-6 weeks old. During the flowering and maturity stage highest mortality of mature plants was seen. The infected plant depicted the withering and drying of green plant parts exactly as if they were suffering from drought. In the beginning it starts with yellowing of leaves and later dark purple band occur on the stem. Drying starts from the collar region and extends upward to the branches and it gradually results in drying of leaves, stem, and branches and finally lead to death of the plant. Partial wilting is also common in the field due to lateral root infection. Tap root infection results in complete wilting of the plants. Stem discoloration can be observed in streaks or patches, which are clearly visible when the bark is peeled off.

Collection of diseased specimen : The leaves of affected pigeonpea plants showing typical *Fusarium* wilt symptoms were collected from susceptible genotype ICP 2376 grown at Agricultural Research Station, Kalaburagi.

Pathogen isolation : The pathogen was isolated by adopting a standard tissue isolation method. Pigeon pea plants showing typical vascular wilt symptoms were collected from different locations and used for isolation. Wilt infected stem and roots were split open longitudinally with the help of sterilized scalpel. The plant parts showing brown discoloration of vascular tissues were cut into small bits, surface sterilized by dipping in sodium hypochlorite (1%) solution for one minute, then rinsed with 3 series of sterilized distilled water, blot dried and then transferred aseptically to the Petriplates containing sterilized potato

Table-2 : Grouping of pigeonpea genotypes against *F. udum*.

Sl. No.	Reaction	Genotypes	No. of entries
1.	Resistant (0-10.00)	GRG-152, GRG-177, GRG-222, GRG-617, KRG-224, KRG-33, KRG-221, KRG-244, KRG-155, PUSA-2017-1, PUSA-2018-2, PUSA-2018-4, PUSA-2018-5, PUSA-171, AL-2211, RKPV-705, RKPV-704, RVKT-314, PKPV-527-01, RVSA-16-1, LRG-133-33, PT-0723-1-2-3, GJP-1606, TDRG 59, MPV-106, TDRG-58, WRG-93, GPT-1, ICPL-15017, BRG-2, BRG-3, BRG-4, BRG-5, ICP-8858, ICP-8859, ICP-2376, TJT-501, BDN-2, JKM-189, MAL-51, IPA-15F, ICPL-99048, ICPL-20114 and KPL-44	44
2.	Moderately resistant (10.10-30.00)	KRG-223, KRG-251, PUSA-151, PUSA 163, PUSA-172, RKPV-807, RKPV-413-02, PT-0012, IARI-IUTL, AGL-1603-2, ISA-59-2, BRG-1, BSMR-736, ICP-8863, ICP-9174, WRG-65, C-11, IPA-8F and KA-17-1	19
3.	Susceptible (>30.00)	DA-18-1, DA-18-2, WRP-R-29-2, BAHAR, ICP-7035, ICPL-15048 and KA-17-2	7
Number of entries			70

Plate-1 : Screening trial against *Fusarium* wilt of pigeonpea.

dextrose agar medium at equidistance at 5 bits/petriplate. The inoculated plates were incubated at 25 ± 2 °C in an incubator.

Maintenance of isolates of *F. udum* : The test tubes / slants containing *F. udum* isolates were stored in refrigerator at 4 °C for further investigations and were renewed through sub culturing once in a month during the course of investigation to maintain the virulence of the pathogen.

Maintenance of inoculum : Uniform sick plots were developed for the past few years in 1 ha of deep black soil

of the vertisol group at Agricultural Research Station, Kalaburagi by incorporating chopped, wilted pigeonpea plants and growing cultivars susceptible to *F. udum*.

Methodology of disease scoring : Disease incidence was recorded at flowering stage on the basis of number of plants wilted i.e., during 60th day of flowering, 80th day of pod filling and 90th day of pod filling stage by visualizing the total number of plants wilted using percentage disease incidence covered in each genotype and in each replication. Disease rating was done based on 1-3 scale as per Nene *et al.* (1981).

$$\text{Disease incidence} = \frac{\text{Number of plants wilted}}{\text{Total number of plants observed}} \times 100$$

Results and Discussion

The utilization of resistant varieties is a classical approach to prevent the catastrophic losses caused by wilt disease, it decreases the cost of production and increases yield. Keeping this in view, investigations on performance of pigeonpea entries against wilt disease under artificial national sick plot were undertaken for the year 2018-19, 2019-20. Average performance of pigeonpea genotypes screened against *Fusarium* wilt under wilt sick plot for two consecutive years (2018-19, 2019-20) revealed that the genotypes viz., GRG-152, GRG-177, GRG-222, GRG-617, KRG-224, KRG-33, KRG-221, KRG-244, KRG-155, PUSA-2017-1, PUSA-2018-2, PUSA-2018-4, PUSA-2018-5, PUSA-171, AL-2211, RKPV-705, RKPV-704, RVKT-314, PKPV-527-01, RVSA-16-1, LRG-133-33, PT-0723-1-2-3, GJP-1606, TDRG 59, MPV-106, TDRG-58, WRG-93, GPT-1, ICPL-15017, BRG-2, BRG-3, BRG-4, BRG-5, ICP-8858, ICP-8859, ICP-2376, TJT-501, BDN-2, JKM-189, MAL-51, IPA-15F, ICPL-99048, ICPL-20114 and KPL-44 were found consistently resistant by recording the wilt incidence ranging from 0.00 to 9.5 per cent . While a total of 19 other genotypes viz., KRG-223, KRG-251, PUSA-151, PUSA 163, PUSA-172, RKPV-807, RKPV-413-02, PT-0012, IARI-IUTL, AGL-1603-2, ISA-59-2, BRG-1, BSMR-736,



Plate-2 : Wilt resistant pigeonpea genotypes.

ICP-8863, ICP-9174, WRG-65, C-11, IPA-8F and KA-17-1 were found to be moderately resistant with wilt incidence ranging from 12.20 to 26.10 per cent. The seven genotypes viz., DA-18-1, DA-18-2, WRP-R-29-2, BAHAR, ICP-7035, ICPL-15048 and KA-17-2 were found susceptible with incidence ranged 33.6 to 52.61 per cent (Plate-1,2 and table-1,2).

The results were in accordance with the studies conducted by Asha *et al.* (2015) out of 41 promising pigeonpea genotypes screened against *Fusarium* wilt under sick plot conditions, 15 genotypes viz., GRG 818, GRG 822, GRG 2009, MA 6, RVSA 073, BSMR 736, BSMR 853, KPL 43, KPL 44, BRG 3, IPA 8F, IPA 204, ICP8858, ICPL 87119 and ICP 8863 showed resistant reaction. In another set of 31 pigeonpea genotypes from ICRISAT screened against the disease indicated resistant reaction against *Fusarium* wilt. Among 10 pigeonpea host differentials evaluated against *Fusarium*, six differentials viz., BDN 2, C 11, ICP 8858, ICP 9174, BRG 3 and ICP 8863 showed resistant reaction and indicated the presence of *F. udum* variant-1 in Bengaluru.

The results were also in conformity with Mahesh *et*

al. (2006), where in among twenty genotypes screened, nine genotypes viz., RA 6, ICPL 96047, ICPL 87119, ICPL 99055, ICPL 99046, ICPL 99048, IPA 04, ICPL 8863 and ICPL 96048 showed resistant reaction with disease incidence of 0-10 per cent, while two genotypes viz., ICPL 96061 and BSMR 736 showed moderately resistant reaction with 11-30 per cent wilt incidence. The susceptible check TTB 7 showed >50 per cent wilt incidence. Similar studies were conducted by Reddy *et al.* (2013) evaluated 59 pigeonpea genotypes against *Fusarium* wilt. Among which 14 were found resistant, and rest of the genotypes showed moderately susceptible to susceptible reaction. Madhukeshwara *et al.* (2004) also screened 226 pigeonpea genotypes to assess their resistance reaction. Out of which 105 genotypes were found to be resistant (0-10 %), 33 genotypes were moderately resistant (10-30 %) and 88 genotypes were susceptible (>30 %) against *F. udum*. In general, resistant and moderately resistant genotypes were greater in number than susceptible genotypes. The resistant donor inbred lines / genotypes identified in the present study may be used as the source of resistance in the development of composites and hybrids.

References

1. Ae, N., Arihara, J., Okada, K., Yoshihara, T. and Johansen, C., 1990, Phosphorous uptake by Pigeonpea and its role in cropping systems of the Indian subcontinent. *Sci.*, 248, 477-480.
2. Anonymous, 2018, FAOSTAT: Food and Agriculture organization of the united nations, FAO Statistic Division. Retrieved from <http://faostat.fao.org/>.
3. Asha, S.M., 2012, Studies on wilt disease of pigeonpea, *Msc.(Agri) Thesis* Univ. Agr. Sci., Bangalore 145 pp.
4. Bidari, V.B., Dayanand, M., Conda, C.R., Patil, J.R. and Rao, T.M., 1995, Field evaluation of short, medium and long duration pigeonpea varieties against wilt in Karnataka, India 1985-94.
5. Butler, E.J., 1906, The wilt disease of pigeonpea and pepper. *Agric. J. India.*, 1: 25-26.
6. Butler, E.J., 1918, Fungi and Plant Diseases in Plants. Periodical Experts, 42-D Vivek Vihar, Delhi. p. 547.
7. Kannaiyan, J. and Nene, Y. L., 1981, Influence of wilt at different growth stages on yield in pigeonpea. *Tropical pest mgt*, 27: 141.
8. Kannaiyan, J., Nene, Y.L., Reddy, M.V., Ryan, J.G. and Raju, T.N., 1984, Prevalence of pigeonpea diseases and associated crop losses in Asia, Africa and the Americas. *Trop. Pest Manage.*, 30: 62-71.
9. Madhukeshwara, S.S., Babu, H.N.R., Seshadri, V.S. and Mantur, S.G., 2004, Screening of pigeonpea genotypes for *Fusarium* wilt resistance. *Environ. Ecol.*, 4: 816-819.
10. Mahesh, M. and Muhammad, M., 2006, Evaluation of bioagents and fungicides against *Fusarium udum*. *Environ. Ecol.*, 245(3): 824-827.
11. Nene, Y.L., Kannaiyan, J. and reddy, M.V., 1981, Pigeonpea disease resistance screening technique. *Information Bull.* Patancheru, Andhrapradesh, India. International crop research institute for the semi-arid tropics. Pp-14.
12. Okiror, M.A., 2002, Breeding of resistance to *Fusarium* wilt of pigeonpea in Kenya. *Ph. D Thesis, Univ. Agri. Sci.*, Nairobi, Kenya. pp.137.
13. Rangaswamy, 2016, Studies on variability in *Fusarium udum* the incitant of wilt in pigeonpea, *Ph. D thesis*, ANGRAU, Hyderabad pp 200.
14. Reddy, M.V., Raju, T.N. and Nene, Y.L. 2013, Low wilt incidence in short duration pigeonpea. *Intl. Pigeonpea Nwsl.*, 7: 26.



Nutrient System (IPNS) in Laterite Soils

B. Aparna*, Gladis R., Biju Joseph and Neethu R.S.

Dept. of Soil Science and Agrl. Chemistry, College of Agriculture, Vellayani, Kerala Agricultural University, 695522

Email : aparna.b@kau.in

Abstract

The present study was undertaken in the Dept. of Soil Science and Agrl. Chemistry, College of Agriculture, Vellayani with the objective to assess the conjugal effect of manures and chemical fertilizers on dynamics of major agriculturally significant soil enzymes, Biological Fertility Index and Enzyme Activity Number. It was observed that treatment T₉ with the combination of 50 % enriched vermicompost (PGPR mix-1) + 50% Chemical fertilizers increased available micro nutrient status (Fe, Cu, B), macro nutrients (N&K) biological properties of soil viz., urease, dehydrogenase, cellulase and protease activities; and yield of bhindi i.e., yield per plant and yield per hectare. With respect to phosphatase activity, treatment T₈ (P (50 %) as PSB enriched vermicompost + P (50%), N & K) recorded the highest value in the rhizosphere soil. For soil respiratory activity, treatment T₁₂ (P (75%) as PSB enriched vermicompost + P (25%), N & K) registered the highest value. For bacteria in the rhizosphere soil, T₈ (P (50 %) as PSB enriched vermicompost + P (50%), N & K) recorded the maximum bacterial and Treatment T₉ (NPK (50 %), PGPR mix-1 enriched vermicompost + N, P & K (50%) recorded maximum number of fungal colonies in rhizosphere soil and actinomycetes in the non rhizosphere soil. A highest value of Enzyme Activity Number, which is an index of biological fertility, was registered by the treatment T₉, revealing its superiority over other treatments. Thus it was confirmed that the treatment T₉ i.e. application NPK as 50% PGPR mix-1 enriched vermicompost in combination with inorganics as the best both in sustaining soil biological activity and economic returns.

Key words : *Enzymes, soil respiratory activity, enrichment of manures.*

Introduction

India has the onerous task of feeding almost 17 percent of global human population and 11 percent of the livestock population with only 2.3 percent of the world's land. The entire burden of producing enough depends upon the first few inches of the earth's crust-SOIL. Increasing crop productivity, to meet food requirements of teeming millions in our country, possesses a greater challenge. Hence the situation calls for efforts to intensify the production in both time and space. The balanced fertilization of major elements (NPK) for plant nutrient could be beneficial for the growth of plant above ground parts and roots. However farmers are often forced to make decision about their fertilization strategy that reflects economic rather than agronomic pressure. When economic pressure is lifted, nitrogen and to a lesser extent, phosphorous are the nutrients of choice and the need for potassium is either under estimated or ignored. As a result imbalanced fertilization is still widespread. Hence the concept of Integrated Plant Nutrient System (IPNS) encompassing adequate and balanced use of nutrients in an integrated manner employing chemical, organic and biofertilizers is the most ideal system of nutrient management.

IPNS is a concept and farm management strategy which embraces and transcends from single crop fertilization effects to planning and management of plant

nutrients in crop rotation and farming systems on long term basis for enhanced productivity, profitability and sustainability. The system enhances nutrient-use efficiency, maintains soil health, enhances crop yields and reduces cost of cultivation. The primary goal of integrated nutrient management is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way.

Thus IPNS approach aims to enhance soil and crop productivity through a balanced use of mineral fertilizers combined with organic and biological sources of plant nutrients to ensure sustainability of the production systems. The present project investigates the effect of biofertilizers in combination with chemical fertilizers on nutrient management in red loam soil with a test crop bhindi. Hence with the aforesaid points in mind the present study is envisaged with the following objectives to assess the conjugal effect of manures and chemical fertilizers on dynamics of major agriculturally significant soil enzymes, available nutrient status of the soil, its relation with the activities of major soil enzymes, soil microflora, yield and yield attributes of the test crop (Bhindi) and to compute Soil Fertility Index through Enzyme Activity Number.

Materials and Methods

The study entitled was carried out at College of Agriculture, Vellayani to assess the conjugal effect of manures and chemical fertilizers on dynamics of major agriculturally significant soil enzymes, available nutrient status of the soil, its relation with the activities of major soil enzymes, soil microflora, yield and yield attributes of the test crop and computation of Biological Fertility Index through Enzyme Activity Number. The field experiment was laid out in RBD with 15 treatments and three replications and the treatment details are as follows.

Table-1 : Treatment Details.

T ₁	Package of practice recommendation (KAU)
T ₂	N (25 %) as neem cake enriched vermicompost + N (75%), P & K
T ₃	N (25 %) as <i>Azospirillum</i> enriched vermicompost + N (75%), P & K
T ₄	P (25 %) as PSB enriched vermicompost + P (75%), N & K
T ₅	NPK (25 %) as PGPR mix-1 enriched vermicompost + N, P & K (75%)
T ₆	N (50%) as Neem cake enriched vermicompost+ N (50%), P & K
T ₇	N (50%) as <i>Azospirillum</i> enriched vermicompost + N (50%), P & K
T ₈	P (50 %) as PSB enriched vermicompost + P (50%), N & K
T ₉	NPK (50 %), PGPR mix-1 enriched vermicompost + N, P & K (50%)
T ₁₀	N (75 %) as Neem cake enriched vermicompost + N (25%), P & K
T ₁₁	N (75 %) as <i>Azospirillum</i> enriched vermicompost + N (25%), P & K
T ₁₂	P (75%) as PSB enriched vermicompost + P (25%), N & K
T ₁₃	N, P, K, (75%) as PGPR mix-1 enriched vermicompost + N P & K (25%)
T ₁₄	N, P, K alone as inorganics
T ₁₅	Absolute control

Enrichment of vermicompost was carried out using *Azospirillum*, PSB and PGPR mix-1 at the rate of 2% and neemcake at a rate of 5%. Bhindi, var. Varsha uphar was used as the test crop.

Enrichment of vermicompost : Enrichment of vermicompost was carried out using *Azospirillum*, Phosphorus solubilizing bacteria, PGPR mix-1 at the rate of 2 %. Other source of enrichment used was Neemcake @ 5%. The nutrient content in the enriched composts were analysed and were applied to the crop to meet the nutrient requirement in specific doses. The rest of the crop requirement was supplemented by the addition of inorganic fertilizers. Enriched vermicompost were analysed for major nutrients using standard analytical procedures and data are presented in Table-2.

Table-2 : Nutritive value of various bioinoculants and additives.

Enriched Vermicompost	Rate	N (%)	P ₂ O ₅ (%)	K ₂ O (%)
Neemcake	@ 5%	4.1	0.7	1.4
<i>Azospirillum</i>	@ 2%	4.7	0.7	0.5
PSB	@ 2%	1.5	1.8	0.5
PGPR mix-1	@ 2%	1.5	1.8	1.9

Methods of enzyme assay

Urease activity (ppm of urea hydrolysed g⁻¹ of soil hr⁻¹)

: The urease activity was determined by following the method described by Broadbent et al. (1964). About 20 g soil was weighed into an Erlenmeyer flask, to which 4 ml of urea substrate solution was added. Enough water was added to each flask to maintain a tension of 1/3 bar and incubated for 24 hours at 30°C. Then the flasks were removed CaSO₄ solution was added to make up the volume to 100 ml. About 15 ml of the supernatant was taken and colour was developed by adding 10ml of p-dimethyl amino benzaldehyde which was then read in a Spectrophotometer at a wavelength of 420 nm. Standards were also prepared by using urea solutions of known concentrations. The results were expressed in terms of urea hydrolysed g⁻¹ of soil hr⁻¹ in ppm.

Phosphatase activity (µg of p-nitrophenol released g⁻¹ of soil hr⁻¹)

: The phosphatase activity was determined by following a procedure described by Eivazi and Tabatabai (1977). To 1 g soil in a 50 ml Erlen Meyer flask, 0.2 ml toluene, 4 ml modified universal buffer (pH-6.5) and 1ml p-nitrophenyl phosphate solution were added and incubated at 23°C for one hour. After incubation, 0.5 ml CaCl₂ (1ml) and 0.05M NaOH (1ml were added). The contents were swirled and filtered through Whatman No.2 filter paper and the intensity of yellow colour developed was read in a spectrophotometer at a wavelength of 420 nm. One percent of p-nitrophenyl phosphate was used for the preparation of standards. The results were expressed in terms of p-nitrophenol hydrolysed/g of soil/hr in micrograms.

Protease activity (µM of amino nitrogen hydrolysed g⁻¹ of soil hr⁻¹)

: The protease activity was estimated as per the procedure defined by Nannipieri *et al.* (1978). About 0.5g of the soil was weighed into a tissue culture tube to which 1.8 ml of 0.1M TRIS buffer and 2 ml of 0.002M phenyl alanine were added, and incubated for 60 minutes at 20°C. After the incubation period, the activity was arrested by adding 0.2 ml of 5M HCl and centrifuged. Supernatant was collected and 2 ml of Ninhydrin reagent was added. The violet colour developed was measured at 570nm using a Spectrophotometer. A series of standards were prepared in the same manner. The results were

expressed as micromoles of amino nitrogen hydrolysed g⁻¹ of soil hr⁻¹.

Dehydrogenase Activity (μg of TPF hydrolysed g⁻¹ of soil 24 hrs⁻¹) : Dehydrogenase activity was estimated as per the procedure described by Casida *et al.*, 1964. About 60 g of the air dried soil was weighed to a 250 ml Erlen Meyer flask. One ml of 3% Triphenyl Tetrazolium Chloride was added and incubated for 24 hrs at 27°C. After incubation, the soil was quantitatively transferred to a glass funnel and was given ethanol washings consecutively till the volume reached 100 ml. The colour intensity was then read in a Spectrophotometer at 485 nm. A series of standards were used for preparing the calibration curve. The results were expressed in terms of Triphenyl Formazon hydrolysed g⁻¹ of soil 24 hrs⁻¹ in micrograms.

Cellulase activity (ppm of glucose hydrolysed g⁻¹ of soil 24 hrs⁺) : Cellulase activity was estimated as per the method suggested by Pancholy and Rice (1973). Five gram of air dried soil was taken in a 100 ml Erlen Meyer flask. Ten ml of acetate buffer and 1% carboxy methyl cellulose was added. Flasks were incubated for 24 hrs at 37°C and left undisturbed. After the incubation, 50ml of the filtrate was taken and 4ml of anthrone reagent was added. The intensity of the green colour developed was read in Spectrophotometer at 620 nm. Glucose was used as standard at different concentration for the preparation of standard calibration graph. The results were then expressed as the amount of glucose hydrolysed/g of soil 24 hrs⁻¹ in ppm.

Results and Discussion

Analysis of post harvest soil for major nutrients revealed that available N, P and K increased significantly after the experiment. Availability of N & K was highest in the treatment T9 (N -50%) as PGPR enriched vermicompost + N (50%), P & K). In the case of available P, treatment T8 where P (50%) as PSB enriched vermicompost + P (50%), N & K recorded the highest value. Enrichment of vermicompost using PGPR mix 1 enhances the decomposition and mineralization leading to the attainment of narrow C/N ratio and thereby leading to increased available soil N. In this context it is believed that the application of enriched vermicompost triggers the microbial population, with the synthesis of higher microbial biomass, which releases N & K upon decomposition. (Banerjee *et al.*, 2006).

Sharma and Gupta (1998) also reported that supplementing organics with inorganic N fertilizers enhances the available N content of the soil due to hastened mineralization, once the requirement of N by microbes is met through inorganic nitrogen. The favorable soil condition under the treatments receiving

organic manures might have helped in the mineralization of soil N leading to build up of available N content.

Table-3 : Effect of treatments on soil chemical properties- Available N, P, K (kg ha⁻¹).

Treatments	Available N	Available P	Available K
T ₁	238.34	55.36	99.56
T ₂	238.34	41.05	73.43
T ₃	238.34	42.22	71.69
T ₄	192.34	57.39	82.58
T ₅	250.88	54.22	105.49
T ₆	213.09	52.49	74.58
T ₇	217.41	44.38	92.15
T ₈	221.59	70.74	105.49
T ₉	250.88	63.38	108.86
T ₁₀	213.23	48.16	73.34
T ₁₁	255.06	50.56	93.70
T ₁₂	238.34	71.71	98.38
T ₁₃	250.88	67.36	109.65
T ₁₄	183.98	38.81	67.43
T ₁₅	175.62	26.60	58.07
CD (0.05)	15.774	2.018	1.936

Table-4 : Effect of treatments on soil chemical properties Micronutrient content in ppm (Fe, Cu, Mn, Zn and B).

Treatments	Fe	Cu	Mn	Zn	B
T ₁	21.267	1.637	16.667	4.667	0.328
T ₂	36.250	1.652	18.010	3.140	0.332
T ₃	25.370	1.915	12.320	3.725	0.334
T ₄	23.346	2.175	17.263	3.421	0.334
T ₅	22.193	2.379	17.353	5.345	0.335
T ₆	29.400	1.656	12.990	3.302	0.337
T ₇	28.145	2.806	15.660	4.238	0.349
T ₈	20.750	2.146	13.306	3.465	0.345
T ₉	36.796	2.844	13.666	5.143	0.359
T ₁₀	33.333	1.897	13.450	5.436	0.338
T ₁₁	32.417	2.038	10.760	3.627	0.342
T ₁₂	34.240	2.199	15.850	5.112	0.358
T ₁₃	33.720	2.117	14.976	4.292	0.355
T ₁₄	24.067	1.575	15.226	3.656	0.317
T ₁₅	20.750	1.528	10.460	2.845	0.315
CD (0.05)	0.2915	0.0179	0.1902	.1601	0.0072

With respect to micronutrient contents in the post harvest soil, Fe, Cu and B were highest in treatment T₉ (NPK (50 %), PGPR mix-1 enriched vermicompost + N, P & K (50%). Highest Mn content was recorded by T₂ (N (25 %) as neem cake enriched vermicompost + N (75%), P & K). Availability of Zn was highest in the treatment T₁₀ (N (75%) as Neem cake enriched vermicompost + N (25%), P & K). Puente *et al.*, (2004) reported that bacteria colonizing the rhizosphere of rock-weathering desert plants were found to release a significant amount of Cu along with the release of other minerals including P, K, Mg, Mn and Zn from the rocks, and were also thermo-tolerant and halo tolerant.

Table-5 : Effect of treatments on soil biological properties—enzyme activities.

Treatments	Urease (ppm of urea hydrolysed g ⁻¹ of soil hr ⁻¹)	Phosphatase (µg p-nitrophenol released g ⁻¹ of soil hr ⁻¹)	Protease (micro moles of amino nitrogen hydrolysed g ⁻¹ of soil hr ⁻¹)	Dehydrogenase (µg of TPF hydrolysed g ⁻¹ of soil 24 hrs ⁻¹)	Cellulase (ppm of glucose hydrolysed g ⁻¹ of soil 24 hrs ⁻¹)
T ₁	158.28	20.64	106.75	98.84	14.68
T ₂	159.61	21.42	112.63	110.64	15.16
T ₃	161.81	22.68	116.60	111.59	15.62
T ₄	164.06	24.49	118.59	122.39	15.00
T ₅	160.09	26.63	120.74	114.82	16.21
T ₆	159.40	26.69	116.62	108.61	16.53
T ₇	168.20	24.75	120.61	112.69	14.29
T ₈	158.28	29.27	122.70	114.57	15.52
T ₉	187.58	26.63	124.43	126.57	17.23
T ₁₀	174.51	29.46	117.84	136.87	14.30
T ₁₁	172.58	27.87	118.63	119.55	16.29
T ₁₂	168.61	28.44	106.49	120.46	15.24
T ₁₃	176.83	25.41	112.65	118.32	18.40
T ₁₄	152.53	21.41	88.64	110.68	13.22
T ₁₅	141.92	17.81	85.42	92.66	11.14
CD (0.05)	0.418	0.503	0.387	0.425	5.672

Table-6 : Effect of treatments on soil respiratory activity and Yield per ha (t/ha) of Bhindi.

Treatments	Soil respiratory activity (µg of CO ₂ evolved g ⁻¹ of soil hr ⁻¹)	Yield (t ha ⁻¹)
T ₁	3.70	8.99
T ₂	3.83	7.13
T ₃	4.17	7.82
T ₄	3.50	7.84
T ₅	3.50	8.13
T ₆	3.67	7.99
T ₇	3.77	8.52
T ₈	3.70	9.48
T ₉	3.90	9.68
T ₁₀	3.70	8.82
T ₁₁	3.47	8.73
T ₁₂	4.20	9.46
T ₁₃	3.70	9.76
T ₁₄	3.70	6.84
T ₁₅	3.10	5.76
CD (0.05)	0.127	0.282

Biological Indicators—Enzyme activities : Enzymes are vital activators in life process, likewise in soil; they are known to play a substantial role in maintaining soil health and its environment. Healthy soils are essential for the integrity of terrestrial ecosystem to intact or to recover from disturbances, such as drought, climate change, pollution and human exploitation including agriculture (Ellert *et al.*, 1997). Therefore it is essential to characterize the soil for the biochemical properties and adopt management strategies to overcome the deterioration and promote rejuvenation by the addition of suitable

amendments. The most substantial index of biological activity in the soil is its enzyme activity and therefore it can give the idea of biochemical processes in the soil. Thus the enzyme activities are sensitive parameters which can be used as an early warning in changes in ecosystem, before they are detectable in other ways.

From the results, it is observed that all the agriculturally significant soil enzymes viz. Urease, protease, cellulase, dehydrogenase except for phosphatase, treatment T₉ (N -50%) as PGPR enriched vermicompost + N (50%), P & K) recorded the highest values. The effect of PGPR mix-1 enriched vermicompost application was most promising in the rhizosphere resulting in an increase in the activity of protease enzyme. This may be attributed to the microbial co-operation in the rhizosphere resulting in the release of C from the organic manures added, thus accelerating the activity of these enzymes to act upon. Similar increase in activity was reported by Vivas *et al.*, (2003). The low activity in the control plot might be due to the non-availability of C sources for these enzymes. The combined application of organic and inorganic nutrient sources might have favoured the multiplication of microflora involved in the synthesis of protease enzymes. This corroborated with the findings of Manero *et al.*, (2003).

The highest available P in the 50% of P as PSB enriched vermicompost in combination with inorganics treated plots might have also contributed to the availability of substrates for the enzymes to act upon. The lowest value recorded in the absolute control might be due to the non availability of P-substrates for the enzyme to act upon. The lowest value in the absolute control plot may

Table-7 : Computation of Enzyme activity number.

Treatments	Catalase (ml O ₂ g ⁻¹ dry soil)	Phosphatase (µg of p-nitrophenol released g ⁻¹ of soil hr ⁻¹)	Protease(µM of amino N-hydrolysed g ⁻¹ of soil hr ⁻¹)	Dehydrogenase (µg of TPF hydrolysed g ⁻¹ of soil per 24 hrs)	Cellulase (glucose hydrolysed g ⁻¹ of soil 24 hrs ⁻¹)	Enzyme activity number
T ₁	2.47	47.53	140.75	158.51	29.24	32.64
T ₂	3.15	48.83	148.31	162.82	33.08	33.54
T ₃	3.47	49.93	154.44	165.46	35.31	34.11
T ₄	7.00	63.71	157.74	203.86	38.30	41.88
T ₅	7.01	59.46	149.5	185.09	40.35	38.06
T ₆	6.14	62.12	163.13	183.01	42.21	37.73
T ₇	6.37	62.22	163.73	188.49	43.59	38.79
T ₈	6.91	79.67	175.49	188.32	44.13	38.97
T ₉	8.27	75.33	181.13	227.79	49.83	46.84
T ₁₀	7.21	51.7	160.76	205.32	38.81	42.12
T ₁₁	7.12	53.54	170.82	208.83	42.84	42.89
T ₁₂	7.30	68.56	173.53	218.63	43.37	44.93
T ₁₃	8.13	67.57	176.38	220.38	45.87	45.29
T ₁₄	2.47	40.46	141.08	132.44	26.79	27.39
T ₁₅	1.57	39.46	101.45	127.18	25.79	26.14

also be due to the bacteria colonizing P-deficient environment with low P mobilizing capacity to sustain their growth which is the basis of stress physiology paradigm as opined by Goldstein *et al.* (1999).

Rhizosphere Microbiomes : Soil microbial populations are immersed in a framework of interactions known to affect plant fitness and soil quality. They are involved in fundamental activities that ensure the stability and productivity of both agricultural systems and natural ecosystems.

In the rhizosphere soil, the significant effect of treatments on soil bacteria was observed (Fig.-8). It is quite interesting to note that treatment involving the application of 50% of P as Phosphate solubilizing bacteria enriched vermicompost along with inorganics was similar in effect with 50% of NPK as PGPR mix-1 enriched vermicompost in combination with inorganics. This might be due to the positive co-operation between PGPR and PSB thus contributing to higher activity of bacteria.

The rhizosphere, the zone of soil under the influence of root is characterized by high microbial diversity, activity, number of organisms and complex interactions and root (Oger *et al.*, 2004). In the rhizosphere soil, fungi population was higher in bio inoculants treated soils. It has been recently postulated that an additional mechanism for plant growth promotion by PGPR could be their altering of microbial rhizosphere communities (Ramos *et al.* 2003). It is inferred from the Fig. 5 that the actinomycetes population had varied significantly with treatments in both rhizosphere and non-rhizosphere soils. Application of PGPR mix-1 enriched vermicompost had increased the actinomycetes population in both the soils.

From the study it is inferred that certain bacteria, fungi and actinomycetes are able to colonize the root soil environment where they carry out a variety of interactive activities known to benefit plant growth and health and soil quality. Under integrated plant nutrient system, it is clearly evident that the microflora was more in rhizosphere than in the non rhizosphere. This might be due to the differing physical, chemical and biological properties of root associated soil, bringing about a drastic change in the microbial diversity in rhizosphere environment. Similar results were reported by Toal *et al.*, (2000).

A comparison of enzyme and microbial activities under integrated plant nutrient system between rhizosphere and non rhizosphere was attempted in this study. It is understood that rhizosphere, the soil adjacent to plant roots is significantly different from bulk soil in chemical, biological and microbiological properties. Activities of enzymes urease, phosphatase, protease, dehydrogenase and cellulase were found to be higher in rhizosphere soil. Similar results were reported by Gregory and Hinisinger, (1999) The rhizosphere is the zone of soil influenced by roots through the release of substrates that affect microbial diversity and activity. These microbes are responsible for key environmental processes, such as biogeochemical cycling of nutrients and matter and the maintenance of plant health and soil quality (Barea *et al.*, 2004). In particular, the varied genetic and functional activities of the extensive microbial populations have a critical impact on soil functions, based on the fact that microorganisms are driving forces for fundamental metabolic processes involving specific enzyme activities (Nannipieri *et al.*, 2003). These factors have contributed to the increased enzyme activities in rhizosphere.

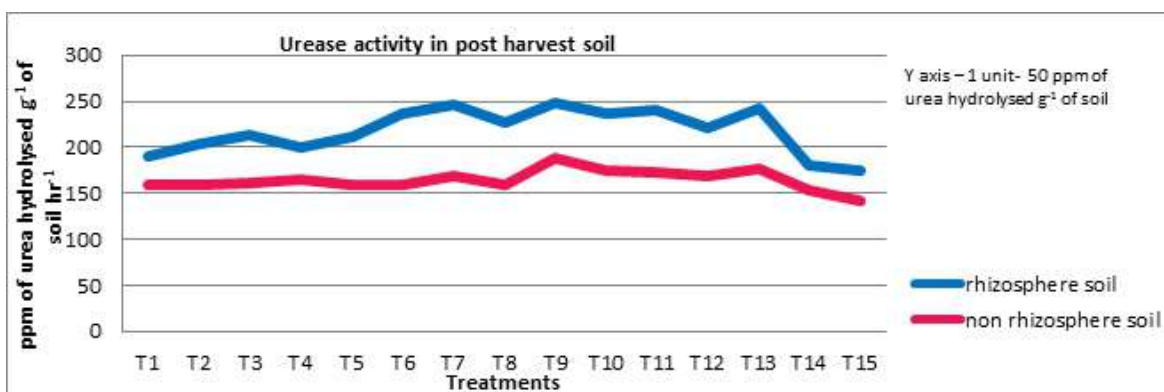


Fig.-1 : Urease activity in post harvest soil.

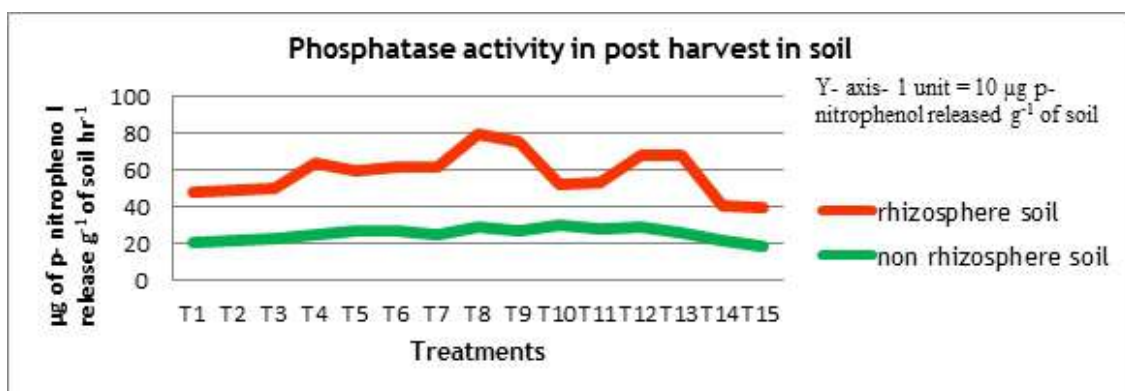


Fig.-2 : Phosphatase activity in post harvest in soil.

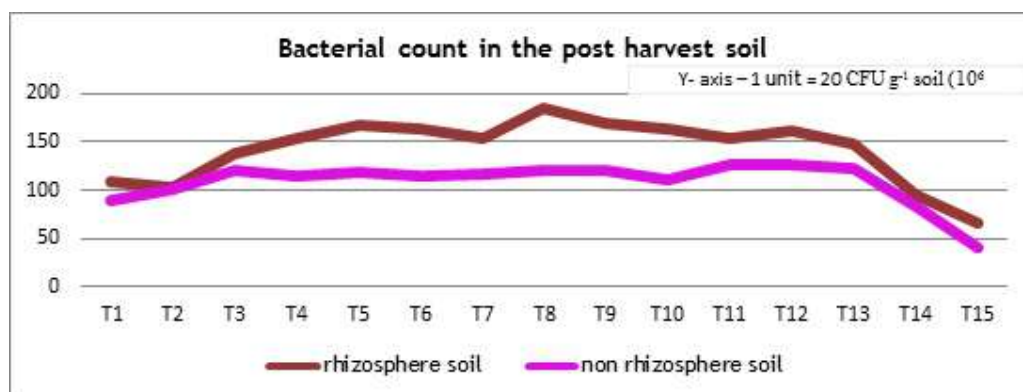


Fig.-3 : Bacterial count in post harvest soil.

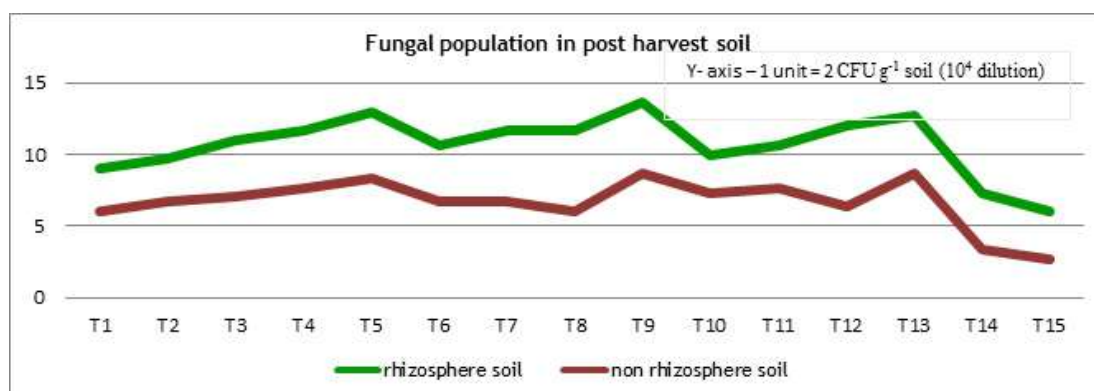


Fig.-4 : Fungal count in post harvest soil.

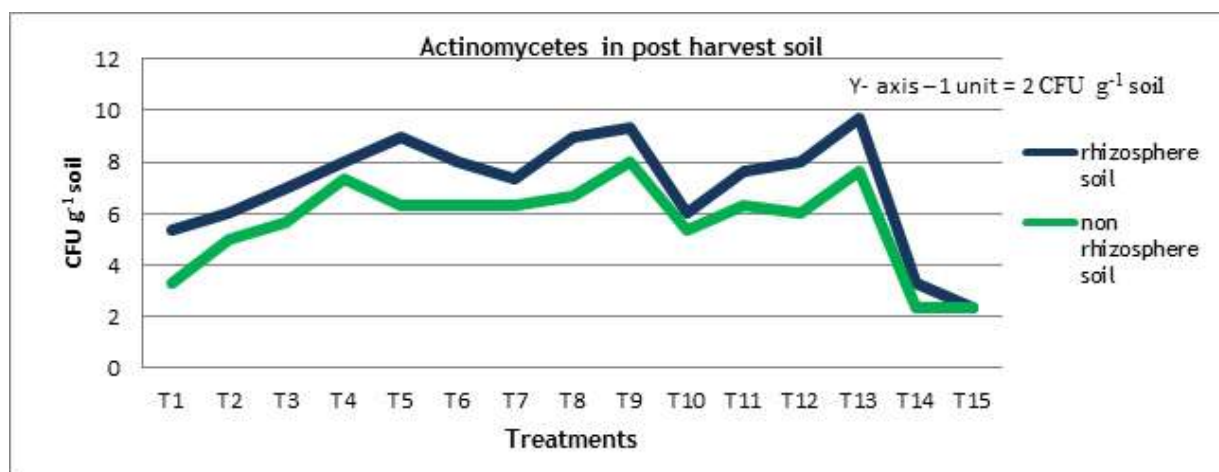


Fig.-5 : Actinomycetes count in post harvest soil.

Respiratory activity of soil belongs among the most important characteristics of the soil biological activity. Usually measured as CO₂ emissions (in laboratory or in situ), it is a strong indicator of the soil metabolism and ecological soil functions (Santruckova, 1993).

Soil enzymes have been suggested as potential indicators of soil quality because of their essential role in soil biology. Ease of measurement and rapid response to changes in soil management (Dick *et al.*, 1994). Enzyme activity number is an index of biological fertility. Treatment T₉ with the application of NPK 50% as PGPR mix-1 enriched vermicompost in combination with inorganics reported the highest value for soil respiratory activity and enzyme activity number indicating the effect of the treatment in sustaining the soil biological health.

Similar results were reported by Riffaldi *et al.* (2002) who reported higher enzyme activity number in untilled management system than the tilled management system. Yield parameters like yield per plant and yield per hectare were significantly influenced by the treatments (Table-6) and the highest values were recorded by T₁₃ (N, P, K, (75%) as PGPR mix-1 enriched vermicompost + N, P & K (25%). Treatment T₁₃ produced 52% increase in yield per hectare over the absolute control plot T₁₅.

Conclusion

This study revealed that the treatment T₉ i.e. application NPK as 50% PGPR mix-1 enriched vermicompost in combination with inorganics as the best treatment for the cultivation of Bhindi var. Varsha uphar. Treatment T₉ increased available micro nutrient status (Fe, Cu, B), biological properties of soil viz., urease, dehydrogenase, cellulase and protease activities; and yield characters of bhindi i.e. yield per plant and yield per hectare. A highest value of Enzyme Activity Number, which is an index of biological activity, was also registered by the treatment T₉, revealing its superiority over other treatments. T₉ found to

be the best treatment both in sustaining soil biological activity and economic returns.

References

1. Banerjee, B., Agarwal P.K., Pathak, H., Singh, A.K. and Chaudhary, A. (2006). Dynamics of organic carbon and microbial biomass in alluvial soil with tillage and amendments in Rice Wheat system. *Environment Monitoring Assessment*. 119:173-189.
2. Barea, J.M., Azcon, R. and Azcon-Aguilar, C. (2004). Mycorrhizal fungi and plant growth promoting rhizobacteria. In: Varma, A., Abbott, L., Werner, D. and Hampp, R. (eds). *Pl. Surf. Microbiol.* Heidelberg, Germany : Springer-Verlag, 351-371.
3. Broadbent, F.E., Hill, G.N. and Tyler, K.B. (1964). Transformation and movement of urea in soils. *Soil Sci. Soc. Am. Proc.* 22: 303-307
4. Casida, L.E., Klein D.A. and Santoro T. (1964). Soil dehydrogenase activity. *Soil Sci.* 98: 371-376.
5. Dick, R.P. (1994). Soil Enzyme Activity as an Indicator of Soil Quality. In: Doran, J. W. (eds.) *Defining soil quality for a sustainable environment*. Madison, WI. p107-124.
6. Eivazi, F. and Tabatabai, M.A. (1977). Phosphatases in soils. *Soil Biol. Biochem.* 9: 167-172.
7. Ellert, B.H., Clapperton, M.J. and Anderson, D.W. (1997). An ecosystem perspective of soil quality. In: Gregorich, E. G. and Carter, M. R. (eds) *Soil quality for crop production and ecosystem health*. Elsevier, Amsterdam, pp 115-141
8. Gregory, P. J. and Hinsinger, P. 1999. New approaches to studying chemical and physical changes in the rhizosphere: An overview. *Pl. Soil.* 211(1): 1-9.
9. Manero, F.J., Probazane, A., Ramos, B., Flores, J.J. and Garcia- Lucas, J.A. (2003). Effect of culture filtrates isolated from wild lupin on germination, growth and biological nitrogen fixation of lupin seedlings. *J. Pl. Nutr.* 26: 1101-1115.
10. Nannipieri, P., Johnson, R.L. and Paul, E.A.B. (1978). Criteria for microbial growth and activity in soil.
11. Nannipieri, P. and Gianfreda, L. (1993). Kinetics of enzyme

- reactions in soil environment, In: Huang, P.M., Senesi, N., Buffle, J. (Eds.), *Structure and Surface Reactions of Soil Particles*. Wiley, New York, pp. 450–479.
12. Pancholy, S.K. and Rice, E.L.L. (1973). Soil enzymes in relation to old-field succession *Soil Sci. Soc. Am. Proceed.* 37: 47-50.
 13. Puente, M.E., Bashan, Y., Li, C.Y. and Lebsky, V.K. (2004). Microbial populations and activities in the rhizoplane of rock-weathering desert plants. I. Root colonization and weathering of igneous rocks. *Pl. Biol.* 6: 629–642.
 14. Riffaldi, R., Saviozzi, A., Levi-Minzi, R. and Cardelli, R. (2002). Biochemical properties of a Mediterranean soil as affected by long term crop management systems. *Soil Tillage Res.* 67: 109-114.
 15. Ramos, B., Garcia, J.A.L., Probanza, A., Barrientos, M.L. and Manero, F.J.G. (2003). Alterations in the rhizobacterial community associated with European alder growth when inoculated with PGPR strain *Bacillus licheniformis*. *Environ. Exp. Bot.* 49: 61–68.
 16. Santruckova, H. 1993. Respiration activity of soil as a criterion of its biological activity. *Rostl. Výr.*, 39: 769–778. (In Czech)
 17. Sharma, M.P. and Gupta, J.P. 1998. Effect of organic materials on grain yield and soil properties in maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system. *Indian J. Agric. Sci.* 68: 715-717.
 18. Tabatabai, M. A. (1994). Soil Enzymes. In: Weaver, R.W., Angel, J. S. and Bottomley, P. S. (eds) *Methods of Soil Analysis. Soil Sci. Soc. Am.* 5: 129-133.
 19. Toal, M.E., Yeomans, C., Killham, K. and Meharg, A.A. (2000). A review of rhizosphere carbon flow modelling. *Pl. Soil.* 222: 263–281.
 20. Vivas, A. Voros, A., Biro, B., Barea, J.M., Ruiz-Lozano and R. Azcon. (2003). Beneficial effects of indigenous Cd-tolerant and Cd-sensitive *Glomus mosseae* associated with a Cd-adapted strain of *Brevibacillus* sp. in improving plant tolerance to Cd contamination. *Appl. Soil Ecol.*, 24: 177–186.



Study of Various Plant Growth Enhancers on Propagation in Betel Leaf Cutting (*Piper betle* L.)

Bhagwat Saran Asati

College of Agriculture and Research Station, Chhuikhadan, Rajnandgaon, Chhattisgarh, India

Email : bsahorti@gmail.com

Abstract

Betelvine (*Piper betle* L.) an important crop of the Piperaceae family, is an evergreen perennial climbing plant with heart-shaped glossy dark green leaves. In India, it is customary to serve betel leaves on various social, cultural and religious occasions and is also offered to guests as a sign of respect (known as tambool). Without Paan, no Hindu religious ceremony is also delivered after lunch and dinner, as well as at other social events. The cultivation of betel vine is known for its greater potential to generate income and employment at the farm level. Few experiments have been carried out to examine the rooting effects of plant enhancers among various plant species. Phytohormones, particularly auxins, contribute primarily to regulating root growth. The experiment was done during the year 2019-20 at protected condition i. e., Shade net at Horticultural farm, Pt. K. L. S College of Horticulture & Research Station Rajnandgaon (C.G.). The present experiment was conducted during the 2019-20 Rabi season at Pt. Kishori Lal Shukla College of Horticulture & Research Station Rajnandgaon (C.G.). The experiment was laid out in CRD (Completely Randomized Design) under shade net conditions with three replication, each replication consisted of 10 treatments. { T₁ (IBA 500 mg / lit), T₂ (IBA 750 mg / lit), T₃ (IAA 500 mg / lit), T₄ (IAA 750 mg / lit), T₅ (NAA 500 mg / lit), T₆ (NAA 750 mg / lit), T₇ (Moringa leaf extract 30 ml / lit), T₈ (IBA 1.5 mg + kinetin 2.0 mg / lit), T₉ (IBA 2 mg + Kinetin 3.0 mg / lit), T₁₀ Control (without plant growth enhancer)}. The result indicated that T₁ (IBA 500 mg / lit) was superior for most of the characters under study i.e. Days taken for sprouting (12.33 days), Sprouting Percentage (80%), Number of leaves per cutting (13.77), Average shoot length per cutting (38.36cm), Number of primary roots (14.99), Fresh shoot weight (8.97g), Dry shoot weight (3.68g) and Survival percentage (83.33%).

Key words : Plant growth enhancers, betelvine, PGRs, cutting, propagation.

Introduction

Betelvine (*Piper betle* L.) an important crop of the Piperaceae family, is an evergreen perennial climbing plant with heart-shaped glossy dark green leaves. In India, it is customary to serve betel leaves on various social, cultural and religious occasions and is also offered to guests as a sign of respect (known as tambool). Without Paan, no Hindu religious ceremony is also delivered after lunch and dinner, as well as at other social events. The cultivation of this crop in the state of Chhattisgarh is concentrated in the Chhuikhadan and Dongargarh blocks of the Rajnandgaon district. The betelvine variety grown in this area is Billori. Another variety of paan, namely Meetha paan and Kalkatia paan, is also popular in this area. The cultivation of Betelvine is essentially an occupation of small marginal farmers who have very small farms. The cultivation of betel vine is known for its greater potential to generate income and employment at the farm level. The initial cost of harvesting beetles is very high, but the benefits per unit area are also good. Few experiments have been carried out to examine the rooting effects of plant enhancers among various plant species (Steffens *et al.* 2006). Phytohormones, particularly auxins, contribute primarily to regulating root growth. For that reason, current

research was carried out to explore the impact of PGRs on the rooting of *Piper betel* nodal cuttings.

Materials and Methods

The experiment was done during the year 2019-20 at protected condition i. e., Shade net at Horticultural farm, Pt. K.L.S College of Horticulture & Research Station Rajnandgaon (C.G.). The experiment was laid out in the Completely Randomized Design and replicated three times. Each replication consisted of 10 treatments i.e. (IBA) 500 mg/lit (T₁), (IBA) 750 mg/lit (T₂), (IAA) 500 mg/lit (T₃), (IAA) 750 mg/lit (T₄), (NAA) 500 mg/lit (T₅), (NAA) 750 mg/lit (T₆), Moringa Leaves Extract 30 ml/lit (T₇), IBA 1.5 mg + Kinetin 2.0 mg/lit (T₈), IBA 2mg + Kinetin 3.0 mg/lit (T₉) and Control/without plant growth enhancer (T₁₀). Observations like days taken for sprouting (days), sprouting percentage (%), average length of sprouts (cm), number of shoots per cutting, average length of shoot per cutting (cm), average diameter of shoot per cutting (mm), number of leaves per cutting, number of primary root, length of primary root (cm), fresh weight of shoot (gm), dry weight of shoot (gm) and survival percentage were recorded. Finally, data was subjected to statistically analysis (Completely Randomized Design) by applying statistical procedure were undertaken on the basis of

observations taken during the experiment for ten treatments as method described by Panse and Sukhatme (1967).

Black polythene bags of size 5x8 inch with thickness of 200 gauges were used in this experiment. The polythene bags were filled with growing media consisted of sand, soil and well decomposed FYM in the ratio of 1:2:1 and in the bottom of the polythene bags 2-3 holes were made to ensure the drainage. The cuttings were taken from the healthy mother plants and uniform shoots were selected as propagating material. The cuttings were made in 15 cm in length with pencil thickness and having 3-5 nodes. The 10 cuttings were treated in each replication and total 30 cutting were planted in each treatment. Therefore, total 300 cuttings were used for rooting of cuttings. The cuttings were made as a slanting cut at top portion and a smooth horizontal cut at basal portion of cutting.

Results and Discussion

Observations related to days taken for sprouting and sprouting percentage are displayed in Table-1 and Figure-1. Significantly minimum days taken to sprouting (12.33) and maximum sprouting percentage (80%) at 30 Days after planting was noted under treatment T1 (IBA 500 mg/lit) which was found at par with treatment T2 (IBA 750mg/lit) noted (13.66 days). Indole-3 Butyric Acetic acid (IBA) is the most efficacious plant growth hormone and causes earliness in sprouting, because it is more sustained (Hartmann *et al.* 2002). Early sprouting may have been synergistically affected by the use of IBA. The results are in agreement with Kesari *et al.* (2009) and Bhagya *et al.* (2014). The highest sprouting percentage might be due to the accumulation of carbohydrate in cutting and external use of Indole-3 Butyric Acid. It may affect the survival percentage of cuttings. Umesha *et al.* (2011) also observed earliness in sprouting, and greater development of shoot, through longer cuttings (1-3 node) of vanilla.

Observations related to average length of sprouts per cutting, number of shoots, average length of shoots per cutting, number of leaves per cutting and average diameter of shoots per cutting are showed in Table 2. Average length of sprouts per cutting showed not significant at 90 Days After Planting under study, whereas treatment T1 (IBA 500 mg/lit) and T5 (NAA 500 mg/lit) showed significantly maximum number of shoots (3.99, 4.21), maximum average length of shoots per cutting (38.36 cm, 36.94 cm) and higher number of leaves per cutting (13.77, 12.88) respectively at 90 days after planting. In combination with application of IBA and higher amount of reserved food material present in nodal cuttings may have established a better root system that

results in more number of shoots and higher number of leaves (Hartmann *et al.* (2002). On other hand, treatment T8 (IBA 1.5 mg + Kinetin 2 mg/lit) significantly exhibited maximum diameter of shoots per cutting (4.37 cm) at 90 days after planting, which was found at par with T2 treatment (IBA 750 mg/lit) noted (3.95 cm). Probably the reason may be due to that the auxins, IBA activates the stem growth and leaf growth. The current findings are in agreement with Khan *et al.* (2011) in tomato and Murthy *et al.* (2010) in vanilla.

Table-1 : Effect of different plant growth enhancers on days taken for sprouting and sprouting percentage (%).

Treatments	Days taken for sprouting	Sprouting percentage (%)
T ₁ (IBA 500mg/lit)	12.33	80.00
T ₂ (IBA 750mg/lit)	13.66	76.66
T ₃ (IAA 500mg/lit)	14.00	66.66
T ₄ (IAA 750mg/lit)	15.00	50.00
T ₅ (NAA 500mg/lit)	13.33	73.33
T ₆ (NAA 750mg/lit)	14.33	63.33
T ₇ (Moringa leaves extract 30ml/lit)	19.00	46.66
T ₈ (IBA 1.5mg+ Kinetin 2mg/lit)	17.33	60.00
T ₉ (IBA 2mg + Kinetin 3mg/lit)	15.66	56.66
T ₁₀ (Control /without plant growth enhancers)	21.66	43.33
SEm ±	0.380	3.801
C.D. at 5%	1.129	11.21
CV	4.211	10.67

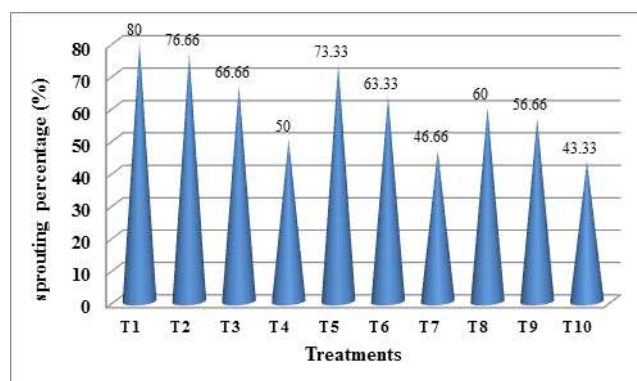


Figure-1 : Effect of different plant growth enhancers on sprouting percentage (%).

Observations related to Number of primary roots was calculated at 90 days after planting and showed in Table 3. Perusal of data indicates that treatment T1 (IBA 500 mg/lit) recorded significantly maximum number of primary roots per cutting (14.99), followed by T5 treatment (NAA 500 mg/lit) noted (13.44), whereas treatment T2 (IBA 750 mg/lit) recorded maximum average length of primary roots (21.75 cm) which was non-significant with T5 treatment (NAA 500 mg/lit) (20.58 cm). It may be because of assembled nitrogenous substance and

Table-2 : Effect of different plant growth enhancers on propagation through betelvine cutting.

Treatments	Average length of sprouts per cutting (cm)	Number of shoots per cutting	Average length of shoots per cutting (cm)	Number of leaves per cutting	Average diameter of shoots per cutting (mm)
T ₁ (IBA 500 mg/lit)	1.95	3.99	38.36	13.77	2.74
T ₂ (IBA 750 mg/lit)	1.99	3.77	36.67	12.77	3.95
T ₃ (IAA 500 mg/lit)	1.92	3.33	35.79	8.10	3.69
T ₄ (IAA 750 mg/lit)	1.88	2.88	33.15	10.66	2.92
T ₅ (NAA 500 mg/lit)	1.97	4.21	36.94	12.88	2.39
T ₆ (NAA 750 mg/lit)	1.89	3.11	35.16	11.10	3.52
T ₇ (Moringa leaves extract 30 ml/lit)	1.78	1.77	31.34	8.88	1.99
T ₈ (IBA 1.5 mg+ Kinetin 2 mg/lit)	1.80	2.33	32.48	12.21	4.37
T ₉ (IBA 2 mg + Kinetin 3 mg/lit)	1.86	2.66	32.50	9.88	3.16
T ₁₀ (Control /without plant growth enhancers)	1.71	1.66	30.71	9.66	3.82
SEm±	0.105	0.217	0.401	0.353	0.060
C.D. at 5%	NS	0.644	1.192	1.049	0.177
CV	9.896	12.617	2.028	5.562	3.169

Table-3 : Effect of different plant growth enhancers on various growths attributes.

Treatments	Number of primary root	Average length of primary roots (cm)	Fresh weight of shoot (gm)	Dry weight of shoot (gm)	Survival percentage (%)
T ₁ (IBA 500 mg/lit)	14.99	19.62	8.97	3.68	83.33
T ₂ (IBA 750 mg/lit)	12.66	21.75	7.59	3.48	81.54
T ₃ (IAA 500 mg/lit)	12.32	17.60	6.61	2.94	75.39
T ₄ (IAA 750 mg/lit)	9.99	15.15	6.08	2.26	72.69
T ₅ (NAA 500 mg/lit)	13.44	20.58	7.30	3.20	82.14
T ₆ (NAA 750 mg/lit)	10.11	16.96	6.59	2.54	73.80
T ₇ (Moringa leaves extract 30 ml/lit)	7.77	10.34	4.82	1.18	65.00
T ₈ (IBA 1.5 mg+ Kinetin 2 mg/lit)	8.66	12.50	5.84	1.20	67.22
T ₉ (IBA 2 mg + Kinetin 3 mg/lit)	9.44	13.75	5.92	1.83	71.10
T ₁₀ (Control /without plant growth enhancers)	6.77	11.67	3.23	1.01	61.66
SEm±	0.573	0.460	0.459	0.054	4.939
C.D. at 5%	1.702	1.367	1.364	0.160	NS
CV	9.343	4.985	12.630	3.985	11.65

hydrolysis of carbohydrates at the basal end of the cutting, that increases the process of cell division and elongation. Prompt callus formation resulting increase in no. of primary roots. The current research is in concurrent with Gohil (2014) in cashewnut.

The characters fresh weight of shoot (gm) and dry weight of shoots (gm) were recorded at 90 days after planting and presented in Table-3. The result revealed that the significantly maximum fresh weight of shoots (8.97 gm) and maximum dry weight of shoots (3.68 gm) was noted by the treatment T₁ (IBA 500 mg/lit) followed by T₂ treatment (IBA 750 mg/lit). This is probably because of early sprouting, increase in number of leaves and leaf area as well as higher fresh weight of shoots. The present finding was supported by Shukla and Bist (1994) in Pear.

Observations on survival percentage was calculated

at 90 days after planting and showed in Table 3 and Figure-2. It is evident from findings that the effect of different plant growth enhancers had shown no significant effect with respect to survival percentage. The highest (83.33%) survival percentage was calculated with T₁ treatment (IBA 500 mg/lit) followed by T₅ treatment (NAA 500 mg/lit) (82.14%). Plant growth regulator IBA (Indole-3 Butyric Acid) increased the survival percentage of the cuttings in various fruit crops (citrus, grape, plum, pear, peach, olive and apple. This present findings are in agreement with Jan et al. (2015) and Soni et al. (2016).

Conclusion

The result indicated that T₁ (IBA 500 mg / lit) was higher for characters, i.e. Days taken for sprouting (12.33 days), Sprouting Percentage (80%), Number of leaves per cutting (13.77), Average shoot length per cutting

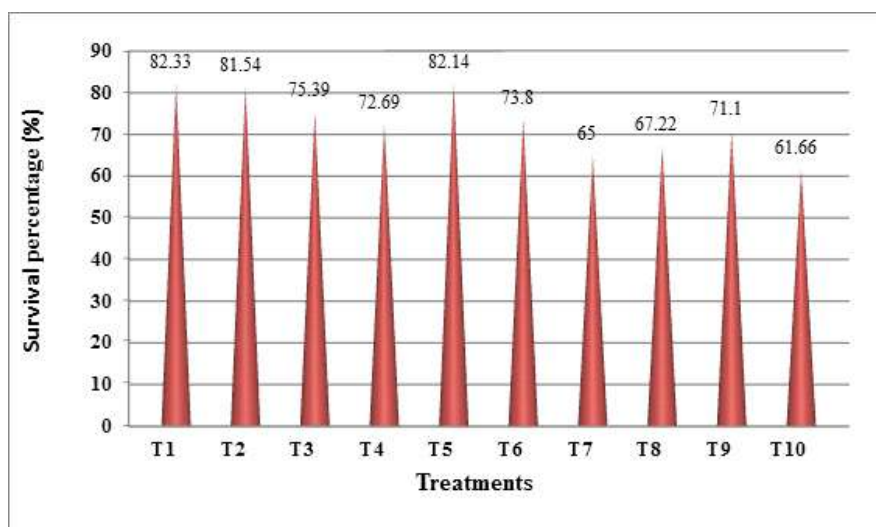


Figure-2 : Effect of different plant growth enhancers on survival percentage (%).



Standardized propagation technique for easy & fast multiplication in betelvine

(38.36cm), Number of primary roots (14.99), Fresh shoot weight (8.97g), Dry shoot weight (3.68g) and Survival percentage (83.33%).

Acknowledgment

We express gratitude to Dr. (Smt) Arti Guhe, Professor & Head, Department of Plant Physiology, Agricultural

Biochemistry and Medicinal & Aromatic Plants, Indira Gandhi Agricultural University, Raipur for giving planting materials and support for conducting this research work. We also thank to Dr M. L. Sharma, Dean, Pt KLS College of Horticulture & Research Station, Rajnandgaon for providing facility, continued encouragement and support throughout the work.

References

1. Bhagya, H., K.A. Lalithya and K. Bharati. 2014. Influence of growth hormones and nodal cuttings on rooting of *Vitex negundo* L. *Indian J. of Agril. Res.* 48(20): 81-88.
2. Gohil, J.H. 2014. Effect of different concentration of IBA and NAA on air layering of cashewnutcv. Vengurla 4. *Trends in Biosci.* 7(5): 351: 354.
3. Hartmann, H.T., D.E. Kester, F.T. Davies and R.L. Geneve. 2002 .Plant Propagation (Principles and Practices) Pearson Education. Pub., New York, U.S.A.
4. Jan, I., M. Sajid, A. Rab, A. Iqbal, O. Khan, Y. Jamal and S.T. Shah, 2015 . Effect of various concentrations of Indole butyric acid (IBA) on olive cuttings. *Mitteilungen Klosterneuburg.* 64: 127-136.
5. Kesari, V., A. Krishnamachari and L. Rangan. 2009. Effect of auxins on adventitious rooting from stem cuttings of candidate plus tree *Pongamia pinnata* L. *A Potential Biodiesel Plant Tree*, 23: 597-604.
6. Khan, T.N., G. Jeelani, S. Tariq, T. Mahmood and S.I. Hussain, 2011. Effect of different concentrations of rooting hormones on growth of Tomato cuttings (*Solanum esculentus*). *J. of Agril. Res.* 49 (2):241-247.
7. Murthy, G., K. Umesha, R. Smitha and Manohar Krishna. 2010. Effect of growth regulator and bio-inoculants on rooting and growth of vanilla stem cuttings. *Indian J. of Horti.* 67(1): 90-93.
8. Panse, V.G. and P.V. Sukhatme. 1995. Statistical Methods for Agricultural Workers. ICAR, New Delhi.
9. Shukla, G.S. and L.D. Bist. 1994. Studies on the efficacy of IBA and NAA on clonal propagation by cutting in low chilling pear rootstocks. *Indian J. of Horti.* 51(4): 351-57.
10. Soni, N., S.K. Pandey, S.S. Singh, S.R.K. Singh, A. Mishra, S.S. Baghel and P.K. Kaurav. 2016. Propagation of guava through cuttage under net house condition at Jabalpur, Madhya Pradesh, India. *Flora and Fauna.* 22(1): 36-40.
11. Steffens, B., J. Wang and M. Sauter. 2006. Interactions between ethylene, gibberellin and abscisic acid regulate emergence and growth rate of adventitious roots in deep water rice. *Planta.* 223(3): 604-612.
12. Umesha, K., G. Murthy and G.R. Smita. 2011. Environmental conditions and type of cuttings on rooting and growth of vanilla (*Vanilla planifolia* Andrews). *J. of Tropical Agri.* 49(1-2): 121-123.



Effect of Phenotypes and Levels of Nitrogen on Yield of Kakrol (*Momordica dioica* Roxb.)

Ch. Bindhu^{1*}, M.B. Nageswara Rao², K. Umajyothi³ and K. Umakrishna⁴

Dr.Y.S.R. Horticultural University, HC&RI, Venkataramannagudem, W.G. Dist.-534101 A.P.

*Corresponding Author Email : bindhuchetti@gmail.com

Abstract

A field experiment was carried out during the kharif, 2013 at Horticultural College and Research Institute, Venkataramannagudem, West Godavari District of Andhra Pradesh with 9 treatments involving combinations of different phenotypes (with single, tri and penta lobed leaves) and levels of nitrogen (with 125, 250 and 375 kg N/ha), laid out in a randomized block design (RBD) with factorial concept replicated thrice. Results showed the influence of different phenotypes on yield contributing parameters like fruit length, number of fruits per plant, mean fruit weight, net plot yield, fruit yield/ha, fresh seed weight and nitrogen uptake which were found highest in vines with single lobed leaves. Among the nitrogen levels, the higher values for yield parameters like number of fruits per plant, mean fruit weight, net plot yield, estimated fruit yield and fresh seed weight, nitrogen uptake were recorded with the nitrogen application of 375 kg N/ha. Among the interaction effects between phenotypes and nitrogen levels, significant influence on yield parameters like number of fruits per plant, maximum net plot yield, fruit yield/ha was noticed.

Key words : Phenotype, nitrogen, kakrol, yield.

Introduction

Kakrol (*Momordica dioica* Roxb.) is also known as teasel gourd or spine gourd and belongs to family Cucurbitaceae under the genus *Momordica*, a genus of annual and perennial climbers that contains about 80 species with chromosome number $2n=28$. Its wild relative *Momordica cochinchinensis* ($2n=56$) is having large leaves, flowers and fruits which is mostly grown in Orissa and other regions. It is generally a vegetatively propagated dioecious crop. Spine gourd is also called as Kantola or kakrol in Hindi, Agakara or Bontha kakara in Telugu.

Sexual propagation is the pre-requisite for genetic improvement in any direction. Propagation of plants in kakrol from true seeds under natural condition is to some extent difficult due to poor germination of seeds because of the hard seed coat (Rashid 1976). In this method about 50% seeds are found to germinate within 30-45 days. A lot of variation with respect to morphological characters were observed. About 50-70% of the seedlings are found male in sex. The male plants were found to bloom earlier than the female plants.

In Andhra Pradesh, commercial method of propagation of kakrol is through seeds. Consistent phenotypic variation was observed in the seed propagated / segregated plants of Kakrol which also greatly affecting the yield of vines. As such, there is an exigency to find out some broad phenotypic variations in the seed propagated vines and to correlate them with their yield potential.

It is being observed that nitrogen fertilization favours

the development of the aerial parts over roots and consequently the promotion of flowering and fruiting of many crops. Spine gourd with huge vegetative growth needs high amounts of nitrogen to cover its requirements. Hence, there is a need to standardize the optimum level of nitrogen for getting higher yields. With this background the present investigation was initiated to study the effects of phenotypes and nitrogen on growth and yield of kakrol.

Materials and Methods

The field experiment was conducted during kharif, 2013 to study the effect of three phenotypes and three levels of nitrogen on growth and yield of kakrol (*Momordica dioica* Roxb.). The seeds of kakrol were collected from three progressive farmers of Venkataramannagudem, Dhoobacherla and Nallajerla villages of West Godavari district. The collected seed under the three samples was utilized for sowing in nursery bed and the seedlings of 30-45 days old are sorted out according to their leaf phenotypes (Penta-lobed, Tri-lobed and Single lobed) and shifted to polybags. The polybags with male and female plants in each phenotype were identified and separated before arranging for planting in the main field as per layout.

The polybags with selected healthy female plants of 60-70 days age in all the three phenotypes were planted in the main field in pits of 1 x 1' size, arranged at 2 x 2 m spacing. Male plants were also grown as bulk at a ratio of 1:10 to ensure enough pollen for females. The field was irrigated immediately after planting.

Experimental Design : The experiment was laid out in

Table-1 : Effect of phenotypes and levels of nitrogen on yield of kakrol (*Momordica dioica* Roxb.).

Phenotypes	Yield Parameters							
	Fruit length (cm)				Number of fruits per plant			
	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean
Vines with Penta lobed leaves (V ₁)	5.14	5.49	5.64	5.42	43.26	49.00	55.97	49.41
Vines with Tri lobed leaves (V ₂)	5.75	5.93	5.94	5.87	51.94	52.15	53.20	52.43
Vines with Single lobed leaves (V ₃)	5.76	5.95	6.10	5.94	69.59	70.03	73.46	69.59
Mean	5.55	5.79	5.89		53.49	57.06	60.88	
	V	N	V x N		V	N	V x N	
CD (P=0.05)	0.28	NS	NS		2.01	2.01	3.40	
SE(m) ±	0.09	0.09	0.16		0.67	0.67	1.16	

Table-1 : Contd.

Phenotypes	Yield Parameters							
	Fruit length (cm)				Number of fruits per plant			
	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean
Vines with Penta lobed leaves (V ₁)	18.00	18.35	18.42	18.26	4.52	4.53	4.62	4.55
Vines with Tri lobed leaves (V ₂)	19.11	19.44	19.46	19.33	5.08	5.13	5.18	5.14
Vines with Single lobed leaves (V ₃)	20.15	20.36	20.43	20.31	5.25	5.32	5.46	5.34
Mean	19.09	19.38	19.44		4.95	4.99	5.08	
	V	N	V x N		V	N	V x N	
CD (P=0.05)	0.17	0.17	NS		0.10	0.10	NS	
SE(m) ±	0.05	0.05	0.10		0.03	0.03	0.05	

two-factor, randomized block design (FRBD) with Factor 1 as phenotypes at 3 levels [Vines with Penta-lobed leaves (V₁), Vines with Tri-lobed leaves (V₂) and Vines with Single-lobed leaves (V₃)] and Factor 2 as Nitrogen with 3 levels [(125 kg N ha⁻¹ (N₁), 250 kg N ha⁻¹ (N₂) and 375 kg N ha⁻¹ (N₃)). Each treatment was replicated thrice.

Data Collection : The four tagged net plot plants in each treatment and replication were utilized for recording observations on different yield characters and mean values were calculated.

Statistical Analysis : The collected data on different yield parameters were statistically analyzed using computer software, programmed by the method of variance, outlined by Panse and Sukhatme (1978). The data was statistically tested for comparison of means at 5% level of significance.

Results and Discussion

Fruit length (cm) : The fruit length (cm) was found significant among the phenotypes. The highest fruit length (5.94 cm) was observed in vines with single lobed leaves (V₃), followed by vines with tri lobed leaves (V₂) with 5.87cm. Lowest fruit length (5.42 cm) was observed in vines with penta lobed leaves (V₁). Similar differences in fruit size in kakrol strains/ cultivars was also reported by

Mishra *et al.* (1989), Hamid *et al.* (1989) and Rasul *et al.* (2004).

Number of fruits per plant : Maximum number of fruits per plant (69.59) was observed in vines with single lobed leaves (V₃) followed by vines with tri lobed leaves (V₂) with 52.43 fruits. The minimum number of fruits per plant (49.41) was observed in vines with penta lobed leaves (V₁). Similar variation in no. of fruits in different strains/cultivars of kakrol was also observed by Mishra *et al.* (1983), Dubey and Gaur (1988), Hamid *et al.* (1989), Maharana *et al.* (1995), Rasul *et al.* (2004) and Anonymous (2000 and 2005).

Maximum number of fruits per plant (60.88) was recorded with the application of 375 kg N ha⁻¹ (N₃) followed by (N₂) 250 kg N ha⁻¹ with 57.06 fruits. Whereas, the minimum number of fruits per plant (53.49) was recorded with the application of 125 kg N ha⁻¹ (N₁). Similar findings was reported by Kiranpatro and Mallareddy (2007) where higher number of fruits/vine (66) was obtained from 240:160:75 kg NPK ha⁻¹. Tripathy *et al.* (1993) and Vishwakarma *et al.* (2007) also found increased number of fruits with increased nitrogen levels in kakrol.

Mean fruit weight (g) : The highest mean fruit weight (20.31g) was observed in vines with single lobed leaves (V₃), followed by vines with tri lobed leaves (V₂) with

Table-1 : Contd.....

Phenotypes	Yield Parameters							
	Fruit length (cm)				Number of fruits per plant			
	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean
Vines with Penta lobed leaves (V ₁)	116.12	136.07	132.08	128.09	3.84	4.47	4.60	4.03
Vines with Tri lobed leaves (V ₂)	123.48	139.00	143.71	135.39	4.52	5.47	5.57	5.19
Vines with Single lobed leaves (V ₃)	130.37	158.07	162.33	150.26	5.95	6.97	7.05	6.66
Mean	123.32	144.38	146.04		4.77	5.63	5.74	
	V	N	V x N		V	N	V x N	
CD (P=0.05)	2.37	2.37	4.11		0.06	0.06	0.11	
SE(m) ±	0.79	0.79	1.37		0.02	0.02	0.03	

Table-1 : Contd.....

Phenotypes	Yield Parameters			
	Estimated fruit yield (q ha ⁻¹)			
	125 kg N (N ₁)	250 kg N (N ₂)	375 kg N (N ₃)	Mean
Vines with Penta lobed leaves (V ₁)	24.50	25.91	27.02	25.81
Vines with Tri lobed leaves (V ₂)	28.21	33.40	34.22	31.91
Vines with Single lobed leaves (V ₃)	37.20	41.90	45.00	41.40
Mean	29.90	33.71	35.40	
	V	N	V x N	
CD (P=0.05)	0.04	0.04	0.08	
SE(m) ±	0.01	0.01	0.02	

19.33g. Lowest mean fruit weight (18.42g) was observed in vines with penta lobed leaves (V₁). Similar variation in fruit weight of different strains/cultivars of kakrol were also reported by Dubey and Gaur (1988), Hamid *et al.* (1989), Maharana *et al.* (1995), Puzari (1999) and Rasul *et al.* (2004) which may be due to increase in fruit length, breadth and seed number and seed weight due to phenotypes.

Highest mean fruit weight (19.44g) was recorded with application of 375 kg N ha⁻¹(N₃) followed by (N₂) 250 kg N ha⁻¹ with 19.38. Whereas, the lowest mean fruit weight (19.09g) was recorded with application of 125 kg N ha⁻¹ (N₁). Increase in fruit weight with increase levels of nitrogen was observed by Arora *et al.* (1989) in kakrol and by Shivashankarmurthy *et al.* (2007), Nek Dara Jan *et al.* (2000) in bottle gourd and Shamima Nasreen *et al.* (2010) in bitter gourd.

Fresh seed weight per fruit (g) : The fresh seed weight per fruit (g) was significant among phenotypes and nitrogen levels. The highest seed weight per fruit (5.34g) was observed in vines with single lobed leaves (V₃), followed by vines with tri lobed leaves (V₂) with 5.14g. Lowest seed weight per fruit (4.55g) was observed in vines with penta lobed leaves (V₁).

Highest fresh seed weight per fruit (5.08g) was recorded with the application of 375 kg N

ha⁻¹(N₃).Whereas, the lowest seed weight per fruit (4.95g) was recorded with the application of 125 kg N ha⁻¹ (N₁). However, the interaction effect of phenotypes and nitrogen was not significant, with regard to fresh seed weight. Similar observations were reported by Puzari (1999) and Rasul *et al.* (2004) in kakrol due to genotypes. The increased weight of seeds due to nitrogen levels could be attributed to better filling of seeds on account of translocation of carbohydrates from source to sink (Sharma, 2001 and Pawar, 1992).

Nitrogen uptake by plant : The nitrogen uptake by plant (kg ha⁻¹) was significant among phenotypes, nitrogen and their interaction levels. The maximum nitrogen uptake (150.26 kg ha⁻¹) was observed in vines with single lobed leaves (V₃), followed by vines with tri lobed leaves (V₂) with 135.39 kg ha⁻¹. Minimum nitrogen uptake (128.09 kg ha⁻¹) was observed in vines with penta lobed leaves (V₁).

Maximum nitrogen uptake by plant (146.04 kg ha⁻¹) was recorded with the application of 375 kg N ha⁻¹(N₃) which was on par with 375 kg N ha⁻¹(N₃) with 144.38 kg ha⁻¹. Whereas, the minimum nitrogen uptake by plant (123.32 kg/ha) was recorded with the application of 125 kg N ha⁻¹ (N₁). Among the interaction levels, the maximum nitrogen uptake by plant (162.33 kg ha⁻¹) was recorded in vines with single lobed leaves with application of 375 kg N ha⁻¹ (V₃N₃). Whereas, the minimum nitrogen uptake by

plant (116.12) was recorded in vines with penta lobed leaves with application of 125 kg N ha⁻¹ (V₁N₁).

Net plot yield (kg) : Maximum net plot yield (6.66 kg) was observed in vines with single lobed leaves (V₃) followed by vines with tri lobed leaves (V₂) with 5.19 kg. The minimum net plot yield (4.03 kg) was observed in vines with penta lobed leaves (V₁). It was reported that kakrol vines with single lobed leaves was found to be prolific and yield better with 90 fruits (1.5 kg/vine) compared with those with penta lobed leaves with 46 fruits giving 0.7 kg/vine. (Anonymous 2003 and 2005)

Maximum net plot yield (5.74 kg) was recorded with the application of 375 kg N ha⁻¹ (N₃) followed by 250 kg N ha⁻¹ (N₂) bearing 5.63 kg fruits. Whereas, the minimum net plot yield (4.77 kg) was recorded with the application of 125 kg N ha⁻¹ (N₁). The maximum yield per net plot by increasing levels of nitrogen was mainly due to cumulative effects of number of primary branches per plant, number of nodes per plant and number of fruits/plant and increased fruit and seed weight. Among the interaction levels, the maximum net plot yield (7.05 kg) was recorded in vines with single lobed leaves with application of 375 kg N ha⁻¹ (V₃N₃). Whereas, the minimum net plot yield (3.84 kg) was recorded in vines with penta lobed leaves with application of 125 kg N ha⁻¹ (V₁N₁).

Estimated fruit yield (q ha⁻¹) : Maximum estimated fruit yield (41.40 q ha⁻¹) was observed in vines with single lobed leaves (V₃) followed by vines with tri lobed leaves (V₂) with 31.91 q ha⁻¹. The minimum estimated fruit yield (25.81 q ha⁻¹) was observed in vines with penta lobed leaves (V₁).

Maximum estimated fruit yield (35.40 q ha⁻¹) was recorded with the application of 375 kg N ha⁻¹ (N₃) followed by (N₂) 250 kg N ha⁻¹ producing 33.71 q ha⁻¹ fruits. Whereas, the minimum estimated fruit yield (29.90 q ha⁻¹) was recorded with the application of 125 kg N ha⁻¹ (N₁). Among the interaction levels, the maximum estimated fruit yield (45.00 q ha⁻¹) was recorded in vines with single lobed leaves with application of 375 kg N ha⁻¹ (V₃N₃). Whereas, the minimum estimated fruit yield (24.50 q ha⁻¹) was recorded in vines with penta lobed leaves with application of 125 kg N ha⁻¹ (V₁N₁).

Conclusion

Results showed that the yield parameters like fruit length, number of fruits per plant, mean fruit weight, net plot yield, fresh seed weight (g) and nitrogen uptake were found superior in vines with single-lobed leaves (V₃) over the other phenotypes. Application of 375 kg N ha⁻¹ (N₃) recorded highest values on yield contributing parameters like number of fruits per plant, mean fruit weight, fresh seed weight and nitrogen uptake by plant. Similarly, the

interaction effect of vines with single lobed leaves with application of 375 kg N ha⁻¹ was significant on yield parameters like number of fruits per plant and nitrogen uptake by the plant.

References

1. Anonymous, 2000. Research High-lights. ANGRAU, Hyderabad. pp:76.
2. Anonymous, 2005. Research High-lights. ANGRAU, Hyderabad. pp:69.
3. Arora, S.K. and Siyag, S. 1989. Effect of nitrogen and phosphorus on fruit yield and quality of sponge gourd (*Luffa cylindrica* L.) cultivar pusa chikni. *Crop Research (Hissar)*. 2(1): 26-29.
4. Baset Mia, M.A, Serajul Islam, Md, Yunus Miah, Md, Das. M.R. and Khan H.I. 2011. Flower synchrony, growth and yield enhancement of small type bitter gourd (*Momordica charantia* L.) through Plant growth regulators and NPK fertilization, *Pakistan Journal of Biological Sciences*. pp: 1-6.
5. Chung, H.Y. and SunJoo C.Y. 1999. Thermophological characteristics and growth of the Korean native bottle gourd (*Lagenaria siceraria* Standl.) plants. *Journal of the Korean Society for Horticultural Science*. 40(3): 306-312.
6. Dubey, A.K. and Gaur, G.S. 1992. Biochemical studies of four strains of Kakrol (*Momordica dioica* Roxb.) *Vegetable Science*. 17(1): 31-37.
7. Hamid, M.M, Sana, M.C, Begum, R.A. and Hussain, S.M.M. 1989. Physio-morphology and yield of different ashgourd (*Benincasa hispida* Cong.). *Bangladesh Journal of Agriculture*. 14(1): 51-55.
8. Hans Raj, Avtar Singh and Baswana, K.S. 2005. Growth and yield of round gourd under various soil moisture regimes and nitrogen levels. *Haryana Journal of Horticultural Sciences*. 34(1/2):176-178.
9. Kiranpatro, T.S.K.K. and Mallareddy, K. 2007. Studies on propagation, production and Post Harvest storage of Kakrol (*Momordica dioica* Roxb.) *PhD. Thesis* 2007. ANGRAU, Hyderabad.
10. Maharana, I, Sahoo P.C. and Tripathy, P. 1995. Floral Biology of *Momordica* species. *Advances in Horticulture and Forestry*. 4: 143-151.
11. Mian, M.A.K, Hossain, M.T, Quadir, M.A. 1989. Propagation of Kakrol (*Momordica dioica* Roxb.) through true seeds. *Annual Research Review*, Gazipur, Bangladesh.
12. Mishra, K.C, Sahu, R.P. and Kishore. 1983. *Indian Horticulture*. 28:(3) 5-8.
13. Pawar, P.B, Desai, U.T and Kale, P.N. 1992. Note on spacing and nutrient requirement of brinjal. *Indian Journal of Horticulture*. 49(1): 75-76.
14. Prasad, P.H, Mandal, A.R, Sarkar, A, Thapa, U. and Maity, T.K. 2009. Effect of biofertilizers and nitrogen on growth and yield attributes of bitter gourd (*Momordica charantia* L.). *International Conference on Horticulture* 2009, pp: 738-739.
15. Premalakshmi, V, Thumbaraj, S, Natarajan, S and Arumugam. 1997. Effect of N and K on growth, flowering,

- yield and quality of gherkin (*Cucumis sativus* L.). *South Indian Horticulture*. 45(5-6): 224-227.
16. Puzari, N.N. 1999. Correlation between fresh weight of fruit and seed content of spine gourd. (*Momordica cochinchinensis* Roxb). *Indian Journal of Hill Farming*. 12(1): 117-118.
 17. Rasul, M.G, Hiramatsu, M, Okubo, H. 2004. Morphological and physiological variations in Kakrol (*Momordica dioica* Roxb.). *Journal of the Faculty of Agriculture*. 49(1): 1-11.
 18. Reddy, P.K. and Rao, P.V. 2004. Growth and yield of bittergourd (*Momordica charantia* L.) as influenced by vermicompost and nitrogen management practices. *Journal of Research ANGRAU*. 32(3): 15-20.
 19. Shamima Nasreen, Ahemed, R. and Nazim Uddin, M. 2010. Requirement of N, P, K, and S application for obtaining higher yield of Bittergourd (*Momordica charantia* L.). *Bangladesh Journal of Agricultural Resources*. 38(2): 355-361.
 20. Shantappa Tirakannanavar, S, Reddy, M, Merwade, B.S, Ravindra Mulge, M. N, Laxman Kukanoor. 2005. Influence of NPK on growth and seed yield in bittergourd (*Momordica charantia* L.). *Journal of Asian Horticulture*. 2(1/2): 40-44.
 21. Shariful Islam, M.D. and Irabangon, J.A. 1994. Influence of different levels of NPK on the growth, fruit and seed yield and quality of bitter gourd (*Momordica charantia* L.). *Central Luzon State University Scientific Journal*. (Jun-Oct 1994), Ref. pp: 36-42.
 22. Sharma, S.K. 2001. Effect of nitrogen and spacing on seed production of Paprika. *Vegetable Science*. 28 (2):175-176.
 23. Shivashankaramurthy, T.C, Nagegowda, V, Basavaiah. and Farooqui, A.A. 2007. Influence of nitrogen, phosphorous and potassium on the yield and quality of gherkin. *Indian Journal of Horticulture*. 64(2): 228-230.
 24. Suresh, J and Pappaiah, M.1991. Growth and yield of bittergourd as influenced by nitrogen, phosphorous and malic hydrazide. *South Indian Horticulture*, 39(5): 289-291.
 25. Tripathy, P, Maharana, T, Nandi, A, Dora, D.K. 1993. Effects of cutting, node number and fertilizer on spine gourd (*Momordica dioica* Roxb.) *Indian Journal of Agricultural Sciences* 6397: 432-43.
 26. Uwah, D.F. and Solomon, M.G. 1998. Effects of nitrogen and phosphorus on yield and yield component of watermelon (*Citrullus lanatus* thunb. Mansf.). *Journal of Applied Chemistry and Agricultural Research*. Vol. 5: pp: 48-53.
 27. Vishwakarma, S.K, Gautam, D.S, Yadav, N.S, Gautam, S.S. 2007. Effect of different levels of nitrogen and phosphorus on growth, yield and quality of spine gourd (*Momordica dioica* Roxb.) *Technofame - A Journal of Multidisciplinary Advance Research*, pp:120-123



Documentation and Validation of Indigenous Technical Knowledge of Dairy Farming in Gwalior Division of M.P.

Reena Rawat, O.P. Daipuria, Prashant Sharma, Prabhakar Sharma and Mona Raghuvanshi

Department of Agricultural Extension and Communication, College of Agriculture, RVSKVV, Gwalior (M.P.)

Abstract

Documentation is any transmittable material that is utilized to depict, clarify or teach with respect to certain ascribes of an article, framework or system. Gwalior division stands third rank in milk production and seventh rank in livestock population among all the division of Madhya Pradesh. Since their wide gap between both production and livestock population, hence were in order to achieve the above mentioned objectives Gwalior division was purposively selected for the present study. If documentations have less than 2.50 mean score that means less effective while, 2.50 to 3.50 mean score that means moderately effective and above 3.50 mean score that means highly effective for the precautions and treatment of the animals.

Key words : Documentation, validation, ITKs, dairy farming

Introduction

The word 'indigenous' signifies "local conceived or starting or delivered normally in a nation or in a predefined region" and the word 'knowledge' signifies "guaranteed conviction, down to earth expertise, that which is known, learning, and edification". Indigenous knowledge: local and indigenous knowledge alludes to the understandings, aptitudes and ways of thinking created by social orders with long accounts of cooperation with their common environmental factors. For rustic and indigenous people groups, local information illuminates dynamic about crucial parts of everyday life. This knowledge is essential to a social complex that likewise incorporates language, frameworks of arrangement, asset use rehearses, social communications, custom and otherworldliness. These extraordinary methods of knowing are significant features of the world's social assorted variety/ cultural diversity and give an establishment to locally-suitable manageable shot of events. Indigenous knowledge is, comprehensively, the information utilized by nearby individuals to get by in a specific domain. After crawling over all of the above information, it was felt there was a need for documenting and validating ITK of dairy farming. Thus, the study "Documentation and Validation of Indigenous Technical Knowledge (ITKs) of dairy farming in Gwalior division (M.P.)." was deliberate and undertaken with the subsequent specific objective : Documentation and validation of indigenous Technical Knowledge (ITKs) in the aspect of breeding and feeding of dairy animals.

Research Methodology

Madhya Pradesh comprises of 52 districts of which 5 districts are in the Gwalior division. Gwalior division stands third rank in milk production and seventh rank in livestock

population among all the division of Madhya Pradesh. Since their wide gap between both production and livestock population, hence were in order to achieve the above mentioned objectives Gwalior division was purposively selected for the present study.

Multistage sampling was employed for constructing sampling plan of the study.

Among the five districts of Gwalior division Shivpuri, Gwalior and Guna districts were selected. These districts stand first, second and third position in milk production. Among the districts of Gwalior division respectively the milk production in Shivpuri, Gwalior and Guna were 496.14, 399.75 and 277.74 thousand tonnes, respectively. This clearly indicates the important of dairy farming in the area.

S. No.	Districts	Block	Number of dairy farmers	Number of selected dairy farmers
1.	Shivpuri	Pichor	966	61
		Pohri	829	53
		Nerwar	718	—
		Knaniyadana	672	—
		Karera	662	—
		Baderwas	656	—
		Shivpuri	643	—
		Kolaras	574	37
2.	Gwalior	Ghatigaon	858	55
		Morar	711	45
		Bhitarwar	391	—
		Dabra	390	25
3.	Guna	Guna	155	10
		Raghogarh	136	9
		Aron	101	—
		Chachaura	98	—
		Bamori	79	5
		Total number of selected dairy farmers	4,698	300

Table-1 : Determination of the validation of ITKs.

S. No.	Category	Mean score
1.	Less effective	< 2.50
2.	Moderately effective	2.50-3.50
3.	Highly effective	> 3.50

Among the three selected districts of Gwalior division their and eight, four and five blocks in Shivpuri, Gwalior and Guna, respectively. A separate list of blocks of each selected districts were prepared and with the help of officials of respective districts, three blocks (two blocks having highest dairy farmer and one block having lowest dairy farmer) was identify for the selection of blocks.

In the last stage of sampling process the block wise list of dairy farmers was prepared for each selected

blocks. Overall 300 dairy farmers were selected as respondents with the help of simple random sampling without replacement under proportional scheme.

Documentation, validation and rational behind the use of ITKs : Documentation is any transmittable material that is utilized to depict, clarify or teach with respect to certain ascribes of an article, framework or system, for example, its parts, establishment, gathering, upkeep and use. Documentation can be given on the web, paper, or on simple or advanced media, for example, CDs or sound tape. Paper or hard-copy documentation has become less common. The main aim of such documentation is to confirm that information is not lost and to protect communities by showing that such information is prior art.

Table-2 : Documentation of the validation of ITKs.

S. No.	Documentation	Validation						
		SA	A	N	DA	SDA	TVS	MS
(A) Breeding : 1. To induce heat								
1	Around 250 gm. Jaggery and 150 gm. ghee were mixed in wheat flour and then chapatti of this mixture was feed to animal once a day to induce heat in animal.	30	25	12	8	5	307	3.837
2	Prajana H.S. 3 herbal capsules per cow/ buffalo with Jaggery or grains should be again after 24 hours.	21	40	9	7	3	309	3.862
3	After boiling fenugreek seeds (250 gm.) + jaggery (500 gm.) in two liters of water, 250 gm. mustard oil is added and given in the evening constantly for 4 days.	22	26	14	10	8	284	3.55
2. Removal of placenta								
4	50-60 gram of replanta powder should be given to cow / buffalo. Double dose should be given immediately after calving and continue to be fed every 6 hours till the animal puts the placenta. Even after 2 to 3 days, it should be given to increase fertility.	22	29	14	11	4	294	3.675
5	4 kg cotton seeds, kulthi beans and kabulichanas are soaked in water thoroughly and kept for 24 hours and then fed to a milch animal.	12	34	14	14	6	272	3.4
6	500 gram of paddy (including the rind) is given after calving. It is automatically pushes out the placenta.	5	8	18	25	24	185	2.312
7	500 gm. of fenugreek seeds and 100 gm. of sugar is feed.it expulses placenta.	10	15	20	19	16	224	2.8
(B) Feeding								
1	1 Kg. Berseem (Trifolium alexandrinum), 500 gram maize (Zea mays), 500 gram bajra (Pennisetum glaucum) and 50 ml sesame oil (Sesamum indicum) was fed to animal one time a day.	25	40	10	3	2	323	4.037
2	Mustard cake (250-500 gram) is drenched overnight and the animals are fed with gram powder in the morning.	41	26	9	3	1	343	4.287
3	50 gram soybean (Glycine max), wheat (Triticum aestivum) and cowpea (Vigna unguiculata) are appropriately mixed and given to animals with the normal concentrated feeds or as a solution after boiling these ingredients in water.	25	32	10	7	6	303	3.787
4	4 kg cotton seeds, 2 kg kulthi and 2 kg bengal gram are soaked, crushed and given to the animals.	29	32	10	5	4	317	3.962
5	Leaves of Khajur (Phoenix dactylofora) were fed to animals.	5	6	18	21	30	175	2.18
6	Ber leaves (Ziziphus mauritiana) were boiled and fed to animal once a day to increase milk production.	4	8	21	24	23	186	2.325

SA= strongly agree, A= Agree, N= neither, DA= Disagree, SDA= strongly disagree, TVS= Total Validity Score, MS= Mean Score

Results and Discussion

Determination of the validation of ITKs : Table-1 inspected that the determination of the validation of all documentation. In this aspect, if documentations have less than 2.50 mean score that means less effective while, 2.50 to 3.50 mean score that means moderately effective and above 3.50 mean score that means highly effective for the precautions and treatment of the animals.

Documentation and validation of ITKs (N=80) : They were documented by asking the dairy farmers about the indigenous treatment of animals that are coming from their ancestors and Questionnaires were sent to the researchers working in the following institutions: veterinary hospitals, veterinary dispensaries, veterinary department, agriculture office, Dairy farm officers and KVKs etc. were validated, which are shown in Table-2.

Conclusion

Knowledge disseminating system and scientists were making frequent contract with the dairy farmers and rural youth for promoting indigenous technical knowledge practices. The main aim of such documentation is to

confirm that information is not lost and to protect communities by showing that such information is prior art.

References

1. Bhanotra, A., and Gupta J., 2016. Mapping of Indigenous technical knowledge (ITK) on animal healthcare and validation of ITKs used for treatment of pneumonia in dairy animal. *Indian Journal of Traditional Knowledge*, 15(2): 297-303.
2. Bhuyan, M. 2016. Perceived effectiveness of Indigenous technical knowledge in dairying. *Journal of Extension Education*, 28(3): 5703-5708.
3. Dudiaishwarya and Meena M.L. 2017. Ethno-veterinary treatment of buffalo in arid region of Rajasthan. *Buffalo Bulletin*, 36(2): 281-295.
4. Pradhan K., Zigme Y., Avishek S., and Vara C. Prashad 2017. "Identification and documentation of indigenous technological knowledge(S) regarding pest control methods in agriculture. *International Journal of Agriculture Sciences*, 38(9): 4580-4584
5. Raikumar C. 2019. Adoption and perceived effectiveness of indigenous technical knowledge among tribal farmers for bovies management: an exploratory study. *International journal of livestock research*, 9(02): 243-253.



Suitable Ingredients for Preparation of Chats Supplemented with Jackfruit-Seed Paste

Akkamahadevi D. Agasimani¹, Roopa S. Patil², Annapurna Neeralgi² and Shivashenkaramurthy M.²

¹ICAR-Krishi Vigyan Kendra, Dharwad, University of Agricultural Sciences, Dharwad, Karnataka

²ICAR-Krishi Vigyan Kendra, Uttara Kannada, Sirsi, University of Agricultural Sciences, Dharwad, Karnataka

Email : adagasimani@gmail.com

Abstract

Jackfruit is grown in an area of 271 ha in Uttara Kannada district. Every year huge quantity of jackfruit produce wasted because of its perishable nature and seasonal glut. To reduce the post harvest losses of nutritive fruit and seed, a study was conducted in ICAR-KVK, Uttara Kannada to develop different chat items with the jackfruit seed paste supplemented with different ingredients at home. The seed paste prepared after pressure cooking for 15 mins and removing seed coats. This paste mixed with different combinations of flours like rice, roasted bengalgram, maida, suji (samolina) etc. in different ratios to prepare chats like chakli and mixture (Sev). After analysis, the best ratio for preparing chats was 1:1:1 jackfruit seed paste, rice flour and roasted Bengal gram powder respectively. Chats prepared by this ratio found most acceptable in terms of organoleptic studies done during trainings, method demonstrations and Jackfruit Melas at Sirsi.

Key words : Jackfruit seed, organoleptic, chakli, value addition

Introduction

Among various fruits which are wasted abundantly, jackfruit (*Artocarpus heterophyllus* Lam.) a member of the family Moraceae is one leading fruit of them. Mondal *et al.*, (2013) reported that the fruit is perishable in nature due to presence of high amount of moisture and cannot be stored for long time because of its inherent compositional and textural characteristics. A considerable amount of jackfruit, specially obtained in the glut season (June-July) in every year goes waste due to lack of proper post harvest knowledge during harvesting, transporting and storing both in quality and quantity. Jackfruit is a heavy and bulky fruit and hence transportation is not very easy and is costly as well. Due to presence of strong aroma sometime it is not preferred by consumer. Proper post harvest technology for prolonging shelf life is therefore necessary. Besides alternate ways of using jackfruits in on-season play significant roles in reducing post harvest losses. Among them, processing is an important one. Reduced post-harvest losses, increased shelf-life and preserved fruit for the out of season period can improve the use of fruits through processing. Raw materials transformed into edible products can increase food security and add variety to the diet, improving nutrition and health. Creation of employment opportunities in production areas is an added bonus. The jackfruit seeds are high protein, fibre and carbohydrate contents (Ocloo *et al.*, 2010). The seeds are also marketed in canned as in boiled form like the beans, in brine and in tomato sauce (Morton, 1987). Jackfruit seed contains lignans, isoflavones, saponins, all phytonutrients and their health benefits are wide-ranging from anticancer to

antihypertensive, antiaging, antioxidant, antiulcer, and so on (Omale and Friday 2010). Seeds contain two lectins namely jacalin and artocarpin. Jacalin has been proved to be useful for the evaluation of the immune status of patients infected with human immunodeficiency virus 1 (Haq, 2006).

Materials and Methods

The experimental study was carried out in ICAR-Krishi Vigyan Kendra Uttara kannada, Sirsi Karnataka (India)

Raw Materials : Rice flour, jackfruit seed paste, roasted Bengal gram flour, salt, jeera, ajwain, coriander seeds, sesame, chilli powder, butter and oil were purchased from local market of Sirsi.

Preparation of jackfruit seed paste : The jackfruit seeds were cleaned and put in pressure cooker along with water. After pressure cooking for 15-20 minutes, seeds were allowed to cool down and then seed coats were removed manually. These seeds were made into paste in grinder with little water.

Ingredients required for Chakli /mixture preparation :

Rice flour-1 bowl

Roasted Bengal gram flour-1 bowl

Jackfruit seed paste-1 bowl

Chilli powder-1 table spoon

Sesame- ½ table spoon

Ajwain- ½ table spoon

Jeera and coriander seed powder-½ table spoon

Table-1 : Formulation of Chakli a spicy chat supplemented with Jackfruit seed paste at different ratios with Rice flour and Roasted bengalgram flour.

Treat-ments	Rice flour	Roasted bengalgram flour	Jackfruit seed paste
T ₀	1(1cup)	1(1cup)	0
T ₁	1(1cup)	1(1cup)	0.25 (1/4 cup)
T ₂	1(1cup)	1(1cup)	0.50 (1/2 cup)
T ₃	1(1cup)	1(1cup)	0.75 (3/4 cup)
T ₄	1(1cup)	1(1cup)	1 (1 cup)
T ₅	1(1cup)	1(1cup)	1.25 (1 and 1/4 cup)
T ₆	1(1cup)	1(1cup)	1.50 (1 and 1/2 cup)
T ₇	1(1cup)	1(1cup)	1.75 (1 and 3/4 cup)

Table-2 : Organoleptic characteristics on effect of incorporation of Jackfruit seed paste at different ratio in chakli/Mixture (Sev).

Treatments	Taste	Color	Flavor	Appearance	Texture	Overall Acceptability
T ₀	7.9	7.8	8	8	7.6	7.86
T ₁	7.2	7.4	7.2	7.1	6.9	7.16
T ₂	7.3	7.5	7.4	7.6	7	7.36
T ₃	7.4	7.6	7.7	7.7	7.1	7.5
T ₄	7.8	7.9	7.9	8.1	7.8	7.89
T ₅	7	7.4	6.9	7.1	6.8	7.04
T ₆	7	7.1	6.8	7	6.9	6.96
T ₇	6.8	6.9	6.8	7.1	6.8	6.88
F-test	NS	NS	S	S	NS	S
CD	-	-	1.00	0.85	-	0.79

Salt - According to taste

Butter - ¼ table spoon

Oil – 250ml for deep fry

The above ingredients were dry mixed thoroughly (except oil) and then half cup of hot water was added to the mix. The ingredients were kneaded with water (little quantity of water used so that dough is hard) into dough. The dough was put into chakli maker and pressed to make chaklis. These chaklis were deep fried until it gets light brown colour. Same dough was used to make mixture (Sev), a different form of spicy chat.

Sensory Evaluation : The deep fried chakli were kept for organoleptic evaluation. The ingredients and method for preparation of chaklis and mixture (Sev) were evaluated by KVK staff, students of forestry college, Post harvest students of Horticulture college, Sirsi and people came for State Level Jackfruit Mela held at Sirsi on 14.06.2014. The organoleptic characters viz., colour and appearance, texture, taste and overall acceptability of chaklis as well as Mixture (Sev), were evaluated on nine point hedonic scale. Where 9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5= neither like or dislike, 4=dislike slightly, 3= dislike moderately, 2=dislike very much

and 1=dislike extremely as described by Ndife *et al.* (2011).

Statistical Analysis : Data obtained from sensory analysis were subjected in terms of average scores for different attributes and analyzed statistically by one-way analysis of variance (ANOVA) and analysis is carried out by using Microsoft Excel.

Results and Discussion

Table-2 : Organoleptic characteristics on effect of incorporation of Jackfruit seed paste at different ratio in chakli/Mixture (Sev).

Taste : Treatment T₀ recorded the highest value of 7.9 for

taste followed by T₄ (7.8), T₃ (7.4), T₂ (7.3), T₁ (7.2), T₅ (7.0), T₆ (7.0) and T₇ (6.8) which were significantly not different from each other. However, the statistical test revealed that, there was no impact of substitution of jack seed paste upto 35per cent at 5 per cent level of significance.

Color : The color of treatment 4 (T₄) chakli recorded the high of 8.0 for its very good color. T₆ and T₇ treatment chakli scored the lower values (7.1 and 6.9, respectively) with dull look. However, the statistical test revealed that, there were no impact of substitution of jack seed paste upto 35 per cent and all the proportions of chaklis are not significant with each other at 5 per cent level of significance.

Appearance : There is significant difference among the treatments with varying ratios of ingredients used in making chakli. The calculated value of F is greater than the tabulated value of F at 5% probability level. Treatment T₄ recorded the highest value of 8.1 for appearance followed by T₀ (8.0), T₃ (7.7), T₂ (7.6), T₁, T₅ and T₇ (7.1) and T₆ (7.0) and which were significantly different from each other.

Texture : According to the texture scores of chakli with the ratio of 1:1:1 rice flour, Roasted Bengal gram, Jackfruit

seed paste respectively recorded highest score i.e. 7.8 and least was observed in ratio of 1:1:1.25 and 1:1:1.75. The statistical test revealed that, there no significant difference among the treatments with each other at 5 per cent level of significance.

Overall Acceptability : The data illustrated in the table-2 shows the average sensory scores for different parameters in control and treated sample of jackfruit seed paste chakli, clearly indicates that treatments T4 (7.89) had the highest score followed by T0 (7.86), T1 (7.16), T2 (7.36), T3 (7.5), T5 (7.04), T6 (6.96) and T7 (6.88). The calculated value of F is greater than the tabulated value of F at 5% probability level. Therefore, it can be concluded that there was significant difference between treatments regarding the overall acceptability of jackfruit seed paste chakli.

Conclusion

The study indicated that, jackfruit seed paste supplementation with rice flour and roasted Bengal gram flour has a great potential in developing chat products like chakli, Mixture (Sev) etc. in spite of affecting sensory qualities. The flavour, appearance and overall acceptability increased as the ratio of jack seed paste increased from 0.25 to 1 where as it decreased when the ratio was increased. The best ratio for preparing spicy chats was 1:1:1 jackfruit seed paste, rice flour and roasted Bengal gram powder, respectively which resulted in overall acceptability in terms of organoleptic parameters

and it can be concluded that, it is feasible to produce nutritionally value added chats from jackfruit seed paste supplementation.

References

1. Haq N., 2006. Jackfruit (*Artocarpus heterophyllus*). Southampton Centre for Under utilized Crops, University of Southampton. Southampton, UK.
2. Mondal C., Remme R.N., Mamun A.A., Sultana S., Ali M.H., Mannan M.A., 2013. Product Development from Jackfruit (*Artocarpus heterophyllus*) and Analysis of Nutritional Quality of the Processed Products-IOSR . *J. Agriculture and Veterinary Science* (IOSRJAVS) -ISSN: 2319-2380, 4
3. Morton J., 1987. Jackfruit (*Artocarpus heterophyllus*). In: Fruits of warm climates. Julia, F., Morton, Miami, F.L p. 58 – 64.
4. Ndife, J., Abdulraheem, L.O. and Zakari U.M., 2011. Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. *African Journal of Food Science* Vol. 5(8), pp. 466 – 472.
5. Ocloo, F.C.K., Bans, D., Boatın, R., Adom, T. and Agbemavor, W.S. , 2010. Physico-chemical, functional and pasting characteristics of flour produced from Jackfruits (*Artocarpus heterophyllus*) seeds. *Agric. Biol. J. N. Am.*, 1(5): 903-908.
6. Omale J. and Friday E., 2010. Phytochemical composition, bioactivity and wound healing potential of Euphorbia Heterophylla (Euphorbiaceae) leaf extract. *International Journal of Pharmaceutical and Biomedical Research* 1(1) 54–63.



Study on Rooting Ability of *Pseuderanthemum carruthersii* var. *reticulatum* (Seem.) Guillaumin under the Influence of Rooting Hormone

A.D. Ashok

Institute of Agriculture, Tamil Nadu Agricultural University, Kumulur- 621712, Trichy

Email : adashok2013@gmail.com

Abstract

The experiment was laid out in Completely Randomized Block Design (CRD) with six treatments replicating 3 times. Treatments viz., Indole Acetic Acid (IAA) 250 ppm, 500 ppm, 1000 ppm, 2000 ppm, 3000 ppm and control (without any treatment). The aim is to find the effect of IAA on rooting of cuttings in *Pseuderanthemum carruthersii* var. *reticulatum* (Seem.) Guillaumin. Minimum days for sprouting (7.12 days), number of roots per cutting (14.23) and root length (9.79 cm) are recorded maximum IAA 3000 ppm. All the IAA treatments are on par with each other and significantly higher than control in survival percentage. From this experiment we conclude that, the rooting and survival capacity of terminal stem cuttings of golden pseuderanthemum under mist chamber conditions, can be improved by quick dipping of basal portion of cuttings on IAA with 3000 ppm concentration.

Key words : IAA, golden pseuderanthemum, root hormone, quick dip method, terminal cutting

Introduction

Golden Pseuderanthemum, scientifically *Pseuderanthemum carruthersii* var. *reticulatum* (Seem.) Guillaumin of Acanthaceae family, is an important colourful ornamental foliage shrub, native to South-Eastern Africa, grows well under wide range of climate all over the world. This plant is used landscaping as shrubbery border, potted plant, for home gardening etc. It is valued mainly for its attractive golden yellow foliage with variegation and easy maintenance in garden. Rapid multiplication using stem cuttings are followed commercially in eranthemum. Horace and James (1987) reported that best method of propagation for *Pseuderanthemum carruthersii* is cutting and Randhawa and Mukhapadhaya (2000) said that *Erathemum* spp. are propagated by cutting, whereas Bose *et al.* (2008) clearly reported that *Erathemum* spp. can successfully propagated by tip cutting.

Among the vegetative propagation methods, stem cutting is the easiest and cost effective method of multiplication mainly for ornamental shrubs. The rooting ability and success percentage of cuttings depends on many factors. Among them, plant growth regulators play an important role in formation of roots and shoot growth in cuttings. Root commencement with the exogenous application of plant growth regulators occupies a significant role in the field of plant propagation (Mukherjee *et al.*, 1976). With this, current study was aimed to find the effect of IAA on rooting of cuttings in *Pseuderanthemum carruthersii* var. *reticulatum*.

Materials and Methods

The experiment was conducted at Institute of Agriculture,

Tamil Nadu Agricultural University, Kumulur, Tiruchirappalli district of Tamilnadu, India. The experiment was laid out in Completely Randomized Block Design (CRD) with 3 replications, including six treatments of various concentration of Indole Acetic Acid (IAA) solutions viz., 250 ppm, 500 ppm, 1000 ppm, 2000 ppm, 3000 ppm and control (without any treatment). Terminal stem cuttings were collected from healthy mother plants, available in the institute. Terminal cuttings of 20 cm length with minimum 3-4 nodes were taken. A slant cut was given at the basal end and a transverse cut at the top of each cutting. The basal end (2.5- 3.0 cm) of the cuttings was dipped for 30 seconds with IAA solutions of fixed treatment. Then, the treated cuttings were planted vertically in sterilized inert sand media under mist chamber condition to promote rooting. All cuttings were maintained under mist chamber and watered regularly. Relative humidity in the mist chamber was maintained at = 85 % and temperature at 30±2°C. Further observations were recorded at 30 days after planting (DAP) on various root parameters such as days taken for sprouting, rooting percentage (%), number of rooted per cutting and root length (cm). Survival percentage (%) of the rooted cutting was recorded at 60 DAP. The inference was drawn after comparing the calculated F values with the tabulated F values at 5% (P= 0.05) level of significance. The estimates of mean, variance and standard error were done as per Panse and Sukhatme (1978).

Results and Discussion

On analysing the parameters taken for observation in this experiment, all shows significance among the treatment, which are shown in table-1. Minimum days for sprouting

Table-1 : Effect of different concentrations of IAA on rooting of *Pseuderanthemum carruthersii* var. *reticulatum*.

Concentrations	Days for sprouting	Rooting percentage (%)	Number of roots per cutting	Root length (cm)	Survival percentage (%)
IAA 250 ppm	14.20	71.70	5.13	3.10	82.50
IAA 500 ppm	13.50	75.70	5.97	3.50	88.30
IAA 1000 ppm	11.50	79.90	8.76	6.55	91.50
IAA 2000 ppm	9.40	91.70	11.33	7.87	99.00
IAA 3000 ppm	7.12	95.60	14.23	9.79	99.00
Control	15.50	55.33	4.76	2.90	75.50
Mean	11.87	78.32	8.36	5.62	89.30
SE.d	1.22	7.94	0.91	0.62	8.97
CD @ 0.05	2.58	16.76	1.9	1.31	18.93

was recorded in the 3000 ppm (7.12 days), followed by 2000 ppm (9.40 days) which are on par with each other. On comparing with control, all the treatments have significant effect in early sprouting. It assures that the treatment of cuttings with IAA induce rooting of cutting much faster than untreated one. On examining after 30 DAP, higher rooting percentage was recorded in 3000 ppm (95.60%), followed by 2000 ppm (91.70%) and 1000 ppm (79.90%) which are on par with each other. Number of roots per cutting (14.23) and root length (9.79 cm) are recorded maximum in 3000 ppm IAA. Our findings are in line with experimental reports of Hossain and Urbi (2016) [6] on adventitious rooting of shoot cuttings in *Andrographis paniculata*. They stated that higher concentration of Auxin resulted in an increased number of adventitious rooting per cutting. Similar reports were given by Raji and Osman (2012) [7] and Dash *et al.*, (2011) [8] as that the higher dosages of auxins induced increased number of roots within a short time.

Shenoy, 1992 [9] in *Rosa damascena* reported that the increase in root length over control may be due to the enhanced hydrolysis of carbohydrates, metabolites accumulation and cell division induced by Auxin. These results were in line with the findings of Patil *et al.*, 1998 [10] in *Jasminum sambac* (Jasmine), Singh *et al.*, 2010 [11] in *Bougainvillea glabra* (bougainvillea), Grewal *et al.*, 2005 [12] in *Dendranthema grandiflora* cv. Snowball, Singh *et al.*, 2013 [13] in *Cestrum nocturnum* (night jasmine) and Sharma, 2014 [14] in *Tagetes erecta* (marigold), though the type of stem cutting utilized were varied. All this findings are in line with the results of IAA 1000, 2000, 3000 ppm by Chowdhuri and Sadhukhan (2017) [15] on *Eranthemum bicolor*.

On observing survival percentage after 60 DAP, all the IAA concentrations shows higher survival, significantly higher than control. The survival capability of the rooted cutting in a inert sand media might be due to the action of plant growth hormones on the stem cuttings and the growth of sprouted roots. This was supported by the statement Abidin and Baker (1984) [16] that plant growth

hormones also have effects on cell elongation and cell division thereby boosting root length, thus enhancing overall growth of cuttings; which improves the survival capacity of the rooted cutting.

In all parameters such as days for sprouting (15.50 days), rooting percentage (55.33 %), number of roots per cutting (4.76), root length (2.90 cm), and survival percentage (75.50%), control recorded the minimum value among the treatments. The production of roots in the control group may be caused by endogenous auxin, which might influence and play important role for root primordia formation in the cuttings (Hossain and Urbi, 2016) [6].

Conclusion

From this experiment we conclude that, the rooting and survival capacity of terminal stem cuttings of Golden *Pseuderanthemum* under mist chamber conditions, can be improved by quick dipping of basal portion of cuttings on IAA with 3000 ppm concentration. Further study may be conducted to find out and standardize the maximum concentration of IAA, below toxic level, to be used to get maximum effect of rooting and root promotion in Golden *Pseuderanthemum*.

References

1. Horace Clay F, James Hubbard C. 1987. Propagation of *Pseuderanthemum carruthersii* var. *atropurpureum*, The Hawaii Garden-Tropical Shrubs, Pub: The University Press of Hawaii, 238.
2. Randhawa GS, Mukhapadhaya A. 2000. Ornamental and Flowering shrubs, Floriculture in India, Pub: Allied Publishers Ltd. Chapter-VIII, 144.
3. Bose TK, Chowdhury B, Sharma SP. 2008. Shrubs, Tropical garden Plants in Colour. Pub: Horticulture and Allied Publishers, Koltata, 117.
4. Mukherjee TP, Roy T, Bose TK. 1976. Standardization of propagation from cuttings under mist, II. Effect of rooting media on root formation in cutting of ornamental plants. *Journal Punjab Hort.*, 16: 153-156.
5. Panse VG, Sukhatme PV. 1978. Statistical methods for

- agricultural workers. 3rd Ed. New Delhi: *Indian Council of Agricultural Research*.
6. Hossain MS, Urbi Z. 2016. Effect of naphthalene acetic acid on the adventitious rooting in shoot cuttings of *Andrographis paniculata* (Burm.f.) Wall. ex Nees: an important therapeutical herb. *International Journal of Agronomy*.
 7. Raji AA, Osman M. 2012. Effects of stem cutting types, position and hormonal factors on rooting in *Stevia rebaudiana* Bertoni. *Journal of Agricultural Science*, 4(1): 49–57.
 8. Dash GK, Senapati SK, Rout GR. 2011 Effect of auxins on adventitious root development from nodal cuttings of *Saraca asoka* (Roxb.) de Wilde and associated biochemical changes. *Journal of Horticulture and Forestry*, 3(10): 320–326.
 9. Shenoy R. 1992 Influence of planting material and growth regulators on the rooting of stem cuttings in *Rosa damascena* Mill, M.Sc., (Hort.) Thesis submitted to the University of Agricultural Sciences, Bangalore.
 10. Patil B, Kanamadi VC. 1998. Effect of growth regulators on the rooting of hardwood cuttings in jasmine. *Advances in Forestry Research in India*, 19: 225-229.
 11. Singh N, Singh BP, Singh HK. 2010. Effect of different concentrations of Indole Butyric Acid (IAA) on rooting potential and root growth of Bougainvillea stem cuttings. *Journal of Ornamental Horticulture*, 13(1): 41-44.
 12. Grewal HS, Kumar R, Chauhan R. 2005. Effect of IAA and NAA on rooting in chrysanthemum (*Dendranthema grandiflora* Tzevlev) terminal cuttings. *Journal of Ornamental Horticulture*, 8(3): 230-232.
 13. Singh KK, Rawat V, Rawat JMS, Tomar YK, Kumar P. 2013. Effect of IAA and NAA concentrations on rooting in stem cuttings of Night queen (*Cestrum nocturnum* L) under sub-tropical valley conditions. *Hort Flora Research Spectrum*, 2(1): 81-83.
 14. Sharma R. 2014. Study on the effect of Auxins on rooting, growth and flowering of African marigold (*Tagetes erecta* L.) propagated through stem cuttings, M.Sc., (Hort.) thesis. I.G.K.V., Raipur.
 15. Chowdhuri TK, Sadhukhan R. 2017. Performance evaluation of different growth regulators on propagation of Eranthemum (*Eranthemum bicolor* and *Eranthemum tricolor*). *Journal of Pharmacognosy and Phytochemistry*, 6(6): 1848-1852.
 16. Abidin M. 1984. Baker A. Effect of growth substances on rooting of cocoa cuttings. *Acta Horticulturae*, 137: 95–102.



Physico-Chemical Properties of Green Peas (*Pisum sativum* L.)

A.K. Senapati^{1*}, A.K. Varshney², V.K. Shrama³, S. Patel⁴, M. Varma⁴, P.R. Pandey⁵

¹Centre of Excellence on Post Harvest Tech., Navsari Agricultural University, Navsari, Gujarat

²Processing and Food Engineering, College of Agril. Engg. and Tech., JAU, Junagadh, Gujarat

³Department of Agricultural Engineering, College of Agriculture, NAU, Waghai, Gujarat

⁴College of Agricultural Engineering and Technology, Navsari Agricultural University, Dediapada, Gujarat

⁵Department of Agricultural Engineering, N.M. College of Agriculture, NAU, Navsari, Gujarat

*Email : ashoksenapati.iitkgp@gmail.com

Abstract

The physico-chemical properties of green peas (*Pisum sativum* L) was conducted which included two pre treatments (un-blanching and blanching). Matured fresh green peas were procured from APMC market, Navsari and deshelled manually to prepare samples. Green peas were blanched at 85°C for 1 min and cooled in running water before drying. The quality characteristics of unblanched and blanched fresh green peas in terms of physical parameters such as bulk density (kg/m³), particle density (kg/m³), porosity (%), coefficient of friction and chemical parameters such as average initial moisture content (% w.b.), protein (g/100g) and enzymatic browning i.e. optical density were studied. The average bulk density, particle density, porosity, coefficient of friction, average moisture content and protein of green peas were 661.6 kg/m³, 1010.9 kg/m³, 34.6 %, 0.341, 77.01% (w.b.) and 5.926 g/100 g, respectively. Significantly lower enzymatic browning was found for blanched fresh green peas i.e. 0.05 (U/g).

Key words : Green peas, physical properties, chemical properties.

Introduction

Pea (*Pisum sativum* L.) is one of the most important and popular leguminous vegetable crops grown throughout the world and it ranks top ten among the vegetable crops and belongs to Fabaceae family. In India, pea is grown in winter as well as summer seasons and each pea pod is having several seed of green or yellow colour. The area and production of green peas in India is about 5, 46,000 ha and 5.45 million tonnes, respectively (NHB, 2017). The major Pea producing states are Uttar Pradesh, Punjab, Himachal Pradesh, Odisha, Karnataka and Haryana, etc. The medicinal action of green peas are antioxidant and anti-inflammatory, blood sugar regulation and heart health promotion and the medicinal uses are heart disease, diabetes, stomach cancer and ulcers, etc. (Nutrition, 2015). Physical and chemical parameters is an important attributes of green peas seed and it is used in grading, sorting and determination of seed surface area which correlate the machine design parameters for different agricultural process operations such as handling, harvesting, threshing, cleaning, conveying, sorting, drying etc. Pre-treatment i.e. blanching prevents the loss of colour by inactivating enzymes, relaxing tissue structure with better quality yields of a finished product. Green peas are blanched in hot water at 85°C for 1 min and then immediately placed under running cold water for at least 3 min and removed the surface moisture (Doymaz and Kocayigit, 2011).

Materials and methods

Sample Preparation : Fresh green peas were procured from the APMC market, Navsari District, Gujarat. The green peas pods were thoroughly washed to remove the dirt adhering to pods. Damaged and diseased pods were sorted out. After the sorting of pods, shelling was done manually by hands and seeds were graded according to their size. Then green peas seeds were blanched at 85°C for 1 min (for blanching treatment only) and cooled in running water and removed the surface moisture.

Bulk Density (kg/m³) : Bulk density of green pea was calculated by placing the sample of green pea in a measuring cylinder which has 5.2 cm of diameter and 26.7 cm of length. The sample was taken out from the cylinder and was weighed using an electronic balance having least count of 1g (Mohsenin, 1986). The bulk density was () determined by the following equation given below :

$$\text{Bulk density (} \rho_b \text{)} = \frac{\text{weight of green peas (kg)}}{\text{volume of flask occupied by the green peas (m}^3\text{)}} \dots (1)$$

Particle density (kg/m³) : Particle density of 100 g green peas was determined using the toluene (C₇H₈) displacement method. 250 mL toluene was used in place of water, because it is not absorbed by peas. The volume of toluene displaced was found by immersing pea of known mass in the toluene. The particle density (ρ_p) were determined by the following equation given below (Mohsenin, 1986).

Table-1 : Bulk density, particle density and porosity of un-blanchd as well as blanchd fresh Green peas.

Treatment	Bulk density (kg/m ³)			Particle density (kg/m ³)			Porosity (%)		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
P1	671	654	662.1	1015	1001	1011	33.9	34.7	34.5
P2	670.8	653.9	661.3	1014	1001	1010.8	33.8	34.7	34.6
Mean			661.6			1010.9			34.6
S.Em. ±			1.47			1.73			0.002
CD at 5%			NS			NS			NS
CV %			0.833			0.592			2.761

P1 (Un-blanchd) and P2 (Blanchd)

$$\text{Particle density (kg/m}^3\text{)} = \frac{\text{weight of green peas (kg)}}{\text{volume of the green peas (m}^3\text{)}} \quad \dots(2)$$

Porosity (%) : Porosity () is defined as the percentage of void space in the bulk grain which is not occupied by the grain. The porosity (%) of green peas () was calculated using the following relationship (Mohsenin, 1986).

$$\text{Porosity ()} = 1 - \frac{\text{Bulk density (kg / m}^3\text{)}}{\text{Particle density (kg / m}^3\text{)}} \times 100 \quad \dots(3)$$

Coefficient of Friction : The coefficient of friction between granular materials is equal to the angle of internal friction for the material. The frictional coefficient depends on the shape, surface characteristics and moisture content of green pea. For this measurement, the material was placed on the surface, and then gradually raised by the screw and tangent value of the angle of friction was taken as coefficient of friction. The coefficient of friction was found by the formula given below (Mohsenin, 1986).

$$\mu_s = \tan \alpha \quad \dots(4)$$

Where, μ_s = Coefficient of friction and α = Angle of friction.

Moisture content (%w.b.) : Moisture content of fresh as well as dried green peas was determined in accordance with standard procedures in a hot air oven (AOAC, 1990). For each treatments, three samples of chopped green peas each weighing 50 g was measured on an electronic weighing balance and taken as fresh weight. The samples were then kept in an oven at a temperature of 70°C for 24 hours until the dried weight was constant during two successive weighing made at an interval of nearly one hour. The weight of dried sample was then measured. The moisture content was calculated on wet basis :

$$\text{Moisture Content (\% wb)} = \frac{(\text{fresh weight} - \text{dry weight})}{\text{fresh weight}} \times 100 \quad \dots(3.11)$$

Enzymatic Browning (OD) (U/g) : The Enzymatic Browning i.e. the activity of polyphenol oxidase (PPO) value in green peas was determined by the spectro photometric method proposed by Esterbaner *et al.* (1977).

The activity of PPO was calculated using the following formula:

$$\text{Enzyme units in the sample} = K \times (A/\text{min}) \quad \dots (3.9)$$

Where,

$$K \text{ for catechol oxidase} = 0.272$$

Estimation of Protein (g/100 g) : The protein content was estimated using Lowry's method as described by Sadasivam and Manickam (1996). The amount of protein was expressed in g/100g.

Statistical analysis of green peas sample : The experimental data were analyzed by factorial completely randomized design (CRD) according to procedure described by Gomez and Gomez (1984). The treatment differences were tested by 'F' test of significance of the basis of null hypothesis. The appropriate standard errors (S.Em.±) were calculated in each case and the critical differences (C.D.) at 5 per cent level of probability were worked out to compare two treatment means wherever the treatment effects were significant.

Results and Discussion

This chapter embodies the results of the investigation on Physico-chemical properties of green peas (*Pisum sativum* L.). The physico-chemical parameters for blanchd as well as un-blanchd fresh green peas samples such as bulk density (kg/m³), particle density (kg/m³), porosity, coefficient of friction, average moisture content (% wb), protein (g/100g) and enzymatic browning(OD) were evaluated. The results along with statistical inference obtained were presented and discussed below :

Bulk density (kg/m³) : The data of bulk density of un-blanchd and blanchd fresh green peas are presented in Table 1. The bulk density of un-blanchd green peas was 662.05 kg/m³ with a minimum value of 654 kg/m³ and maximum value of 671 kg/m³ whereas the bulk density of blanchd green peas was 661.28 kg/m³ with a minimum value of 653.9 kg/m³ and maximum value of 670.8 kg/m³. It was evident from data that there is no

significant difference between the shrinkage ratio of blanched and un-blanched green peas. Blanching has no effect on bulk density of fresh green peas. Similar results on bulk density were reported by Dutta *et al.* (1988); Deshpande *et al.* (1993) for soybeans; Gupta and Das (1997) for sunflower seed; Senadeera *et al.* (1999) for peas; Amin *et al.* (2004) for lentil seeds and Khanbarad *et al.* (2014) for pigeon pea.

Particle density (kg/m^3) : The data of particle density of un-blanched and blanched fresh green peas are presented in Table 1. The mean particle density of un-blanched green peas was 1011.08 kg/m^3 with a minimum value of 1001 kg/m^3 and maximum value of 1015 kg/m^3 whereas the mean particle density of blanched green peas was 1010.75 kg/m^3 with a minimum value of 1001.2 kg/m^3 and maximum value of 1014 kg/m^3 . It was evident from data that there is no significant difference between the particle density of blanched and un-blanched green peas. Blanching has no effect on particle density of fresh green peas. Similar results on particle density were reported by Senadeera *et al.* (1999) for green peas; Khanbarad *et al.* (2014) for pigeon pea; Ganjloo *et al.* (2018) for green peas; Sonboier *et al.* (2018) for green peas (cv. Arkel) and Pandey *et al.* (2019) for green peas.

Porosity (%) : The data porosity of un-blanched and blanched fresh green peas is presented in Table-1. The mean porosity of un-blanched green peas was 0.338 % with a minimum value of 0.321 % and maximum value of 0.345 % whereas the mean porosity of blanched green peas was 0.336 % with a minimum value of 0.321 % and maximum value of 0.344 %. It was evident from data that there is no significant difference between the porosity of blanched and un-blanched green peas. Blanching has no effect on porosity of fresh green peas. Similar results on porosity were reported by Khanbarad *et al.* (2014) for pigeon pea; Singh and Chandra (2014) for kidney bean; Elton *et al.* (2017) for physical properties of safflower and Ganjloo *et al.*, (2018) for physical properties of green peas.

Coefficient of friction (μ) : The data of coefficient of friction of un-blanched and blanched fresh green peas are presented in Table 2. The mean coefficient of friction of un-blanched green peas was 0.341 with a minimum value of 0.332 and maximum value of 0.345 whereas for blanched green peas it was 0.340 with a minimum value of 0.328 and maximum value of 0.346. It was evident from data that there is no significant difference between the coefficient of blanched and un-blanched green peas. Blanching has no effect on coefficient of friction of fresh green peas. This property is the key element for calculation of compressibility and flow behaviour of

materials used for designing storage structures. Similar data on coefficient of friction were reported by Athmaselvi *et al.* (2013) for papaya; Ganjloo *et al.* (2018) for green peas and Sonboier *et al.* (2018) for green peas (cv. Arkel).

Table-2 : Co-efficient of friction of un-blanched as well as blanched fresh Green peas.

Treatment	Co efficient of friction(μ)		
	Max	Min	Mean
P1	0.345	0.332	0.34
P2	0.346	0.328	0.340
Mean			0.34
S.Em. $\pm$			0.001
CD at 5%			NS
CV %			1.304

P1 (Un-blanched) and P2 (Blanched)

Average Moisture content (% wb) : The data of average initial moisture content (% wb) of un-blanched and blanched fresh green peas are presented in Table 3. The average initial moisture content (% wb) of un-blanched green peas was 77.01 % (wb) with a minimum value of 77.05 % (wb) and maximum value of 76.98 % (wb) whereas for blanched green peas it was 77.02 % (wb) with a minimum value of 76.98 % (wb) and maximum value of 77.06 % (wb). It was evident from data that there is no significant difference between the average initial moisture content (% wb) of blanched and un-blanched green peas. Blanching has no effect on average moisture content of fresh green peas. Similar results on average moisture content (% wb) were reported by Attri *et al.* (2016) for green peas; Ganjloo *et al.* (2018) for green peas; Sonboier *et al.* (2018) for green peas (cv. Arkel), and Pandey *et al.* (2019) for green peas

Protein (g/100g) : The data pertaining to protein (g/100g) of un-blanched and blanched fresh green peas are presented in Table 3. The mean protein content of un-blanched green peas was 5.93 g/100g with a minimum value of 5.91 g/100 g and maximum value of 5.95 g/100g whereas for blanched green peas it was 5.93 g/100 g with a minimum value of 5.91 g/100 g and maximum value of 5.94 g/100 g. It was evident from data that there is no significant difference between the protein content of blanched and un-blanched green peas. Blanching has no significant effect on protein (g/100g) of fresh green peas. Similar results on protein (g/100g) were reported by by Savage and Deo, (1989); Black *et al.* (1998) for peas, for green pea and Manzoor *et al.* (2019) for the fresh green beans.

Enzymatic browning (U/g) : The data pertaining to enzymatic browning of un-blanched and blanched fresh green peas are presented in Table 3. The mean enzymatic browning of un-blanched green peas was 0.012 (U/g) with a minimum value of 0.011 (U/g) and maximum value of

Table-3 : Average initial moisture content, protein and enzymatic browning of unblanched as well as blanched fresh Green peas.

Treatment	Average initial moisture content (% wb)			Protein (g/ 100 g)			Enzymatic browning (U/g)		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
P1	77.05	76.98	77.01	5.95	5.91	5.93	0.013	0.012	0.012
P2	77.06	76.98	77.02	5.94	5.91	5.93	0.005	0.004	0.005
Mean			77.01			5.93			0.008
S.Em. $\pm$			0.007			0.003			0.001
CD at 5%			NS			NS			0.003
CV %			0.032			0.189			4.98

P1 (Un-blanched) and P2 (Blanched)

0.013(U/g) whereas for blanched green peas it was 0.05 (U/g) with a minimum value of 0.04 (U/g) and maximum value of 0.05 (U/g). It was evident from data that the enzymatic browning of blanched green peas was found significant as compared to un-blanched green peas. Blanching has significant effect on enzymatic browning of fresh green peas sample. The peroxidase activity decreases as blanching is applied in the fresh green peas sample. Similar results were reported by Lin and Brewer (2005) for microwave blanching prior to freezing for frozen peas. The blanching has significant effect as the enzyme activity of polyphenol oxidase (PPO) as reported by Fante and Noreña (2012) for Garlic and Jia *et al.* (2012) for quality evaluation of sour cherry juice.

Conclusion

The physico chemical attributes of green peas seed is used in grading, sorting and which correlate the machine design parameters for different agricultural process operations such as handling, harvesting, threshing, cleaning, conveying, drying etc. From above study it could be concluded that the average bulk density, particle density, porosity, coefficient of friction, average moisture content, protein and enzymatic browning of green peas were 661.6 kg/m³, 1010.9 kg/m³, 34.6 %, 0.341, 77.01% (w.b.) and 5.926 g/100 g and 0.05 (U/g) respectively.

Acknowledgement

The research was carried out as part of a Ph.D. thesis of the first author. The researchers are grateful to Navsari Agricultural University, Navsari, Gujarat for allowing them to conduct the above research study.

References

- Anonymous. (2017). National Horticultural Board (NHB), Gurgaon.
- AOAC (1990). Official methods of Analysis. Association of Official Analytical Chemist, Washington, DC, USA.
- Amin, M.N.; Hossain, M.A. and Roy, K.C. (2004). Effects of moisture content on some physical properties of lentil grains. *Journal of Food Engineering*, 65: 83-87.
- Athmaselvi, K.A., Jenney P., Pavithra C. and Roy I. (2013). Physical and biochemical properties of selected tropical fruits. *Int. Agrophys.*, 28: 383-388.
- Attri, S.; Dhiman, A.K.; Kumar, R. and Sharma, R. (2016). Effect of pre-drying treatments on the retention of quality characteristics of green peas (*Pisum sativum* L.) cv. Lincoln during mechanical drying. *Journal of Applied and Natural Science*, 8(2):1049-1052.
- Black, R.G.; Brovwer, J.B.; Meares, C. and Lyer, L. (1998). Variation in physicochemical properties of field peas (*Pisum Sativum*). *Fd.Res. Int.* 31 (2): 81-86.
- Deshpande, S.D.; Bal, S. and Ojha, T.P. (1993). Physical properties of soybean. *Journal of Agricultural Engineering Research*. 56: 89-98.
- Doymaz and Kocayigit (2011). Drying and rehydration behaviour of convection drying of green peas. *Drying Technol.* 29: 1273-1282.
- Dutta, S.K.; Nema, V.K. and Bhardwaj, R. K. (1988). Physical properties of gram. *Journal of Agricultural Engineering Research*. 39: 259-268.
- Elton, A.S Martins ; André, L.D. Goneli; Cesar P. Hartmann Filho; Munir Mauad; Valdiney, C. Siqueira and Alexandre, A. Gonçalves (2017). Physical properties of safflower grains. Part I: Geometric and gravimetric characteristics. *Revista Brasileira de Engenharia Agrícola e Ambiental*. Vol.-21(5):344-349.
- Fante, L. and Noreña, C.P.Z. (2012). Enzyme inactivation kinetics and colour changes in Garlic (*Allium sativum* L.) blanched under different conditions. *Journal of Food Engineering*. 108: 436–443.
- Ganjloo, A.; Bimakr, M.; Zarringhalami, S.; Jalili Safaryan, M. and Ghorbani, M. (2018). Moisture- dependent physical properties of green peas (*Pisum sativum* L.), *International Food Research Journal*. 25(3): 1246-1252.
- Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*, 2nd Edition, Publish by John Wiley and Sons, New York, p. : 84 – 91.
- Gupta, R.K. and Das, S.K. (1997). Physical properties of sunflower seeds. *Journal of Agricultural Engineering Research*. 66:1-8.
- Jia, G.A.O.; Baogang, W.A.N.G.; Xiaoyuan, F. E. N. G. and Yongqing, Z.H.U. (2012). Effect of Blanching on Quality of Sour Cherry (*Prunus cerasus* L. C.V. CAB) Juice,

- Am-Euras. *Journal of Agricultural and Environmental Sciences*. 12(1): 123-127.
16. Khanbarad, S.C.; Joshi, N.D.; Mohapatra, D.; Sutar, R.F. and Joshi, D.C. (2014). Effect of moisture content on some selected physical properties of pigeon pea (*Cajanus cajan*), *Journal of Grain Processing and Storage*. 1(1): 6-12.
 17. Manzoor, N.; Dar, A.H.; Khan, S.; Hakeem, H.R. and Makroo, H.A. (2019). Effect of Blanching and Drying Temperatures on Various Physico-chemical Characteristics of Green Beans. *Asian Journal of Dairy and Food Research*. 38(3): 213-223.
 18. Mohsenin, N.N. (1986). Physical Properties of Plant and Animal Materials. 2nd ed. New York: Gordon and Breach Science Publishers.
 19. Nutrition Facts (2015) : Peas. Nutrition. vegonline. org. Retrieved February 28.
 20. Pandey, O.P.; Mishra, B.K. and Misra, A. (2019). Comparative study of green peas using with blanching & without blanching techniques. *Information Processing in Agriculture*. 6(2): 285-296.
 21. Sadasivam, S. and Manickam, A. (1996). Biochemical Methods. (2nd edn.), New Age International Publishers, New Delhi, India, p: 1-256.
 22. Savage, G.P. and Deo, S. (1989). The nutritional value of peas (*Pisum sativum*): A literature review. *Nutrition Abstracts and Reviews (series A)*. 59 : 66-83.
 23. Senadeera, W.; Bhandari, B.R., Young, G. and Wijesinghe, B. (1999). Change in physical properties of green peas during fluidised bed drying. In Abdullah, K., Tambunan, A.H. and Mujumdar, A.S., Eds. *Proceedings First Asian-Australian Drying Conference (ADC'99)*, Bali, Indonesia. p. 164 - 172.
 24. Singh, Y. and Chandra, S. (2014). Evaluation of physical properties of kidney beans (*Phaseolus vulgaris*). *Food Science Research Journal*. 5: 125-129.
 25. Sonboier K.K.; Mahilang, K.K.S.; Minj, P.; Porte, P. and Taran, T. (2018). Some Physical Properties of Green Pea. *Int. J. Pure App. Biosci*. 6 (1): 573-579.



Farmers' Coping Mechanism for Mitigating Adverse Effect of Flood-A Study in Flood Affected Districts of Assam

A. Rahman^{1*}, S. Barman² and P. Saikia³

¹Regional Agricultural Research Station, Titabar, Assam Agricultural University, Jorhat

²Department of Extension Education, Faculty of Agriculture, Assam Agricultural University, Jorhat

³Department of Extension Education, Faculty of Agriculture, Assam Agricultural University, Jorhat

*Email : rahmanafsana1111@gmail.com

Abstract

Recurring flood is a major challenge in the Flood Prone Areas of Assam. Annually 39.58% area and around 33,27,968 population are affected by flood. The present study was conducted in Jorhat and Majuli district of Assam to assess coping mechanism adopted by farmers for mitigating adverse flood effect in the flood affected areas. All total 160 farmers were selected randomly as respondents from eight purposively selected villages of Jorhat and Majuli district of Assam where flood occurred regularly for last ten years. "Floor elevation of dwelling house", "making elevated grain storages" are found to be adopted by people at a higher rate (98.13% and 95.63% respectively) as infrastructural coping mechanism to avoid damages of household articles and seed and planting materials. Practice of mixed cropping with season specific cereals, pulses oilseeds and vegetables for avoiding total loss and satisfying household food security was another coping mechanism adopted by majority of farmers (91.88%). "Cultivation of *baor* rice in low land", "cultivation of traditional tall *salor* rice variety with low inputs but cultivation *rabi* crops with high input" were technological coping mechanism adopted by majority farmers possessing low land for compensate the loss due to flood damage. In medium land of flood affected areas, cultivation of submergence tolerance varieties, "raising of seedlings with fellow farmers in nearby flood free areas with sharing basis" for ensuring quality seedling after flood were followed as coping mechanism by more than 80% farmers. Documentation of location specific flood coping mechanisms of farmer can be replicated in other similar regions and also help the policy makers to develop more appropriate flood adaptation policies for the state.

Key words : Farmer's perception, flood coping mechanism.

Introduction

Recurring flood is a major challenge in the Flood Prone Areas of Assam. Annually 39.58% area and around 19,92,727 population are affected by flood (Economic Survey of Assam, Transformation and Development Department, Government of Assam, 2017-18). Brahmaputra Valley of Assam is one of the most flood-prone valleys in India. Every year, floods, flash floods, riverbank erosion, and sand deposition on fields demolish the landscape. However, flash floods have become more destructive since the mid 1990s, especially on the northern bank of the Brahmaputra Valley (District Agricultural Development Strategy, Agricultural Technology Management Agency, 2006 Report). With time the flood situation got worse and created serious hurdles for the people to survive. Flash flood and erratic submergence regimes are the major limitations in increasing the productivity of rice cultivated in rainfed situation in Assam (S.K.Chetia, T. Ahmed *et al*) These are the most recurrent water- induced vulnerabilities affecting these areas of Assam. All of these hazards have affected the farming society living in the flood prone areas of Assam. Both flood and flash flood leave people homeless

and displaced, destroy their crops, damage public property, and damage development infrastructure, located in the northeastern region of India in the eastern Himalayas, almost every year (S.K. Chetia, T. Ahmed) Flood pose an increased threat in Assam especially in 'agriculture sector'. Flood has affected the farming community which caused migration, unemployment, food insecurity, poverty. Native communities living by these riverbanks have developed conventional coping mechanisms in their dwellings, agriculture, livestock-rearing practices, and food storage. They have ways of foresightedness of floods and the weather, which have enabled them to cope and adapt with various adaptation and mitigation measures perceived at local levels in order to alleviate human suffering. Hence, the main objectives of the study was to document location specific flood coping mechanisms of farmer via a case study investigation conducted in a flood prone region which can be replicated in other similar regions and also help the policy makers to develop more appropriate flood adaptation policies for the state.

Materials and Methods

The study was conducted in Upper Brahmaputra valley

Table-1 : Socio economic profile of the respondents.
(n=160)

Variables	Frequency	Percentage
Age		
22-40	30	18.75
41-59	97	60.63
60-77	33	20.63
Educational Status		
Illiterate	16	10.00
Primary school level	51	31.90
Middle school level	59	36.90
High school level	23	14.40
Higher secondary level	6	3.80
Graduate and above	5	3.10
Family size		
Small size (<4 members)	12	7.50
Medium size (4-6 members)	132	82.50
Large size (> 6 members)	16	10.00
Operational land holding		
Marginal	56	35.00
Small	85	53.13
Medium	19	11.88
Cropping pattern		
Paddy	11	6.88
Paddy + pulses	24	15.00
Paddy + vegetables	29	18.13
Paddy + oilseeds	21	13.13
Paddy + pulses + vegetables	34	21.25
Paddy + pulses + oilseeds	41	25.63
Farming experience		
Low (5-12 years)	27	16.88
Medium (13-32 years)	100	62.50
High (33-49 years)	33	20.63
Annual income		
Low (0.31-0.47 lakh)	27	16.88
Medium (0.48-1 lakh)	109	68.13
High (1.01-1.48 lakh)	24	15.00
Livestock and bird reared		
Small (4-8 number)	19	11.88
Medium (9-12 number)	129	80.63
Large (13-15 number)	12	7.50
Employment Status		
Low	45	28.13
Medium	95	59.38
High	20	12.50
Source of employment		
Only farming	72	45.00
Farming + skill labour activities	47	29.38
Farming + small business	24	15.00
Farming + daily wage earner	11	6.88
Farming + skill labour activities + small business	5	3.13
Farming + skill labour activities + small business + daily wage earner	1	0.63

zone of Assam. Two districts namely Jorhat and Majuli were selected purposively by considering the flood affected areas and numbers of farmers. Four villages from each two districts, thus a total of 160 farmers were selected from eight villages by proportionate cum random sampling technique. Selected respondents were interviewed personally with the help of specially structured schedule. Socio-economic characteristics of the respondents were studied as independent variables. To assess farmer's flood coping mechanisms an open ended questionnaire was prepared to identify the coping mechanisms. After collecting coping mechanisms those were properly worded, categorized and ranked them based on the frequency of respondents.

Results and Discussion

Socio economic profile and employment status of the respondents : It is evident from table1 that majority of the respondents(60.63%) belong to age range 41-59 years while 20.63 percent of the respondents were in the age range of 60-77 years. The education level of most of the farmers was ranging from primary to middle school level and only 3.10% farmers had education of graduate and above level. Family size of 4-6 members was found for around 82.50% farmers and only 7.50% farmers had less than 4 members in their family. Majority of the farmers were small (53.13%) and marginal farmers (35.00%) and they mostly follow "paddy + pulses + oilseed" type of cropping pattern. Majority (62.50%) of the respondents had farming experience for about 13-32 years and rear livestock and birds number of medium size (80.63%). As regard to annual income majority of the respondents (68.13%) belongs to income range 0.48- 1lakh.

It was observed from the data presented in Table 1 that 59.38 per cent respondents had medium level of employment status, followed by 28.13 percent of respondents having low level of employment status. Only 12.50 percent of respondents had high level employment status. It also reveals that majority (45.00%) of the respondents followed "only farming" as their source of employment, followed by "Farming + skill labour activities" (29.38%), "Farming + small business" (15.00%), "Farming + daily wage earner" (6.88%). Very few respondent were involved in "Farming + skill labour activities + small business" (3.13%) and "farming + skill labour activities + small business + daily wage earner" (0.63%).

Farmer's coping mechanism to mitigate the adverse effect of flood : Various flood coping mechanisms adopted by farmers are shown in Table-2. "Floor elevation of dwelling house", "making elevated grain storages" are found to be adopted by people at a higher rate (91.25% and 95.63% respectively) as infrastructural coping

Table-2 : Distribution of respondents according to their various coping mechanisms adopted to mitigate the adverse effect of flood. N=160

Coping mechanism	Rationale for use	Frequency of farmers adopted
Construction of floor elevated dwelling house at about 1.2-1.5m from the ground.	It keeps the moisture away from the household items, so that they remain at a good condition	146 (91.25)
Digging furrows or drains across the cultivation fields during dry season	Excess water in the fields gets an easy way of passage	102 (63.75)
Construction of floor elevated storages for storing of food.	It keeps the moisture away from the food grains stored inside the gain storages even in flood.	153 (95.63)
Storage of harvested paddy without threshing in elevated storage house	The loss due to storage pest attack is minimum and grains are remained dry.	135 (84.35)
Regular renovation of dwelling and storage houses before onset of summer season.	It helps the house structure to withstand the flood waves	99 (61.88)
Seasonal migration of family members for engagement in non farming activities specifically lean period	Non-farm income provide financial support during the time of flood	109 (68.13)
Collected money in advance from marketing agents against their produce which will be sold in next year. (Informal contact farming)	It helps them to meet their short term household demands and basic amenities during flood.	96 (60.00)
Preserving fruits and vegetables either in dry or wet form for meeting need during flood.	It controls their expenditure according to their needs and fulfil the requirement of fruits and vegetables during floods.	135 (84.38)
Using flood tolerant crop varieties as well as late transplanted traditional varieties	It can withstand the submerged condition in the field with minimum crop loss	129 (80.63)
Mixed crops cultivation in home stead areas	To fulfil household food and nutritional requirement even in the period of flood.	148 (92.50)
Raising the seedlings in sharing basis	Farmer's having flood free areas allow other farmers to raise their seedlings in times of need	116 (72.50)
Cultivation of bao paddy	Being a tall variety, bao paddy can withstand in the flood condition	119 (74.38)
Natural fishing during flood	Dried fishes for selling purpose and thus fishing became an income generating activities.	100 (62.50)
Keeping drains and ditches clean around the household	No Water stagnation or water logging	109 (68.13)
Shifting of livestock to high land area before onset of rainy season.	Reduce the chance of diseases during flood	148 (92.50)
Cow-dung is burnt in open fireplaces.	The fumes of cow dung keep the mosquitoes away	39 (24.38)
Drying of meat through smoking	No fungal growth during food preservation	50 (31.25)

mechanism to avoid damages of household articles and seed and planting materials. Practice of mixed cropping with season specific cereals, pulses oilseeds and vegetables for avoiding total loss and satisfying household food security was another coping mechanism adopted by majority of farmers (92.50%). "Cultivation of bao rice in low land" (74.38%), "cultivation of traditional tall *sali* rice variety with low inputs but cultivation *rabi* crops with high input" were technological coping mechanism adopted by majority farmers possessing low land for compensate the loss due to flood damage. In medium land of flood affected areas," cultivation of submergence tolerance varieties", "raising of seedlings with fellow farmers in nearby flood free areas with sharing basis" for ensuring quality seedling after flood were followed as coping mechanism by more than 72.50% of farmers. 84.38% of farmers spent less

money on household requirements during the time of flood & 92.50% of the farmers prefer to shift their livestock to higher grounds for safety measures. About 31.25 % of the farmers prefer food preservation specially items like meat to keep fungal growth at bay. Documentation of location specific flood coping mechanisms of farmer can be replicated in other similar regions and also help the policy makers to develop more appropriate flood adaptation policies for the state.

Conclusion

Flood threatened the agrarian economy of Assam and caused considerable social and economic impacts on farming communities. Research system should developed more location specific technologies and blend the indigenous coping strategies with scientific knowledge

which may be more cost effective as well as environment friendly. Hence for developing mitigation strategy the emphasis must be laid upon socio-psychological empowerment to farmers through motivational, attitudinal and infrastructural supporting order to develop the capabilities for better and community-centric adaptive mechanism.

Acknowledgements

Authors are grateful to farmers of the study area for providing necessary cooperation and support to conduct the study.

References

1. Anonymous (2006). District Agricultural Development Strategy, Agricultural Technology Management Agency, Jorhat.
2. Anonymous (2010). Assam State Disaster Management Policy 2010, ASDMA, Govt of Assam.
3. Anonymous (2017-18). Economic Survey of Assam, Transformation and Development Department, Government of Assam.
4. Barman, S. Pathak, K. and Pathak, P.K. (2013). Training need of Tribal farmers in Rapeseed production technology of Upper Brahmaputra Valley Zone of Assam. *J. Acad. Indus. Res.*, 1(11): 686-688.
5. Dabbadi, A. and Singh, B.K (2012). Farmers Vulnerability to Flood and Adapted Mitigation Strategy : A Critical Analysis. *Indian. J. Ext. Edu.*, 12(2) : 101-106.
6. Chetia, S.K., Ahmed. T., Singh. R., Feroze. S.M. (2015). Impact of floods on rice based farming in Assam: A Gender Study. *Journal of Eco-friendly Agriculture* 10(1): 43-46.
7. Sing, R. and Singh, U. (2001). Socio economic profile of migrant rural labourers. *Indian. J. Ext. Edu.*, 37(3 & 4) : 159-163.
8. Udmale, P., Ichikawa, Y., Manandhar, S., Ishidiara, H. and Kiem, A. (2014). Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction.*, 10: 250–269.



Influence of Lime and Organic Manures on Yield Performance of Baby Corn (*Zea mays* L.) under Rainfed Condition

Abdul Rahman Munib and K. Pathak*

Department of Agronomy, Assam Agricultural University, Jorhat, Assam

*Corresponding Author Email : dr.kalyanaau@yahoo.co.in

Abstract

A field experiment was conducted at the Assam Agricultural University, Jorhat during the *summer* season of 2018 to study the effect of lime and manures on growth of baby corn under rainfed condition. The treatment consisted of seven different sources of nutrients viz., Control, Enriched compost (EC) @ 2.5 t/ha, FYM @ 2.5 t/ha, Lime (50% LR) + FYM @ 2.5 t/ha + ash (2.5 kg/ha), Lime (50% LR) + EC @ 2.5 t/ha + ash (2.5 kg/ha), EC @ 2.5 t/ha + Lime (25kg/ha) + ash (2.5 kg/ha) mixture at sowing and 30 days after sowing (DAS) and FYM @ 2.5 t/ha + Lime (25kg/ha) + ash (2.5 kg/ha) mixture at sowing and 30 DAS. The experiment was laid out in RBD with four replications and soil of the experimental field was medium in available nitrogen, potassium and low in available P_2O_5 with pH value of 5.2 and O.C. value of 0.62%. G-5414 was used as the test variety of baby corn. Among the treatments, application of enriched compost (2.5 t ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS has shown the significantly better results with respect to yield attributing characters (viz., length of the cob (with and without husk), number of cobs plant⁻¹ weight of the cob (with and without husk) and finally the highest cob yield (42.88 q ha⁻¹) followed by FYM (2.5 t ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS (36.63 q ha⁻¹).

Key words : Baby corn, organic, lime, enriched compost, yield, green fodder yield.

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat (Murdia *et al.*, 2016). Besides, its use as feed and fodder, maize is of several uses viz., maize flour or meal and corn oil are one of the best cooking oil. It is rich in unsaturated fatty acids. Considering the diversification and value addition of maize as well as the growth of food processing industries, a recent development is of growing maize for the vegetable purpose, which is commonly known as baby corn. Baby corn is the small (6-7 cm long), young, unfertilized corn ear harvested at the stage of silk emergence (*i.e.* within 2 - 3 days of silk emergence). Development of production technology, particularly appropriate nutrient management strategy for baby corn particularly in acid soils is necessary for realizing higher yield and economic returns (Naveen and Saikia, 2020). Under such circumstances, the present investigation was taken up to evaluate the effect of lime and manures in baby corn under rain-fed condition.

Research Methodology

A field was carried out in the Instructional-cum- Research (ICR) Farm, Assam Agricultural University, Jorhat during the summer season of 2019 to evaluate the effect of lime and manures in baby corn under rain-fed condition. The treatment consisted of seven different sources of nutrients viz., T₁: Control, T₂: Enriched compost, EC (2.5 t ha⁻¹), T₃: FYM (2.5 t ha⁻¹), T₄: Lime (50% LR) + FYM (2.5 t ha⁻¹) +

ash (2.5 kg ha⁻¹), T₅: Lime (50% LR) + EC (2.5 t ha⁻¹) + ash (2.5 kg ha⁻¹), T₆: EC (2.5 t ha⁻¹) + Lime (25kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 days after sowing (DAS) and T₇: FYM (2.5 t ha⁻¹) + Lime (25kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS. The experiment was laid out in a randomized block design (RBD) with four replications. The soil of the experimental site was sandy loam in texture, medium in available N (285.36 kg ha⁻¹), P_2O_5 (22.85 kg ha⁻¹) and K₂O (138.04 kg ha⁻¹) and organic carbon (0.62%) with pH value of 5.2. The baby corn variety "G-5414" was used. Sowing of seeds was done manually at a spacing of 45 cm x 20 cm on 20th March 2019 and harvesting by picking was started on 30th May 2019 and completed on 17th June 2019. The rainfall received during the crop season was only 680 mm. The weekly average maximum temperature ranged from 24.9 to 32.9°C and minimum temperature 16.0°C to 26.1°C, respectively.

Table-1 : NPK content of organic manures used.

Treatments	Nutrient content		
	N (%)	P (%)	K (%)
Enriched compost	2.30	2.10	2.20
FYM	0.65	0.32	0.84
Ash	13.8	3.4	48

Results and Discussion

In most of the yield attributing characters, viz., length of the cob (with and without husk), number of cobs plant⁻¹ weight of the cob (with and without husk) application of EC (2.5 t

Table-2 : Effect of lime and manures on yield attributing characters of baby corn.

Treatment	No. of cobs per plant	Length of cob (cm)		Weight of individual cob (g)	
		With husk	Without husk	With husk	Without husk
T ₁ : Control	1.85	18.29	9.12	36.06	13.67
T ₂ : Enriched compost (2.5 t ha ⁻¹)	2.25	19.76	10.37	41.01	16.75
T ₃ : FYM (2.5 t ha ⁻¹)	2.20	19.59	9.86	38.75	16.05
T ₄ : Lime (50% LR) + FYM (2.5 t ha ⁻¹) + ash (2.5 kg ha ⁻¹)	2.30	19.78	10.39	42.66	17.58
T ₅ : Lime (50% LR) + EC (2.5 t ha ⁻¹) + ash (2.5 kg/ha)	2.35	20.08	10.42	45.01	18.58
T ₆ : EC (2.5 t ha ⁻¹) + lime (25 kg ha ⁻¹) + ash (2.5 kg ha ⁻¹) mixture at sowing and 30 DAS	3.10	24.38	12.29	56.35	24.08
T ₇ : FYM (2.5 t ha ⁻¹) + lime (25 kg ha ⁻¹) + ash (2.5 kg ha ⁻¹) mixture at sowing and 30 DAS	2.75	22.37	11.25	52.74	20.97
SEm (+)	0.11	0.39	0.24	0.86	0.80
CD (5 %)	0.32	1.16	0.73	2.55	2.37

Table-3 : Effect of lime and manures on cob yield with husk (q ha⁻¹), cob yield without husk (q ha⁻¹) and green fodder yield (t ha⁻¹) of baby corn.

Treatment	Cob yield with husk (q ha ⁻¹)	Cob yield without husk (q ha ⁻¹)	Green fodder yield (t ha ⁻¹)
T ₁ : Control	21.40	3.02	12.30
T ₂ : Enriched compost (2.5 t ha ⁻¹)	31.00	4.38	14.91
T ₃ : FYM (2.5 t ha ⁻¹)	27.63	3.93	13.93
T ₄ : Lime (50% LR) + FYM (2.5 t ha ⁻¹) + ash (2.5 kg ha ⁻¹)	31.18	4.40	16.35
T ₅ : Lime (50% LR) + EC (2.5 t ha ⁻¹) + ash (2.5 kg ha ⁻¹)	32.45	4.37	17.95
T ₆ : EC (2.5 t ha ⁻¹) + lime (25 kg ha ⁻¹) + ash (2.5 kg ha ⁻¹) mixture at sowing and 30 DAS	42.88	6.63	24.62
T ₇ : FYM (2.5 t ha ⁻¹) + lime (25 kg ha ⁻¹) + ash (2.5 kg ha ⁻¹) mixture at sowing and 30 DAS	36.63	5.25	20.29
pdefaultSEm (+)	1.30	0.29	0.49
CD (5%)	3.88	0.87	1.46

ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS (T₆) exhibited significantly the highest values (Table-2.). This might be due to the subsequent release of nitrogen after application of manures under this treatment. The length of the baby corn cob, number of cobs per plant and baby corn weight without husk increased significantly with increase in nitrogen levels (Gossavi and Bhagat, 2009). Similar reports were also given by Naveen *et al.*(2020).

The highest cob yield, both with and without husk was obtained under treatment T₆, i.e. with application of EC (2.5 t ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS (T₆) (Table 3.), which might be due to the positive joint effect of yield attributing characters, like number of cobs plant⁻¹, weight of the cob (with and without husk) and length of the cob (with and without husk). This is in consonance with the findings of Madhavi *et al.* (1995) and Thavaprakash *et al.* (2005), since the yield of the crop is a function of several yield components which are dependent on the complementary interaction between the vegetative and reproductive

growth of the crop. Increased nutrient availability *vis-à-vis* enhanced mineralization of organic nitrogen might have increased photosynthetic rate, which has resulted in more cob yield. Similar observations were reported by Raja (2001) and Kar *et al.* (2006) who reported an increase in baby corn yield due to nitrogen application.

Green fodder yield also reflected the superiority of treatment T₆, where EC (2.5 t ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS was applied. Since green fodder yield is a function of plant height, number of leaves and leaf area index and this might have realized in higher green fodder yield in EC (2.5 t ha⁻¹) + lime (25 kg ha⁻¹) + ash (2.5 kg ha⁻¹) mixture at sowing and 30 DAS (T₆). Kar *et al.* (2006) and Dadarwal *et al.* (2009) also reported an increase in fodder yield with a successive increase in nitrogen application.

From the present investigation it was observed that application of enriched compost (EC) @2.5 t ha⁻¹ + lime @25 kg ha⁻¹ + ash @2.5 kg ha⁻¹ mixture at sowing and 30 DAS in baby corn resulted in better yield attributing characters including both green fodder and corn yield.

Therefore, organic sources of nutrients along with ash could be a better proposition so far nutrient management of baby corn is concerned.

References

1. Dadarwal, R.S.; Jain, N.K. and Singh, D. (2009). Integrated nutrient management in baby corn (*Zea mays*). *Indian J. Agric. Sci.* 79: 1023-25.
2. Gosavi, S.P. and Bhagat, S.B. (2009). Effect of nitrogen levels and spacing on yield attributes, yield and quality parameters of baby corn (*Zea mays*). *Ann. Agric. Res.* 30(3&4).
3. Kar, P.P.; Barik, K.C.; Mahapatra, P.K.; Garnayak, L.M.; Rath, B.S.; Bastia, D.K. and Khanda, C.M. (2006). Effect of planting geometry and nitrogen on yield, economics and nitrogen uptake of sweet corn (*Zea mays*). *Indian J. Agron.* 51(1): 43-45.
4. Madhavi, B. L.; Reddy, M.S. and Rao, P.C. (1995). Integrated nutrient management using poultry manures and fertilizers for maize. *Indian J. Agron.* 40:307-310.
5. Murdia, L.K., Wadhwani, R., Wadhawan, N., Bajpai, P., Shekhawat, S., (2016). Maize Utilization in India: An Overview. *American Journal of Food and Nutrition*, 4(6) 169-176.
6. Naveen, J., Saikia, M., Borah, N., Pathak, K., and Das, R. (2020). Yield Performance of Organic Baby Corn (*Zea mays* L.) as Influenced by Nutrient Management and Moisture Conservation Practices in Sandy loam Soils of Assam. *Indian Journal of Agricultural Research*, 54(2), 256-259.
7. Naveen, J., and Saikia, M. (2020). Nutrient Management in Organic Baby Corn Production: A Review. *Agricultural Reviews*, 41(1), 66-72.
8. Raja, V. (2001). Effect of nitrogen and plant population on yield and quality of super sweet corn (*Zea mays*). *Indian J. Agron.* 46 (2): 246-249.
9. Thavaprakash, N.; Velayudham, K. and Muthukumar, V.B. (2005). Effect of crop geometry, intercropping systems and integrated nutrient management practices on productivity of baby corn (*Zea mays* L.) based intercropping systems. *Res. J. Agric. Biol. Sci.* 1(4): 295-302.



Constraints Perceived by the Growers in Adoption of Recommended Jute Production Technology

Amit Kumar, M.N. Ansari* and A.K. Paswan

Department of Extension Education, Tirhut College of Agriculture Dholi, Muzaffarpur, Bihar

*Corresponding Author Email : mnansari.tca@gmail.com

Abstract

The study was conducted in Madhepura, Saharsa and Supaul districts of Kosi region in Bihar. One block from each districts were selected on the basis of major area under jute cultivation. And from each block, two villages were selected randomly. From each village fifteen respondents were selected thus the total no. of respondents was ninety. The major constraints perceived by growers in Kosi region were lack of mechanization for post harvest processing of jute, intensity of flood and drought and lack of well structured market. The important suggestion given by jute growers were provide good quality seed at cheaper rate, release of flood tolerant varieties, develop mechanization and develop market structure.

Key words : Constraints, jute growers, production technology.

Introduction

Jute is one among the important commercial crops in India. It plays a key role in country's economy, which is cultivated particularly in the Eastern and North Eastern states. Jute is considered as the golden fibre of India. It is the commercially available natural fibre which is mostly utilized as packaging material, nowadays facing a steep competition from cheap synthetics in packaging sector. Jute is eco-friendly, biodegradable and has much higher CO₂ assimilation rate which is creating an opportunity for the survival and growth of jute industry in the era of environmental concern. It is evident that cultivation of jute generates huge employment in the rural as well as urban areas.

Global production of jute and allied fibres is around 3.0 million tonnes, 92.5% of which comes from India and Bangladesh alone. India is the largest producer of Jute in the world. The cultivation of Jute in our country is mainly confined to the Eastern states of West Bengal, Bihar, Assam and Odisha. Jute productivity in Bihar state is low as compared to national average due to several problems faced by the jute growers in its cultivation. In Bihar, the major drawback related with jute production technology may be the lack of knowledge of recommended package of practices. The present production of jute could be increased considerably if the available technology is effectively transferred to the growers. Therefore, it is desirable to make them aware about latest know how of recommended practices of jute cultivation, which in turn facilitates higher adoption of technology. In view of the present situation, the study has been conducted with the specific objective :

1. To find out the constraints in adoption of recommended practices of jute as perceived by the growers and suggest a strategy for higher production.

Materials and Methods

The Kosi region of Bihar state has been identified as a locale of present research enterprises in view of its importance in major jute growing belts of the state. The Kosi region consists of Saharsa, Madhepura and Supaul district. Three major jute producing blocks, one from each district was selected purposely on the basis of maximum area under jute cultivation and having maximum number of jute growers. Two villages from each blocks having maximum area under jute were selected as sample villages for this study. Fifteen jute growers were taken from each of the selected villages. Thus, a total number of 90 jute growers were constituted as the sample for the present study.

Results and Discussion

Constraints faced by the jute growers in jute cultivation : An attempt was made to ascertain from the respondents, the constraints encountered by them in the adoption of recommended package of practices of jute and also their suggestions to overcome them. During the interview, the respondents were asked to enumerate the constraints faced by them in the adoption of recommended package of practices of jute and to give their suggestions so the future researcher and scientist were able to solve their problems and helping the jute growers in opting maximum benefit from the jute production. As many as sixteen constraints in connection with practices of jute cultivation were identified.

From the table, it was depicted that in Kosi command

Table-1 : Constraints faced by the jute growers in jute cultivation.

Sl.No.	Statements	f	%	Rank
1.	Non availability of labors at the time of retting of jute	60	66.66	XIII
2.	Intensity of flood and drought	75	83.33	VI
3.	Unavailability of quality seed and high cost of seed	45	50.00	XV
4.	Unaware of the practice of seed treatment and lack of knowledge	73	81.11	VII
5.	Do not know fertilizer calculation	50	55.55	XIV
6.	Non availability of fertilizers in time.	40	44.44	XVI
7.	Labor scarcity at the time of weeding and costly availability	63	70.00	XII
8.	Appearance of different types of insect, pest and diseases	80	88.88	III
9.	Lack of technical knowledge with respect to use of pesticides	71	78.88	VIII
10.	Lack of assured and adequate irrigation facility and poor drainage system	70	77.77	IX
11.	There is lack of proper marketing channel due to which respondents are not getting good return.	76	84.44	V
12.	Lack of government support.	65	72.22	XI
13.	Lack of extension service	67	74.44	X
14.	Lack of mechanization for processing of jute after harvesting	85	94.44	I
15.	Lack of water resources for efficient retting of jute and lack of technical guidance	78	86.66	IV
16.	Lack of proper storage house	82	91.11	II

Table-2 : Suggestion given by the jute growers.

Sl. No.	Suggestions	f	%
1.	Providing good quality seed at cheaper rate	80	88.88
2.	Provision of credit facility	73	81.11
3.	Provision of fertilizers on subsidized rates	75	83.33
4.	Supply of effective plant protection chemicals	74	82.22
5.	Timely technical guidance and soil testing	78	86.66
6.	Appropriate control measures of pest and diseases	79	87.77
7.	Release of flood tolerant varieties	85	94.44
8.	Good transport facility	65	72.22
9.	Establishment of retting tanks	86	95.55
10.	Develop mechanization for extraction of jute	88	97.77
11.	Develop water resources and timely availability of water for retting	87	96.66
12.	Develop proper market structure to overcome the problem by middle man	70	77.77

area regarding jute cultivation the major constraints were lack of mechanization for processing of jute after harvest gets first rank, after that lack of proper storage house get second rank, thereafter appearance of different types of insect, pest and diseases gets third rank, intensity of flood and drought gets fourth rank, lack of proper marketing channel gets fifth rank, intensity of flood and drought gets sixth rank, unaware of the practice of seed treatment gets seventh rank, lack of technical knowledge with respect to use of pesticides gets eighth rank, lack of assured and adequate irrigation facility and poor drainage system gets ninth rank, Lack of extension service gets tenth rank, Lack of government support gets eleventh rank, Labour scarcity at the time of weeding and costly availability gets twelfth rank, Non availability of labours at the time of retting of jute gets thirteenth rank, Do not know fertilizer calculation gets fourteenth rank, Unavailability of quality seed and high cost of seed gets fifteenth rank followed by Non availability of fertilizers in time gets sixteenth rank in overall constraints faced by the jute growers in Kosi region of Bihar.

Suggestions given by the jute growers to overcome the constraints of Jute Cultivation : In this section the attempt has been made to describe the suggestion given by the farmers to solve their problems in jute cultivation so the future researcher able to make some solution based on their suggestion and hence the farmers of the Kosi region of Bihar were able to get maximum production and profit from the jute cultivation.

The suggestion given by the farmers to overcome the constraints in above table by the jute growers were described as, develop mechanization for extraction of jute (97.77%), develop water resources and timely availability of water for retting (96.66%), establishment of retting tanks (95.55%), release of flood tolerant varieties (94.44%), providing good quality seed at cheaper rate (88.88%), appropriate control measures of pest and diseases (87.77%), timely technical guidance and soil testing (86.66%), provision of fertilizers on subsidized rates (83.33%), supply of effective plant protection chemicals (82.22%), provision of credit facility (81.11%),

develop proper market structure to overcome the problem by middle man(77.77%) and Providing good transport facility (72.22%), in that order as perceived by the jute farmers. Thus, the responsibility of state department of agriculture, state and central agricultural universities and government of India to see that the above suggested facilities that are provided to the respondents to overcome the constraints in adoption of recommended practices in jute cultivation.

Conclusions

The constraints identified by the researcher attract the view of government towards the jute growers, and also help in designing the future plan of work towards jute cultivation in order to achieve high awareness among the farmers and hence more adoption of jute cultivation practices. The problems expressed by the farmers and suggestions offered by them could be kept in view in order to make jute cultivation practices more practical and strategic should be followed for up gradation of extent of adoption level of jute growers.

References

1. Basanayak, R.T., Manjunath, L., Salunke, R., Agasimani, S. and Jahagirdar, K.A. (2012). Study on the profile of papaya growers in Bidar and Gulbarga districts of Karnataka, *Adv. Res. Jr. Soc. Sci.*, 3(2): 125-128.
2. Bhimraj, S.K. and Singh, N. (2015). Constraints in Papaya Production and Marketing Faced by the Farmers in South Gujarat Region. *Trends in Biosciences*, 8(2): 498-499.
3. Kumar R, Ansari M.N, Kumar N. and Kumar B. (2018). Constraints perceived by the papaya growers in adoption of improved papaya production technology in Begusarai district of Bihar, India. *Int. J. Curr. Microbiol. App.Sci.*, 7: 2590-2595.
4. Singh, P.K. and Varshney, J.G. (2010). Adoption Level and Constraints in Rice Production Technology. *Indian Res. Jr. of Extn. Edu.*, 10 (1):45-49.
5. Singh, S.P. and Laharia, S.N. (1992). Constraints in transfer of Sugarcane Technology, *Indian Jr. of Extn. Edu.*, XXVIII (1&2): 65 -69.
6. Todmal, S.B., Khalache, P.G., Gaikwad, J.H. and Jadhav, R.M. (2013). Constraints faced by the sericulturists in adoption of sericulture production technology. *Adv. Res. Jr. Soc. Sci.*, 4(1): 112-114.



Production of Kachri (*Cucumis callosus*) (AHK-119) with Saline Water Irrigation in Hot Arid Region

Anita Meena*, P.L. Saroj, M.K. Jatav and B.D. Sharma

ICAR–Central Institute for Arid Horticulture, Bikaner, Rajasthan 334 006

*Corresponding Author Email : anumeena5@gmail.com

Abstract

In hot arid region, Kachri (*Cucumis callosus*) is the most important vegetable crop and potential source of income for farmers. The availability of good quality of irrigation water is very less. Thus sustainable irrigation systems using saline soils and waters have the potential to improve crop production in arid region. The field experiment was conducted at ICAR- Central Institute for Arid Horticulture, Bikaner during 2017-18 and to investigate the effect of saline water with the combination of different amendments on Kachri crop performance. It was observed that the maximum vine length (cm), number of fruit plant⁻¹, number of vine plant⁻¹ and leaf size (cm) were (1.47cm, 16, 5, 9.0cm x 8.8 cm) respectively observed under the treatment of gypsum @5ton/ha + 4EC (dS m⁻¹)_{IW} followed by vermicompost @ 10 ton/ha+ 4EC(dS m⁻¹)_{IW}, FYM @ 15 ton/ha + 4EC (dS m⁻¹)_{IW}, 4EC (dS m⁻¹)_{IW}, 2EC (dS m⁻¹)_{IW} and .5EC (dS m⁻¹)_{IW}. The highest yield was observed with the treatment of gypsum @5ton/ha+ 4EC (dS m⁻¹)_{IW} that was (66.25 q/ha) followed by vermicompost @ 10 ton/ha+ 4EC (dS m⁻¹)_{IW} (60.00 q/ha) and FYM @ 15 ton/ha+ 4EC(dS m⁻¹)_{IW} (57.50 q/ha). 4EC (dS m⁻¹)_{IW} (32.30 q/ha), 2EC (dS m⁻¹)_{IW} (40.00 q/ha) and .5EC (dS m⁻¹)_{IW} (50 q/ha). This is clearly indicated that Kachri crop performance was good in the treatments where gypsum @5ton/ha+ 4EC (dS m⁻¹)_{IW} were applied.

Key words : Saline water, kachri, arid region, saline water.

Introduction

The continuous increase in the earth's population while the earth's renewable water resources are finite requires more water for domestic, industrial environmental, recreational and agricultural needs. Water shortage in western part of Rajasthan is becoming a major constraint for agriculture and sustainable regional development. These water-deficient regions are characterized by high spatial and temporal imbalances of water demand and supply, seasonal water uses, inadequate water resources and poor institutional water management. Nowadays, water is becoming scarce not only in arid and drought prone areas, but also in regions where rainfall is relatively abundant.

Throughout the world, irrigation with saline water has some effects on the growth, production and quality of crop plants (Mizrahp and Pasternak 1985). The cucurbitaceous crop production is able to contribute in nutraceutical values (Meena and Balai, 2020) and income source also for the people; particularly those are sustaining life in hot arid region of north-western parts of Rajasthan. The native cucurbitaceous crop like *Kachri* is support to livelihood in the unfavorable situations. However, limited attention was required for saline water management practices and other agronomic aspects in agriculture. The cucurbitaceous crop *requires* hot and dry climate and a long growing season preferably with warmer days for cultivation both as rainy and summer

season crop. The high temperature and dry climatic conditions are favorable for crop, fruit maturity and quality. Arid region of Rajasthan, having the problem of sand dunes which are characterized by light texture, low organic carbon content, high pH, low CEC and salinity/alkalinity problems (Shyampura *et al.* 2002). The crop production in the hot arid regions is constrained by low and irregular rainfall, high evapotranspiration (1500-2000 mm year⁻¹) and poor in soil fertility. Arid region soils are low in organic matter, macronutrient and micronutrient (Mahesh Kumar *et al.*, 2011). The high temperature, scanty vegetation and single grained structure of soil were attributed through low organic matter percentage in soil.

In the future, sustainable irrigation systems using saline soils and waters have the potential to improve crop production with minimized adverse environmental effects. This will require a comprehensive approach to soil, water and crop management. This will need to be on reclamation of new lands, rehabilitation of saline lands generated by past irrigation practices, improved productivity per unit of water and environmental protection. Crop and water management will play key roles in such a comprehensive approach. To achieve this, detailed knowledge of a crop's response to salinity is required. Based on this issue, the present experiment was designed to use of saline water for the irrigation of Kachri crop to examine its effects on yield and fruit quality.

Table-1 : Effect of different salinity level of irrigation water on growth parameter of Kachri (*Cucumis callosus*) crops.

S. No.	Treatments	Number of vine / plant	Number of leaf per vine	Vine length (cm)	No. of branches /plant	No. of fruit plant	Leaf size (cm) L x W	
1.	.5EC (dS/m ⁻¹) IW (Control)	6	10	1.41	4	14	6.4	8.3
2.	2EC (dS/ m ⁻¹) IW	11	9	1.32	3.5	12	6.8	8.0
3.	4EC (dS/ m ⁻¹) IW	10	7	1.18	3	10	6.5	5.0
4.	Gypsmm@ton/ha + 4EC (dS/m ⁻¹)	12	17	1.47	5.2	16	9.0	8.8
5.	VC @10 ton/ha + 4EC (dS/ m ⁻¹) IW	11	16	1.35	4	14	6.1	7.6
6.	FYM @15 ton/ha + 4EC (dS/ m ⁻¹) IW	12	16	1.31	4	14	5.6	8.4
	Mean	10.33	12.50	1.34	3.95	13.33	6.73	7.68
	SD	2.25	4.32	0.10	0.73	2.07	1.18	1.37

Table-2 : Effect of different salinity level of irrigation water on Kachri (*Cucumis callosus*) fruit weight (gm), fruit size (cm), fruit yield (cm) and yield response (%).

S.No.	Treatments	Average fruit weight (gm)	Average fruit size (cm) L x W	Average Fruit yield (q/ha)	TSS (°B)	Yield response (%)	
1	.5EC (dS/m ⁻¹) IW (Control)	30.93	4.3	3.6	50.00	3.74	
2	2EC (dS/ m ⁻¹) IW	19.19	3.5	3.0	40.00	3.68	39.0
3	4EC (dS/ m ⁻¹) IW	15.23	3.0	2.7	32.30	3.62	31.3
4	Gypsmm@ton/ha + 4EC (dS/m ⁻¹)	36.58	5.0	3.8	66.25	3.91	65.3
5	VC @10 ton/ha+ 4EC (dS/m ⁻¹) IW	22.22	3.5	3.1	60.00	3.94	59.0
6	FYM @15 ton/ha+4EC (dS/m ⁻¹) IW	26.19	2.9	2.7	57.50	4.09	56.5
	Mean	25.06	3.70	3.15	51.01	3.83	50.22
	SD	7.84	0.81	0.46	12.86	0.18	14.39

Materials and Methods

The field experiment was conducted at ICAR-CIAH during 2017-18, research farm with cucurbitaceous crop (*Kachri*) in the kharif season to investigate the effect of different level of salinity in irrigation water with combination of soil amendments for *kachri* crop performance. The soil was sandy, pH 8.3, low in organic carbon (0.11%) and available nitrogen (110 kg ha⁻¹), medium in available phosphorus (12 kg ha⁻¹) and high in available potassium K (320 kg ha⁻¹). The six treatments consisting of irrigation water .5EC (dS m⁻¹)_{IW}, 2EC (dS m⁻¹)_{IW}, 4EC (dS m⁻¹)_{IW}, gypsum @5ton/ha + 4EC (dS m⁻¹)_{IW}, vermicompost @10 ton/ha + 4EC(dS m⁻¹)_{IW} and FYM @15 ton/ha + 4EC (dS m⁻¹)_{IW}. The other cultural practices were applied as per recommendation for the crop in the arid area.

Results and Discussion

The growth parameter like vine length (cm), number of branches plant⁻¹ and leaf size (cm) were showed significant effect under different level of salinity in irrigation water with the combination of soil amendments like gypsum, vermicompost and FYM. It was observed that the maximum vine length (cm), number of fruit /plant, number of vine plant⁻¹, number of branches plant⁻¹, leaf size (cm) and no. of leaf/vine (1.47cm, 16,12 5.2, 9.0 cm x 8.8 cm and 17) respectively was observed under the treatment of gypsum @5ton/ha + 4EC_{IW} (dS m⁻¹) followed

by .5EC (dS m⁻¹)_{IW}, vermicompost @10 ton/ha+ 4EC_{IW} (dS m⁻¹) and FYM @15 ton/ha+ 4EC_{IW} (dS m⁻¹), 2EC (dS m⁻¹)_{IW}, 4EC (dS m⁻¹)_{IW}, (Table -1). With the application of saline water with different soil amendment increased growth parameters of Kachri as compared to control (Table-1).

The treatment of gypsum @5ton/ha+ 4EC_{IW} (dS m⁻¹) gave higher yield parameters like number of fruits plant⁻¹, fruit size(cm), average fruit weight (gm) and fruit yield (g/ha) was (16, 5cm x 3.8 cm, 36.58 gm respectively) followed by .5EC (dS m⁻¹)_{IW}, vermicompost @10 ton/ha+ 4EC_{IW} (dS m⁻¹) and FYM @15 ton/ha+ 4EC_{IW} (dS m⁻¹), 2EC (dS m⁻¹)_{IW}, 4EC (dS m⁻¹)_{IW}, (Table-1). The highest yield was observed with the treatment of Gypsum @5ton/ha+ 4EC_{IW} (dS m⁻¹) that was (66.25 q/ha) followed by vermicompost @10 ton/ha + 4EC_{IW} (dSm⁻¹) (60.00 q/ha) and FYM @15 ton/ha + 4EC_{IW} (dSm⁻¹) (57.50 q/ha). (Table -1). This is clearly indicated that in the treatments where Gypsum @5ton/ha + 4EC_{IW} (dS m⁻¹) were applied kachri crop was able to maintain highest moisture percentage (6.67%), followed by vermicompost @10 ton/ha + 4EC_{IW} (dSm⁻¹), (6.42%), FYM @15 ton/ha+ 4EC_{IW} (dS m⁻¹) (6.33%). The highest dry matter percentage was observed (%) with the application of Gypsum @5ton/ha+ 4EC_{IW} (dSm⁻¹) (Figure-2). The treatments where Gypsum @5ton/ha+ 4EC (dSm⁻¹) irrigated water were applied, *kachri* crop was able to

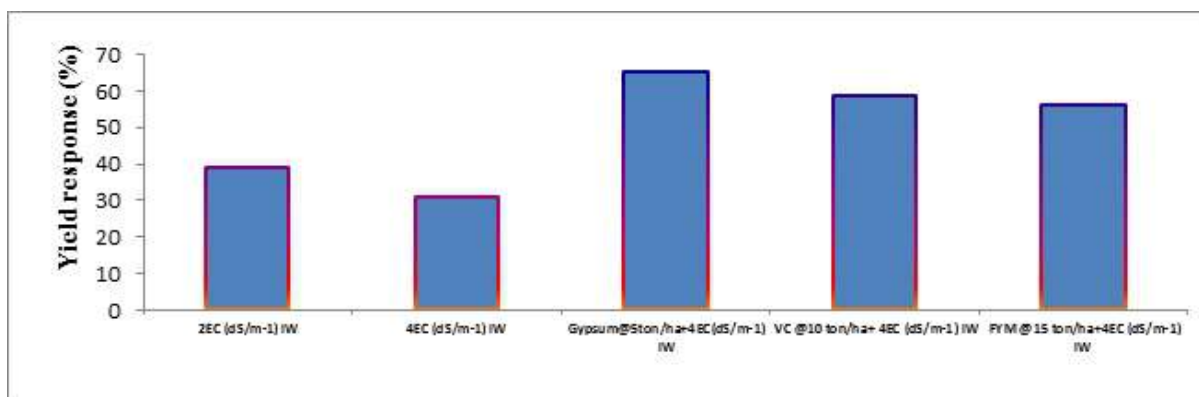


Figure-1 : Yield response (%) of Kachri (*Cucumis callosus*) under different level of salinity in irrigation water.

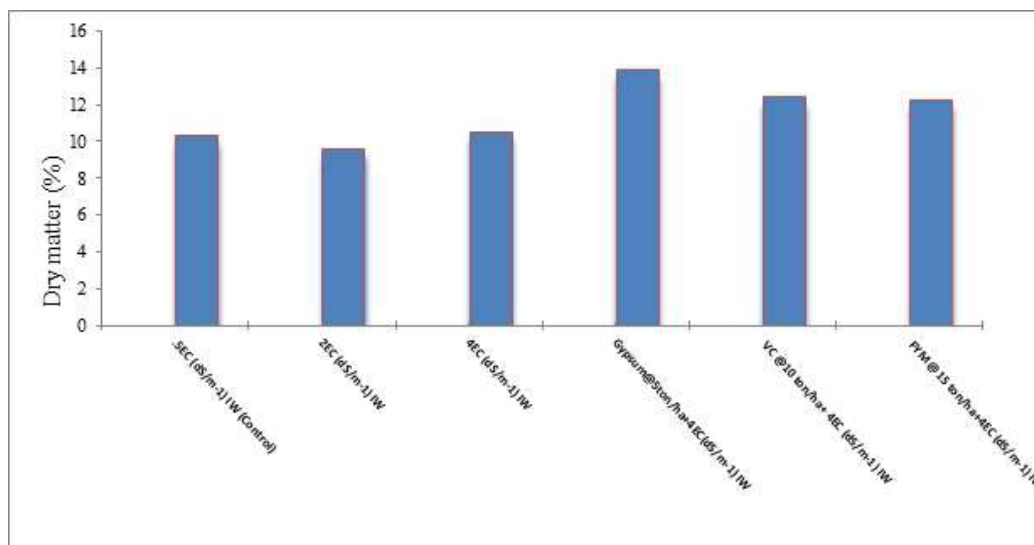


Figure-2 : Dry matter percentage of Kachri (*Cucumis callosus*) under different level of salinity in irrigation water.

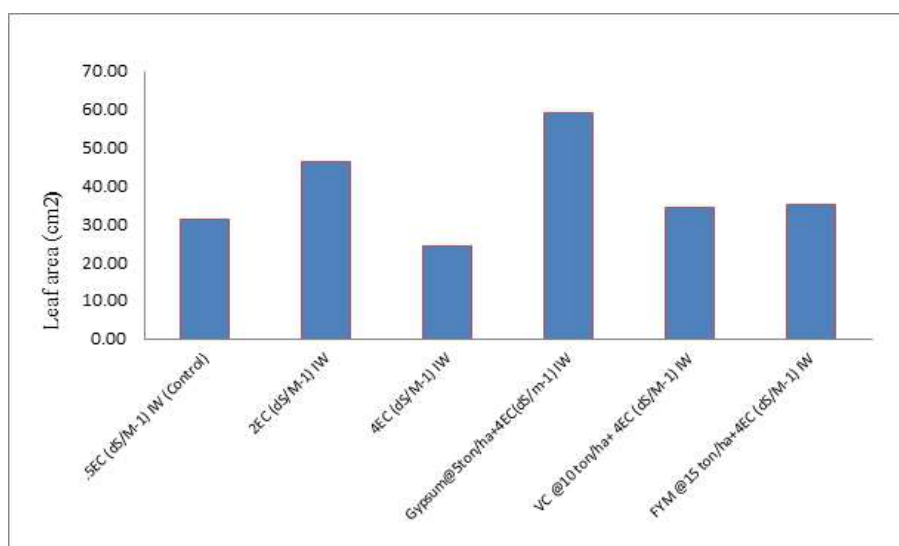


Figure-3 : Leaf area (cm²) of Kachri (*Cucumis callosus*) under different level of salinity in irrigation water.

maintain highest dry matter percentage (12.67%) followed by other treatments (Figure-2). These results are conformity with saline water irrigation with gypsum application merely increased soil EC and Ca²⁺

concentration but did not affect most plant parameters. (Qing Wang *et al.* 2017).

The data of Kachri crop revealed that effect of salinity levels with their combination of amendments on

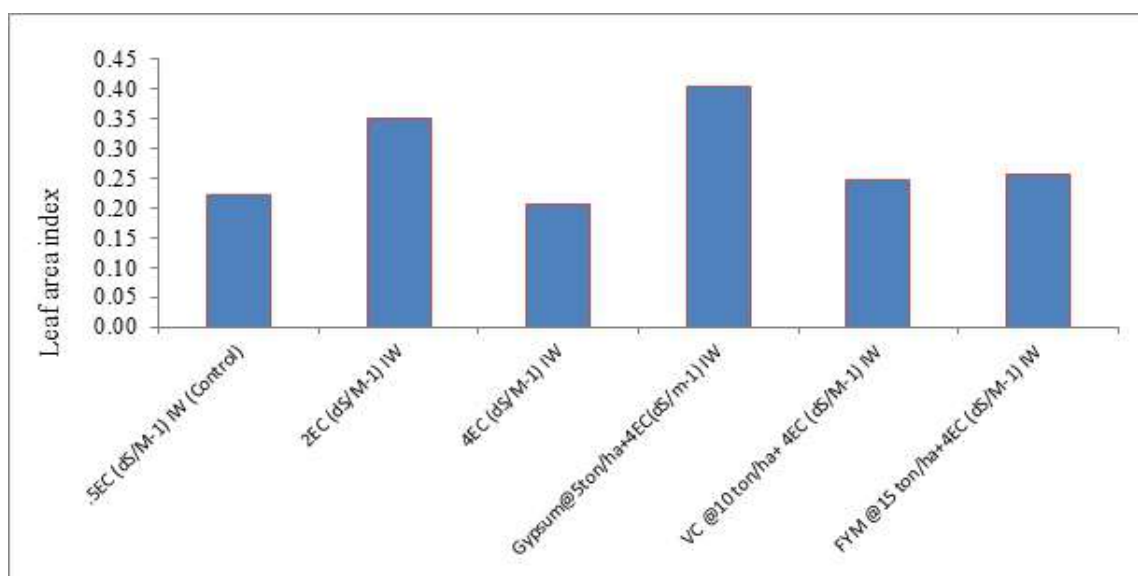


Figure-4 : Leaf area index of Kachri (*Cucumis callosus*) under different level of salinity in irrigation water.

leaf area are presented in Table no.3. It was observed that in both salinity level, the leaf area were high in gypsum amendment with saline water application that was highest leaf area (60.34cm^2) in 5EC_{IW} + Gypsum @ 5ton/ha and followed by other treatments, (Figure- 3). With the 4EC_{IW} the result on the leaf area was significantly influenced by treatments levels with their combinations. It is clear from data that application of saline water with amendment had maximum leaf area which was found at par with other treatment while minimum leaf area were registered under control treatment. The data presented showed that saline water irrigation had significant on leaf area and Irrigation water salinity did not influence the leaf area estimation (Flavios *et al* 2015). LAI is a measure for the total area of leaves per unit ground area and directly related to the amount of light that can be intercepted by plants. It is an important variable used to predict photosynthetic primary production, evapotranspiration and as tool for crop growth. The data on LAI of *Kachri* crop growth significantly affected by salinity levels, their combination with amendments. The highest LAI value for *Kachri* crop was (0.40) observed under the treatment of Gypsum @ 5ton/ha + 4EC_{IW} (dS m^{-1}) which was at par with other treatments. The saline water irrigation to be statistically significant with respect to leaf area index. The TSS (total soluble salt) of *Kachri* fruits were not significantly affected by amendments. The maximum TSS 4.09% were observed under the FYM @ 15ton/ha + 4EC (dS/ m^{-1})_{IW} and followed by other treatments. Data revealed that the treatment Gypsmm@ton/ha+4EC (dS/m^{-1}) was recorded maximum DM% (13.80) (Figure-2) and TSS (4.09) were recorded with the treatment of FYM @ 15ton/ha + 4EC (dS/ m^{-1}) IW (Table-2). The treatment of Gypsmm@ton/ha+4EC (dS/m^{-1}) IW were registered well

for leaf area, leaf area index and DM%. It may concluded that the treatment of Gypsmm@ton/ha+4EC (dS/m^{-1}) IW gave higher yield as well as yield response for *Kachri* (*Cucumis callosus*). Besides more yield, this treatment also showed better for quality parameters under hot arid agro-climate.

References

1. Flavio Favaro Blanco, Marcos Vinicius Folegatti (2005) Estimation of leaf area for greenhouse cucumber by linear measurements under salinity and grafting, *Sci. Agric.* 62(4) : 305-309.
2. Mahesh Kumar, Singh, S.K., Raina, P. and Sharma, B.K.(2011). Available major and micronutrients in arid soils of Chauru district of western Rajasthan. *Journal of the Indian Society of Soil Science* 59: 188-192.
3. Meena Anita and Balai R.C. (2020): Impact of quality of irrigation water on nutraceutical values of Kachri, ICAR-CIAH: Beechhwal Rural, India, *Bikaner Newsletter*, July–December, 20(1): 156-160.
4. Meena Anita, Jatav M.K. and Balai R.C.(2020): Popularization of Kachri (*Cucumis callosus*) crop production under saline water irrigation in arid zone; ICAR-CIAH: Beechhwal Rural, India, *Bikaner ,News Letter* January –June, Vol.20, No.02.
5. Mizrahp, Y. and Pasternak, D.(1985): Effect of salinity on quality of various agricultural crops. *Plant and Soil*, 89: 301-307.
6. Qing Wang, Lizhi Men, Lihong Gao, Xianchang Yu (2017): Effect of grafting and gypsum application on cucumber (*Cucumis sativus* L) growth under saline water irrigation. *Agricultural Water Management* 188: 79-90.
7. Shyampura R.L., Singh S.K., Singh R.S., Jain B.L. and Gajbhiye K.S. (2002). Soil Series of Rajasthan. *Technical Bulletin*, NBSS and LUP, Udaipur.



Evaluation of Soil Fertility, Correlation and Nutrient Indexing of Available Macro and Micro Nutrients in Arid Vegetable Growing Pockets of Rajasthan

Anita Meena*, M.K. Jatav, P.L. Saroj R.C. Balai B.D. Sharma and S.R. Meena

ICAR-Central Institute for Arid Horticulture, Bikaner-334006 Rajasthan

*Corresponding Author Email : anumeena5@gmail.com

Abstract

The present study was undertaken to assess the available plant nutrients and their indexing in soils of arid vegetable growing areas of Bikaner district to find out sufficiency/deficiencies and refine fertilizer recommendation for getting higher productivity. The results revealed that the soils were neutral to alkaline in reaction ranging between 7.0-8.30 with an average pH of 7.61. The organic carbon content ranged from 0.05% to 0.13% with an average value of 0.10%. Available nitrogen (N), phosphorus (P) and potassium (K) content of these soils ranged from 151.20 to 324.80, 9.40 to 22.43 and 119.25 to 295 kg ha⁻¹ with an average value of 234.02, 14.76 and 215.01 kg ha⁻¹, respectively. Among major nutrients, about 95.19% of the soil samples were low in available nitrogen, whereas, rests of the samples (4.81%) were found medium in available nitrogen 33.65 and 66.35% soil samples were observed in low respectively. In case of available potassium 95.19 and 4.81% samples were in medium and high in available potassium respectively. Nutrient indexing of the areas was low for N (1.05), phosphorus (1.66), whereas, it was medium in case of potassium (2.05). With respect to micro-nutrients 99.04, 14.42 and 19.23% samples were found deficient in DTPA-Zn, Cu, and Fe, respectively. However, all the soil samples were sufficient in available Mn in soil.

Key words : Arid vegetables, fertilizer recommendations, macro and micronutrients.

Introduction

The farmers use blanket fertilizer recommendation which often leads to an imbalance in nutrients and soil degradation where the nutrients are under applied. On the other hand, over-application of fertilizer results in lower profit for the farmers and causes environmental pollution. Soil, the source of infinite life is the most vital and precious natural resource, and not renewable in short time. Soil fertility may be a dynamic natural property and it can change under the influence of natural and human induced factors. As human population still increase, human disturbance on the earth's ecosystem to provide food and fiber will place greater demand on soils to supply essential nutrients. Continuous cropping for enhanced yield removes substantial amounts of nutrients from soil. Inadequate and Imbalanced use of chemical fertilizers, also deplete the soil quality rapidly Medhe *et al.*, (2012).

Soil fertility is an important aspect of the soil-plant relationship. The fertility status of the soils is primarily dependent upon both the macro and micro nutrient reserve of that soil and also depends on the character of vegetation, climate, and texture of soil, topography, and decomposition rate of organic matter. Continued removal of nutrients by crops, with little or no replacement increases the nutrient stress in plants and lowers the fertility of soil resulted low crop productivity. Optimum productivity of any cropping systems depends on adequate supply of plant nutrients during growth periods.

Soil fertility status, resulting crop response to applied fertilizer nutrients and net profit that can be obtained, are the important constituents to be taken into consideration before arriving at any decision on judicious use of fertilizers. It was obvious that the increased use of fertilizers would benefit the farmers and entire nation. The more immediate problem was to determine balance of application of fertilizer for the various crops in each region. Soil fertility may fluctuates the growing season throughout every year due to alteration in availability and the quantity of mineral nutrients by the addition of fertilizers, compost, manure, mulch and lime or sulfur, in addition to leaching and uptake of crops.

Hence, soil testing will determine the present fertility status and provides information regarding nutrient availability in soils which forms the idea for the fertilizer recommendations for maximizing crop yields and further to maintain the soil fertility in soil year after year. The application of fertilizer should be determine the right rates for the various crops in each region. A country wide survey of responses to fertilizers had become essential.

High yielding fertilizers responsive variety of crops and high cost of fertilizers have necessitated the development of a quantitative basis of making fertilizer recommendations for obtaining economic yield of crop. The growth, development and yield of plant govern by Soil nutrients and the information about the fertility status of an area can go a long way in planning of judicious

Table-1 : Descriptive statistics of soil properties of samples collected from Bikaner district of Rajasthan.

S. No.	Minimum	Maximum	Mean	Standard deviation
pH	7.04	8.31	7.58	0.2
EC (dS/m ⁻¹)	0.75	2.71	1.50	0.4
OC (%)	0.1	0.2	0.1	0.0
Available Nitrogen (kg ha ⁻¹)	151.2	324.0	234.0	40.4
Available phosphorus (kg ha ⁻¹)	9.4	22.4	14.8	3.1
Available potassium (kg ha ⁻¹)	119.3	295.7	215.0	39.4
Zn (mg kg ⁻¹)	0.3	1.1	0.6	0.1
Fe (mg kg ⁻¹)	4.1	23.5	14.3	2.8
Cu (mg kg ⁻¹)	3.1	14.2	8.0	2.0

Table-2 : Soil samples (%) falling in different ranges of pH, EC, OC and available N, P, K at Bikaner District.

Parameter	Value	Rating	Sample %
pH (1:2)	less than 6.5	Acidic	0
	6.5 to 8.5	Normal	100
	Greater than 8.5	Alkaline	0
EC (1:2) (dS/m)	Less than or equal to 1.0	Normal	0
	Greater than 1.0	Saline	100
Organic carbon (%)	Less than 0.50	Low	100
	0.50 to to 0.75	Medium	0
	Greater than 0.75	High	0
Available N (kg/ha)	Greater than 560	High	0
	Less than 280	Low	100
	280 to 560	Medium	0
Available P ₂ O ₅ (kg/ha)	Less than 25	Low	100
	25 to 50	Medium	0
	Greater than 50	High	0

Table-3 : Correlation between soil properties and available nutrients.

Available Nutrient	Soil Properties		
	pH	EC	OC
N	0.083	0.021	1.000
P	-0.046	0.050	0.090
K	-0.025	0.083	0.072
Zn	-0.029	-0.113	0.027
Fe	0.074	0.031	0.153
Cu	-0.135	-0.181	0.094
Mn	-0.111	-0.240	-0.185

management practices of fertilizers and soil to develop economically viable alternatives for the farming community Singh (1996). Status of fertility of soil is known in terms of soil test values.

The soil tests are calibrated into different fertility categories such as low, medium and high Welch *et al.* (1987) and Rashid and Memon (1996). In general, the soils are most of the fertilizer recommendations given out by soil testing laboratories in India are based on soil

test ratings and these rating for real site specific nutrient recommendation.

Hence, present investigation was undertaken to study the status of macro, micronutrients and their relationship with important soil properties in sandy soil in arid region of Rajasthan.

Research Methodology

The study area district Bikaner is a city in the north Indian state of Rajasthan, east of the border with Pakistan. It's surrounded by the thar desert. The climate is extremely hot during summer with maximum temperature reaching up to 49.20°C and extremely cold during winter with minimum temperature in the range of 10°C The variation in temperature from morning to noon and the late midnight is a sudden phenomenon. Desert soils and sand dunes aeolian soil loamy coarse in texture and calcareous soils are found in this region. In order to study on assessment of soil fertility status of Bikaner district 104 surface soil samples with the depth of 0-15 cm were collected from Khichiya, Dholera and Sarayrupayat villages.

Table-4 : Micronutrient status (mg kg⁻¹) of soils in Bikaner district of Rajasthan.

Available micronutrients	Rating Sample %	Sample %
Zinc (Zn) ppm	Deficient <0.60 ppm	78.85%
	Sufficient > 0.60 ppm	21.15%
Iron (Fe) ppm	Deficient < 4.50 ppm	0%
	Sufficient > 4.50 ppm	100%
Copper (Cu) ppm	Deficient < 0.20 ppm	2%
	Sufficient > 0.20 ppm	98%

Table-5 : Nutrient index of soils in Bikaner district of Rajasthan.

Nutrient index	Range	
I	<1.67	LOW
II	> 1.67-2.33	MEDIUM
III	>2.33	HIGH
Nitrogen	.96	LOW
Phosphorus	.96	LOW
potassium	1.92	MEDIUM
OC	.96	LOW

The composite surface soil samples (0-15 cm) were air dried and sieved through 2 mm sieve to remove stones and organic residues by following standard procedure. The processed samples were analyzed for their chemical properties employing conventional methods. The soil pH, EC and organic carbon were estimated by the standard procedures as described by Jackson (1973). Available nitrogen was determined following the method of Subbiah and Asija (1956). Available phosphorus and potassium were determined by Bray and neutral ammonium acetate methods, respectively. DTPA extractable zinc, iron, manganese and copper contents in the soils were determined by atomic absorption spectrophotometer Lindsay and Norwell (1978). The soil nutrient index was calculated according to the procedure given by Parker *et al.*, (1951).

**Fig-1 : Soil sampling sites.**

Results and Discussion

Soil reaction : Soil pH is a measure of the acidity or alkalinity in soils. Soil pH affects nutrients availability for

plant growth. A perusal of data revealed that the soils were neutral to alkaline in reaction ranging from 7.04 to 8.31 with a mean value of 7.58. (Table-1). The 2.88 % and 97.11% soil samples had soil pH values between 7.0 to 8.0 and more than 8.0, respectively. The high degree of sodium saturation which on hydrolysis gives OH⁻ ion and high carbonate and bicarbonate resulted increasing soil pH. Similar results were also reported by Singh *et al.*, (2010). The pH may have favorable effect on the retention of basic cations on exchangeable complex of the soil. The wide variation in soil pH might be due to variation in site topography, flooding zone and FYM use. Cheng *et al.*, (2014) and Hong *et al.*, (2017). Studies indicated that temperature and precipitation are important factors that control soil pH. The soils from arid climates are commonly alkaline with high soil pH. (Brady and Weil, 2002, 2008). Whereas the EC value of the soils was in range *i.e.* 0.75 to 2.71 dS/m⁻¹ (Table-1) and the average value of soil EC was 1.5 dS/m⁻¹). These values are fairly comparable to the result reported by Singh *et al.* (2010).

Organic carbon : The readily oxidisable organic carbon content of the soils ranged from 0.10 to 0.20 per cent with a mean value of 0.11 per cent indicating that these soils were low in organic carbon. (Table-1). The distribution of all soil samples (100%) were low (Table-2 & Figure-2). The most of soil samples were deficient in soil organic carbon. The low OC content of these soils may be attributed to occasional addition of organic materials, lack of natural vegetation, decomposition due to low rainfall, oxidation due to high summer temperature and wind erosion. The similar results were also reported by Jatav *et al.*, (2015, 2016). The contrasting moisture regimes under rates of organic matter decomposition and change in C input to soil can promptly influence these total organic C (TOC) pools Benbi *et al.*, (2012) and Bolinder *et al.*, (1999). Nutrient management influences C input to soil by stimulating crop residue production and retention in soil after crop harvest. Schumacher *et al.*, (2002).

Available nitrogen : Available N determined by alkaline KMnO₄ method ranged from 151.20 kg ha⁻¹ to 324 .00 kg ha⁻¹ with mean value of 234.02 kg ha⁻¹ with all the samples falling in low (Table-1). On the perusal of data it is observed that the nitrogen was the most deficient nutrient in these soils. About 100% of the soil samples were found to be low in nitrogen status and non of single soil sample was in medium to high category (Table-2 and Figure-3). A significant and positive correlation of available N was observed between OC ($r = 1$). Available N was positively and significant correlated with pH ($r = 0.083$) and EC ($r = -0.021$) (Table-3). The reasons for low available N in soils of area under study might be due to low organic matter content, low precipitation and prevailing high temperature which aggravates the problem of organic matter oxidation.

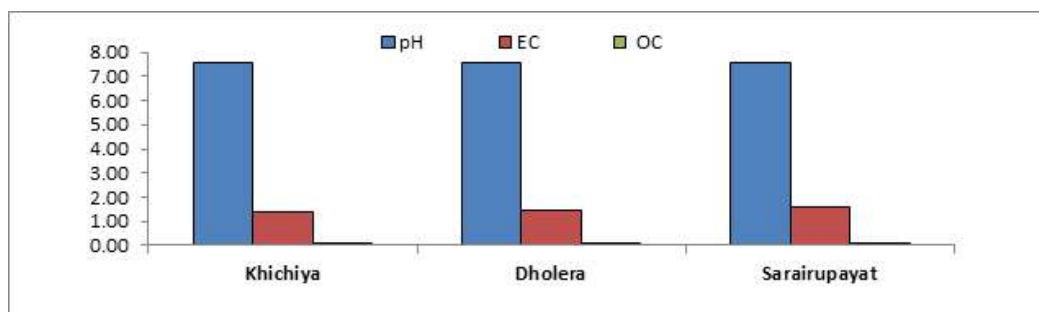


Figure-2 : Soil properties at Khichiya, Dholera and Sarairupayat villages in Bikaner district.

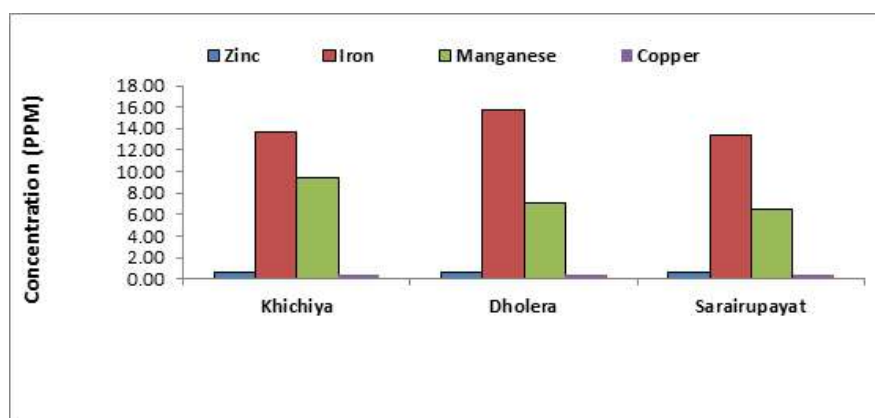


Figure-3 : Micro nutrient (kg/ha) at Khichiya, Dholera and Sarairupayat villages in Bikaner district.

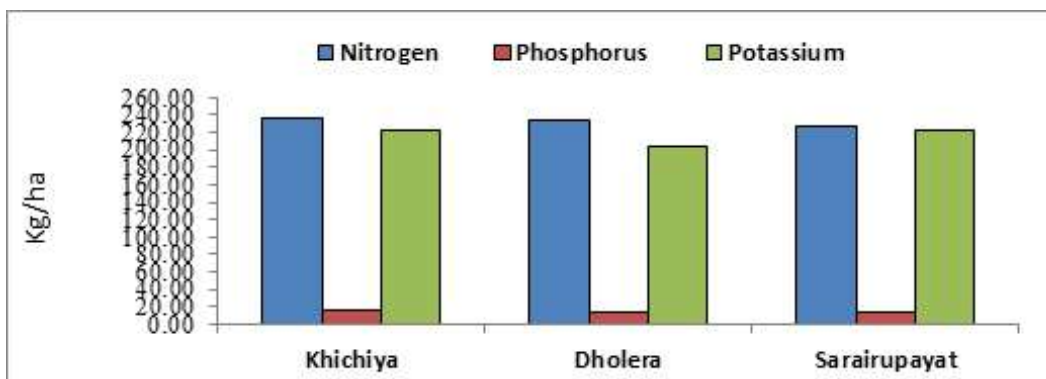


Figure-4 : Macro nutrient (kg/ha) at Khichiya, Dholera and Sarairupayat villages in Bikaner district.

The results of present study are in conformity of those reported by Dhale and Prasad (2009). The level of soil nitrogen is very much associated with soil carbon level. When the soil carbon is adequate and legumes are used in the farming system there is no need that soil may be necessarily deficient in soil Nitrogen, Since most soils are deficient in carbon and are not optimized for legume in rotation or organic amendment there is an artificial deficiency which is prevalent but not inevitable or a real deficiency in Nitrogen. The increase in the N uptake with FYM and other fertilizer application, as would an improvement in the nutritive value of the soil, which in turn would have major implications for resource-poor farmers to major feed source in the dry season. Therefore, farmers need to apply nitrogen regularly to get optimum yield

based on target yield equation and soil test based fertilizer recommendation.

Available phosphorus : Available phosphorus content in the surface soil as determined by Olsen P varied from 9.40 to 22.43 kg ha⁻¹ with a mean value 14.76 kg ha⁻¹ (Table-1). Almost 100% of soil samples were low (Table-2 and Figure-3) and the available P was found to low due to low mobility of phosphorus. A non significant positive correlation of available P was observed between OC ($r = 0.090$). This relationship might be due to the presence of less percentage of P in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P-fixation with Al and Fe, thus reduce P adsorption/ fixation Tisdale *et al.* (1997). Available P

was no significant and negatively correlated with pH ($r = 0.046$) (Table-3). This is because at higher, calcium precipitates with P as Ca-phosphate and reduce P availability Tisdale *et al.* (1997). Similar results were also reported by Meena *et al.* 2006.

Available potassium : Available potassium content of surface soils ranged from 119.25 to 295 kg ha⁻¹ with a mean value of 215.01 kg ha⁻¹ (Table-1). About 0.96% soil samples were low and remaining 99.04 % were in medium category (Table-2). A significant and positive correlation of available K was observed between OC ($r = 0.072$) and EC ($r = 0.083$) (Table-3). Similar results were also reported by Meena *et al.* (2006). Available K showed negative and non-significant correlation with pH ($r = -0.025$). The available K low to Medium was found due to presence of potash bearing minerals (Muscovites, biotite and feldspar) which on weathering slowly release potash. The results of presents study are in accordance with those reported by Marathe and Bharambe (2007). Similar results were also reported by Singh *et al.*, (2018a).

Available micronutrients : The status of available Zn content in the soils of vegetable growing areas of Bikaner district varied from 0.32 to 1.13 mg kg⁻¹ with an average of 0.58 mg kg⁻¹ (Table-1). Based on the critical limit of Zn, 78.85% soil samples were below to critical limit of Zn (<.60 ppm) of samples were found to be deficient in DTPA-extractable Zn and remaining 21.15 % were sufficient. The availability of Zn increased significantly (Table-4) with increase in OC ($r = 0.027$). The DTPA-Zn was significantly negative correlated with pH ($r = -0.029$) and EC ($r = -0.021$). The results confirm the findings of Sharma *et al.*, (2006) and Bhanwaria *et al.*, (2011).

The available Fe content of the soils under investigation varied from 4.10 to 23.48 mg kg⁻¹ with a mean value of 14.26 mg kg⁻¹ (Table-1). The all soil samples were rich in Fe content. Considering the critical limits (> 4.5 mg kg⁻¹) proposed by Lindsay and Norvell (1978) and all the soils sufficient and none of the soil samples were deficient in Fe content. (Table-4). The DTPA-Fe had significantly positive correlation with OC ($r = 0.153$) and significant correlation with pH ($r = 0.074$). Non-significant and positive correlation was observed with DTPA-Fe and EC ($r = 0.031$) (Table-3). Similar results were also reported by Sharma *et al.*, (2006) and Bhanwaria *et al.*, (2011).

Available Cu content in soil samples varied from 3.1 to 14.2 mg kg⁻¹ with mean value of 8.0 mg kg⁻¹ in soil. (Table-1). Considering critical limits (< 0.2 mg Cu kg⁻¹) as suggested by Lindsay and Norvell (1978) and the 98% samples in all soils were found sufficient in Cu and remaining only 2% soil samples were deficient (Table-4). The availability of Cu increased significantly with increase

of OC ($r = 0.094$) and whereas decreased with increase in pH ($r = -0.135$) and EC ($r = -0.181$) (Table-3). The result resembles to the findings of Sharma *et al.*, (2006) and Bhanwaria *et al.*, (2011). Available Mn in the soil samples varied from .20 to .60 mg kg⁻¹ with mean value of .40 mg kg⁻¹ in soil, considering the critical limits (> 0.02 mg kg⁻¹) as suggested by Lindsay and Norvell (1978), 99% soil samples falls under deficient in soil. The DTPA-Mn showed significant and negative correlation with OC ($r = -0.185$), whereas significantly decreased with decreasing of pH ($r = -0.111$) (Table-4). The results are close conformity with the findings of Sharma *et al.*, (2006) and Bhanwaria *et al.*, (2011) and Singh *et al.*, (2014). Electrical conductivity had non-significant relationship with DTPA-Mn ($r = -0.240$).

Nutrient indexing of soil test : Nutrient indexing approach (Ramamoorthy and Bajaj, 1969) was followed to evaluate the nutrient status of all the vegetables growing region of Bikaner area as in this strategy the variation in individual field is not taken into consideration but the fertilizer recommendations are made on the basis of overall nutritional status of the study area. As per nutrient index study of the vegetables growing areas of Bikaner, soils were deficient in available nitrogen (0.96) and phosphorus (0.96) and whereas in case of potassium (1.92) it was medium (1.67-2.33). It shows that soil has great demand for nitrogen followed by phosphorus, potassium was in adequate amount in most of the soils, and hence fertilizers recommendation should be applied on the basis of soil test (Table-5) similar results were found by Singh *et al.*, (2018b).

Conclusions

The arid region soils were neutral to alkaline. In general, the soils were low in organic carbon as per nutrient index study of the vegetables growing areas of Bikaner, soils were deficient in available nitrogen (0.96) and phosphorus (0.96) and whereas in case of potassium (1.92) it was medium (1.67-2.33). It shows that soil has great demand for nitrogen followed by phosphorus; potassium was in adequate amount in most of the soils. The available micronutrient Fe was sufficient Cu and Zn was deficient and Manganese was moderate sufficient.

References

1. Benbi D.K., Brar K., Toor A.S., Singh P., Singh H. (2012). Soil carbon pools under poplar-based agroforestry, rice-wheat, and maize-wheat cropping systems in semi-arid India. *Nutr Cycl Agroecosys.* 92: 107–118.
2. Bhanwaria, Rajendra, Kameeria, P.R. and Yadav, B.L. (2011): Available micronutrient status their relationship with soil properties of Mokala soil series of Rajasthan. *Journal of the Indian Society of Soil Science* 59: 392–396.
3. Bolinder M.A., Angers D.A., Gregorich E.G., Carter M.R.

- (1999). The response of soil quality indicators to conservation management. *Can J. Soil Sci.* 45: 79:37.
4. Brady N.C. and Weil R.R. (2002). The Nature and Properties of Soils 15th edn, 375–419.
 5. Brady N.C. and Weil R.R. (2008). The Nature and Properties of Soils. Prentice-Hall Press, Beijing.
 6. Cheng-Jim J.I., Yuan-He Y.A.N.G., Wen-Xuan H.A.N., Yan-Fang H.E., Smith J., Smith P. (2014). Climatic and edaphic controls on soil pH in alpine grasslands on the Tibetan Plateau, China: a quantitative analysis, *Pedosphere*, 24(1): 39–44.
 7. Dhale, S.A. and Jagdish Prasad. (2009). Characterization and classification of sweet orange growing soils of Jalna District, Maharashtra, *Journal of the Indian Society of Soil Science*, 57(1): 11-17.
 8. Hong S, Liu Y, Piao S. (2017). Spatial patterns of soil pH and the factors that influence them in plantation forests of northern China[C]//EGU General Assembly Conference Abstracts., 19: 4328.
 9. Jaction, M.L. (1973). Soil Chemical Analysis, Prentice Hall India (Pvt.) Ltd., New Delhi.
 10. Jatav M K, Dua V K, Kumar, Manoj, Kumar, Sushil, Trehan S P and Lal S S. (2015). Effect of integrated use of organic and inorganic sources of nutrients on micronutrients uptake in potato-radish crop sequence under rainfed conditions of hills. *International Journal of Agricultural and Statistical Sciences* 11: 143–148.
 11. Jatav M K, Hare Krishna. Meena S.R, Bhargava R. and Sharma, B.D. (2016): Yield and nutrient dynamics under fruit-based diversified cropping models for arid region of Rajasthan. *Indian J. Hort.* 73(3): 437-440
 12. Lindsay WL, Norwell A.(1978). Development of DTPA soil test for Zn, Fe,Mn and Cu. *Society of American Journal*, 42: 421-428
 13. Marathe, R.A. and Bharambe, P.R. (2007). Correlation of integrated nutrient management induced change in soil properties with yield and quality of sweet orange on Udic Haplustert. *J. Indian Soc. Soil Sci.*, 55(3): 270-275.
 14. Medhe SR, Tankankhar VG, Salve AN. (2012). Correlation of chemical properties, secondary nutrients and micronutrient anions from the soils of Chakur Tahsil of Latur district, Maharashtra. *Journal of Trends in life sciences*, 1(2).
 15. Meena, H.B., Sharma, R.P. and Rawat, U.S. (2006). Status of macro- and micronutrients in some soils of Tonk district of Rajasthan. *Journal of the Indian Society of Soil Science* 54: 508-512.
 16. Parker, F.W., Nelson, W.L., Winter Eric and Miller, I.E. (1951). The broad interpretation of soil test informations. *Agronomy Journal* 43, 105-102.
 17. Ramamurthy, B. and J.C. Bajaj (1969). Soil Fertility Map of India, Indian Agricultural Research Institute, New Delhi .
 18. Rashid, A. and Memon, K.S. (1996): Soil Sci. National Book Foundatin, Islamabad, Pakistan.
 19. Schumacher, B.A. (2002). Methods for the determination of total organic carbon (TOC) in soils and sediments, Ecological Risk Assessment Support Centre. Office of Research and Development US. *Environmental Protection Agency*, p.p.23
 20. Sharma, P.K., Sood, Anil, Setia, R.K., Verma, V.K., Mehara, Deepak, Tur, N.S. and Nayyar, V.K. (2006). Use of information technology for mapping of DTPA-extractable micronutrients in soils of Amritsar district, Punjab, *Journal of the Indian Society of Soil Science* 54, 465–474
 21. Singh, J.P., Singh, S. and Singh, V. (2010): Soil potassium fractions and response of cauliflower and onion to potassium. *J. Indian Soc. Soil Sci.*, 58(4): 384-387.
 22. Singh, K. and Raj, H. (1996). Micronutrient status of cotton wheat growing soils in relation to soil properties. *J. Indian Soc. Soil Sci.*, 44(1): 176-177
 23. Singh, S.K., Reddy,V.R., Sicher, R.C. (2018a). Seasonal critical concentration and relationships of leaf phosphorus and potassium status with biomass and yield traits of soybean. *J Plant Nutr Soil Sci* 181: 575–585.
 24. Singh, S.P., Singh, S., Kumar, A. and Kumar, R. (2018b). Soil Fertility Evaluation for Macronutrients Using Parkers Nutrient Index Approach in Some Soils of Varanasi District of Eastern Utter Pradesh, India., *Int. J. Pure App. Biosci.* 6(5): 542-548.
 25. Subbiah, B. V. and Asija, G. L.(1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Sci.* 25: 259.
 26. Tisdale, S.L. W.L. Nelson,W.L.(1997). Soil Fertility and Fertilizers Macmillan Publishing, New York.
 27. Welch, C.D., Nelson, R.W. and Beaton, J.D. (1987). Opportunities to improve soil testing programme. In: Soil testing and plant analysis. Revised Publication *Soil Science Society of Ammerica Washington, USA.* 1-10.



Comparative Economics of Sprinkler and Surface Irrigation in Raipur District of Chhattisgarh

Ashwin Anthony* and V.K. Choudhary

Department of Agricultural Economics, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

*Corresponding author email : choudhary.igkv@gmail.com

Abstract

An attempt has been made in the study to deal with, "Comparative Economics of Sprinkler and Surface Irrigation in Raipur District of Chhattisgarh. The Primary data was collected from selected farmers through personal interview method with the help of interview schedule and the secondary data was collected through different Government offices such as District Directorate of Agriculture, Rajya Beej Nigam and through other sources. Wheat crop was selected specifically for the study as it covered the maximum area under sprinkler irrigation. The cost of installation of the sprinkler system for 0.203-0.405 ha, 0.405-1 ha, 1.01– 2 ha and >2 ha worked out as Rs.15418, Rs. 25531, Rs 40722 and Rs. 48131 respectively. Whereas the cost of installation of tube well worked out to be Rs. 72,900. On sprinkler irrigated farms, the per hectare overall gross returns was higher Rs. 77,270.66 whereas on surface irrigated farms it was Rs.62781.66.

Key words : Irrigation, comparison, gross return, income.

Introduction

The majority of the country's agricultural land is irrigated using traditional surface systems such as border, furrow, and check basin, with application efficiency of less than 50%. Indian agriculture has one of the lowest water-use efficiency rates in the world. In comparison to numerous other states in the India, nature has been generous to Chhattisgarh in terms of rainfall. The state's average rainfall is roughly 1400 mm, with the Monsoon season, which runs from June 15 to September 30, accounting for nearly 90% of total rainfall. The state's rainfall has an unpredictable temporal and spatial distribution. The state's agriculture productivity is harmed as a result of this volatility in rainfall. Drought is always a problem in every third year, although this is due to inconsistent rainfall rather than a lack of rain. It is obvious irrigation is clearly the state's most pressing necessity. With the increase in population, deforestation and industrialization the ground water rapidly decreasing with the number of years passing. Due to this there has been a decrease in ground water recharge and eventually this would affect agriculture drastically in years to come and Chhattisgarh being a state in which 80% of the population is involved in agriculture and allied industries, the effect is going to be more drastic. As a result, the challenge is to enhance agricultural productivity while consuming a smaller amount of available water to keep up with population expansion. Only with the use of contemporary technology and management this can be achieved. Even if it is costly and ineffective for certain crops, pressure irrigation by drip and sprinklers could be quite beneficial in broad sections of Chhattisgarh. It however, deserves attention despite its

high capital cost in view of the serious water shortage. Even if a small farmer installed such a system on half an acre of land, they would reap significant benefits. Sprinkler irrigation systems are suitable for practically all crops (excluding rice and jute) due to increased yields, good quality, and water use efficiency, according to various research works conducted.

Materials and Methods

Raipur district consists of four blocks Tilda, Abhanpur, Aarang and Dharsiwa. Only two out of the total four blocks i.e., Dharsiwa and Abhanpur blocks was selected purposively on the basis of maximum area under sprinkler and tube well system of irrigation. Tor village was selected from Dharsiwa and Parasada village was selected from Abhanpur.

Analytical Tools :

Cost Concepts

1. Cost A1: It included

1. Value of hired human labour.
2. Value of owned and hired animal labour.
3. Value of owned and hired machine labour.
4. Value of seeds (both farm produced and purchased).
5. Value of manures, fertilizers, insecticides and pesticides.
6. Irrigation charges.
7. Depreciation.

Table-1 : Cost of installation of sprinkler system.

S. No.	Item	1.01-2.00 ha (75 mm diameter)			>2 ha (75 mm diameter)		
		Qty.	Unit Price	Total Cost	Qty.	Unit Price	Total Cost
1.	HDPE pipes with quick action coupler (2.0 to 2.5 kg/sq cm) of 6 meter long	41	710	29110	52	710	36920
2.	Sprinkler coupler with foot batten assembly	7	340	2380	9	340	306
3.	Sprinkler nozzles	9	390	3510	11	390	4290
4.	Riser pipe	11	110	1210	13	110	1430
5.	Connecting nipple	1	210	210	1	210	210
6.	Bend with coupler 90 Degrees	1	215	215	1	215	215
7.	Tee with coupler	1	305	305	1	305	305
8.	End plug	2	40	80	2	40	80
	Total System Cost			37020			43756
	Transportation and Installation charges @ 10 Percent			3702			4375.6
	Total cost			40722.00			48131.60

Table 2 : Cost of installation of sprinkler system.

S. No.	Item	0.203-0.405 ha (63 mm diameter)			0.405-1 ha (63 mm diameter)		
		Qty.	Unit Price	Total Cost	Qty.	Unit Price	Total Cost
1.	HDPE pipes with quick action coupler (2.0 to 2.5 kg/sq cm) of 6 meter long	18	620	11160	30	620	18600
2.	Sprinkler coupler with foot batten assembly	2	250	500	5	250	1250
3.	Sprinkler nozzles	3	390	1170	5	390	1950
4.	Riser pipe	5	110	550	7	110	770
5.	Connecting nipple	1	210	210	1	210	210
6.	Bend with coupler 90 Degrees	1	157	157	1	160	160
7.	Tee with coupler	1	190	190	1	190	190
8.	End plug	2	40	40	2	40	80
	Total System Cost			14017			23210
	Installation charges @10%			1401.7			2321
	Total cost			15418.70			25531.00

8. Land revenue.

9. Interest on working capital.

10. Miscellaneous expenses.

Cost A2 : Cost A1 + rent paid for leased-in land.

Cost B1 : Cost A1 + interest on fixed capital assets (excluding land)

Cost B2 : Cost B1 + rental value of owned land + rent paid for leased in land.

Cost C1 : Cost B1 + imputed value of family labour.

Cost C2 : Cost B2 + imputed value of family labour.

Cost C3 : Cost C2 + 10 per cent of cost C2 as management cost.

Income measures :

1. Farm Gross Receipts (FGR) = $Q_m \times P_m + Q_b \times P_b$

where, Q_m = Quantity of main product

P_m = Price of main product

Q_b = Quantity of by-product

P_b = Price of by-product

2. Farm Business Income

= Gross Income – Cost A1 (cost A2 in case of tenant operated land)

3. Family labour Income (Returns to family labour and management)

= Gross Income – Cost B2

4. Farm Net Income = Farm Gross Receipts - Cost C2

5. B : C Ratio = $\frac{\text{Gross Income}}{\text{Total Cost / ha}}$

Results and Discussion

The Table-1 and 2 reveals that for the following land size classification i.e. 0.203-0.405 ha, 0.405-1 ha, 1.01–2ha

Table-3 : Cost of installation of Tube well system of irrigation.

Particulars	Cost (Rs.)	Total Cost (Rs.)
A. Installation		
1. Drilling	Rs.70/ft	14,000
2. Casing pipe	280/ft	11,200
3. Socket (125/150 mm)	100	100
4. Well Cap	100	100
B. Equipment's		
5. Submersible pumpset (5HP)	26000	26000
6. Starter Box	4500	4500
7. Cable wire	10000	10000
8. Bore pipes (20ft)	5000	5000
9. Gate valves and other misc. items	2000	2000
Total Cost		72,900

and >2 ha, the cost of installation of the sprinkler system was Rs.15418, Rs. 25531, Rs 40722 and Rs. 48131 respectively. The recommended pipe diameter was 63 mm for 0.203-0.405 ha, 0.405-1 ha and for 1.01–2 ha and >2 ha it was 75 mm.

In Raipur district of Chhattisgarh (Table-3), the average drilling depth of tube wells is around 200 feet, therefore the cost of installation of the tube wells is calculated on the basis of average depth of 200 feet. The average price of drilling is Rs. 70/ft i.e. the total cost of drilling is Rs. 14000. The cost of installation of casing pipe is Rs. 280/ft therefore for the depth of 200 feet the cost is Rs. 11200. The socket (125/150 mm) and well cap accounts for Rs. 100 each.

The second phase includes installation of

Table-4 : Breakup of cost cultivation of wheat cultivation on different size holdings of Sprinkler irrigated farms.

Particulars	Costs/ha			
	Small	Medium	Large	Overall
Machine labour	3098.00 (9.15)	3293.00 (9.18)	3562.00 (8.84)	3317.66 (9.04)
Family labour	4491.00 (13.26)	3592.00 (10.01)	2984.00 (7.40)	3689.00 (10.06)
Casual hired labour	1025.00 (3.02)	3186.00 (8.85)	4913.00 (12.20)	3041.33 (8.29)
Seed	3041.30 (8.98)	3044.80 (8.49)	3043.50 (7.55)	3043.20 (8.30)
FYM	3175.00 (9.37)	3410.00 (9.50)	3575.00 (8.87)	3386.66 (9.23)
Fertilizers Urea DAP	637.75 (1.88)	673.19 (1.87)	709.31 (1.76)	673.41 (1.83)
	968.83 (2.86)	1016.62 (2.83)	1094.75 (2.71)	1026.73 (2.80)
Plant protection chemicals	785.00 (2.31)	975.00 (1.01)	1040.00 (2.58)	933.33 (2.54)
Irrigation charges	4740.40 (14.00)	5130.51 (14.30)	5682.78 (14.11)	5184.56 (14.14)
Total variable cost	21962.28 (64.86)	24321.12 (67.82)	29084.59 (72.22)	25122.66 (68.52)
Interest on working capital@7%	1537.35 (4.54)	1702.47 (4.74)	2035.92 (5.05)	1758.58 (4.79)
Depreciation of fixed assests@8%	922.71 (2.72)	593.25 (1.65)	270.60 (0.67)	595.52 (1.62)
Interest on fixed assets	951.54 (2.81)	922.89 (2.57)	894.83 (2.22)	923.08 (2.51)
Rental value of owned land	10000.00 (29.53)	10000.00 (27.88)	10000.00 (24.83)	10000.00 (27.27)
Land revenue	20.00 (0.05)	20.00 (0.05)	20.00 (0.04)	20.00 (0.05)
Total fixed cost	11894.25 (35.13)	11536.14 (32.17)	11185.43 (27.77)	11538.60 (31.47)
Total Cost	33856.53 (100.00)	35857.26 (100.00)	40270.02 (100)	36661.27 (100)

Table-5 : Breakup of cost cultivation of wheat cultivation on different size holdings of surface irrigated farms (through tube well).

Particulars	Costs/ha			
	Small	Medium	Large	Overall
Machine labour	2610.00 (8.34)	2735.00 (8.30)	3120.00 (8.90)	2821.66 (8.52)
Family labour	3625.00 (11.58)	3092.00 (9.39)	2295.00 (6.54)	3004.00 (9.08)
Casual hired labour	920.00 (2.94)	2208.00 (6.70)	3594.00 (10.25)	2240.66 (6.77)
Seed	2945.40 (9.41)	3034.60 (9.21)	3042.90 (8.63)	3007.63 (9.09)
FYM	3075.00 (9.82)	3475.00 (10.55)	3615.00 (10.31)	3388.33 (10.24)
Fertilizers Urea DAP	627.29 (2.00)	637.75 (1.93)	682.16 (1.94)	649.06 (1.96)
	976.72 (3.12)	1052.58 (3.19)	1179.02 (3.36)	1069.44 (3.23)
Plant protection chemicals	690.00 (2.20)	770.00 (2.33)	840.00 (2.39)	766.66 (2.31)
Irrigation charges	3665.34 (11.71)	3931.38 (11.94)	4963.28 (14.16)	4186.66 (12.65)
Total variable cost	19134.75 (61.16)	20936.31 (63.59)	23331.36 (66.58)	21134.14 (63.88)
Interest on working capital@7%	1339.43 (4.28)	1465.54 (4.45)	1663.19 (4.74)	1488.38 (4.94)
Depreciation of fixed assests	1159.15 (3.70)	1006.89 (3.05)	753.66 (2.15)	973.23 (2.94)
Interest on fixed assets	972.10 (3.10)	958.86 (2.91)	936.84 (2.67)	955.93 (2.88)
Rental value of owned land	10000.00 (31.96)	10000.00 (30.37)	10000.00 (28.53)	10000.00 (30.22)
Land revenue	20.00 (0.06)	20.00 (0.06)	20.00 (0.05)	20.00 (0.06)
Total fixed cost	12151.25 (38.83)	11985.75 (36.40)	11710.50 (33.41)	11949.16 (36.11)
Total Cost	31286.00 (100.00)	32922.06 (100.00)	35041.36 (100.00)	33083.14 (100.00)

Table-6 : Cost of cultivation of wheat on different cost concepts basis on sprinkler irrigated farms.

Costs	Small	Medium	Large	Overall Average
Cost A1	18413.99	21342.37	26391.19	22049.18
Cost A2	18413.99	21342.37	26391.19	22049.18
Cost B1	19365.53	22265.26	27286.02	22972.27
Cost B2	29365.53	32265.26	37286.02	32972.27
Cost C1	23856.53	25857.26	30270.02	26661.27
Cost C2	33856.53	35857.26	40270.02	36661.27
Cost C3	37242.18	39442.99	44297.02	40327.4

Table-7 : Cost of cultivation of wheat on different cost concepts basis on surface irrigated farms (through tube well).

COSTS	Small	Medium	Large	Overall Average
Cost A1	16688.90	18871.20	21810.02	19123.37
Cost A2	16688.90	18871.20	21810.02	19123.37
Cost B1	17661.00	19830.06	22746.86	20079.31
Cost B2	27661.00	29830.06	32746.86	30079.31
Cost C1	21286.00	22922.06	25041.86	23083.31
Cost C2	31286.00	32922.06	35041.86	33083.31
Cost C3	34414.60	36214.27	38546.05	36391.64

Table-8 : Gross income from wheat on different size holdings of Sprinkler irrigated farms.

Size holdings	Yield (q/ha)	By product (q/ha)	Gross income (Rs./ha)
Small	30.18	53.21	72908.00
Medium	31.85	58.34	77488.75
60 Large	33.28	62.75	81415.50
Overall	31.77	58.10	77,270.66

Table-9 : Gross income from wheat on different size holdings of surface irrigated farms (through tube well).

Size holdings	Yield (q/ha)	By product (q/ha)	Gross income (/ha)
Small	25.31	46.24	50283.49
Medium	27.54	49.58	66786.50
Large	29.30	53.63	71275.00
Overall	27.38	49.81	62781.66

equipment's such as submersible pump (Rs. 26000), starter box (Rs. 4500), cable wires (Rs. 10000), Bore pipes of 20ft each (Rs. 5000), gate valves and other miscellaneous items (Rs. 2000). Thus the final cost of installation of Tube well is Rs. 72900.

From table-4 and 5, it could be concluded that the per cent share of machine labour, family labour, casual hired labour, chemicals, irrigation charges, interest on working capital, depreciation of fixed assets and interest on fixed assets in total cost were higher on Sprinkler irrigated farms than on surface irrigated farms while, on surface irrigated farms the per cent share of seed, manure, fertilizer and rental value of owned land in total cost was higher than on Sprinkler irrigated farms as compared to tube well irrigated farms.

The Table-6 and 7 reveal that cost A1, on an overall basis, was Rs. 23430.70 on Sprinkler irrigated farms. It increased with the increase in size of holding while on surface irrigated farms Cost A1, on an overall basis, was Rs. 19123.27. It increased with the increase in size of holding on surface irrigated farms also. The difference between Cost A1 on Sprinkler and surface irrigated farms was mainly due to more depreciation charges on fixed capital resources in Sprinkler category such as farm implements, Sprinkler system cost, electricity charges, pump set cost etc. and also because of more charges on irrigation in Sprinkler category. Cost A2 was worked out to be same as Cost A1 in both categories (Sprinkler and surface) because none of the farmer had leased-in land. Cost B1 and B2 on Sprinkler irrigated farms were worked out to be Rs. 22972.27 and Rs. 32972.27, respectively while on surface irrigated farms Cost B1 and B2 were worked out to be Rs. 20079.31 and Rs. 30079.31, respectively. The Costs C1 and C2, on an overall basis, were worked out to be Rs. 26661.27 and Rs. 36661.27, respectively, on Sprinkler irrigated farms while on surface irrigated farms Cost C1 and C2, on an overall basis and were worked out to be Rs. 23083.31 and Rs. 33083.31, respectively. Cost C3, which includes managerial cost, was worked out to be Rs. 40327.4 and Rs. 36391.64 per hectare, on an overall basis, on Sprinkler and on surface irrigated farms, respectively. Thus, on an average, the total cost (Cost C2) of cultivation of wheat on Sprinkler irrigated farms was higher about 9.75 per cent to the surface irrigated farms.

In case of gross income (table 8 and 9), the overall gross income was worked out to be Rs.77270.66 in case

Table-10 : Returns on Sprinkler irrigated farms in wheat crop (Rs./ha).

Particulars	Size Holdings			Overall Average
	Small	Medium	Large	
Gross Income	72908.00	77488.80	81416.00	77270.75
Farm Business Income	54494.00	56146.40	55024.00	55221.56
Family Labour Income	43542.50	45223.50	44129.00	44298.48

Table-11 : Returns on surface irrigated farms (through tube well) in wheat crop (Rs./ha).

Particulars	Size Holdings			Overall Average
	Small	Medium	Large	
Gross Income	50283.50	66786.50	71275.00	62781.66
Farm Business Income	33594.60	47915.30	49465.00	43658.29
Family Labour Income	22622.50	36956.40	38528.00	32702.35
Net Income	18997.50	33864.40	36233.00	29698.35

Table-12 : Comparison of gross income in cultivation of wheat through sprinkler and surface irrigation through tube well.

Size holdings	Yield (q/ha)	By product (q/ha)	Gross income (Rs/ha)
Small	25.31	46.24	50283.49
Medium	27.54	49.58	66786.50
Large	29.30	53.63	71275.00
Overall	27.38	49.81	62781.66

Table-13 : Comparison of returns between sprinkler irrigation and surface irrigation through tube well (Rs./ha).

Particulars	Overall Average (Sprinkler) (Rs/ha)	Overall Average (Tube well) (Rs/ha)
Gross Income	77270.75	62781.66
Farm Business Income	55221.56	43658.29
Family Labour Income	44298.48	32702.35
Net Income	40609.48	29698.35

Table-14 : Table regarding benefit-cost ratio in wheat cultivation.

Particulars	Small	Medium	Large	Overall
Sprinkler irrigated farms	2.15	2.16	2.02	2.11
Surface irrigated farms	1.60	2.02	2.03	1.88

of sprinkler irrigated farms and Rs.62781.66 in case of surface irrigated (Tube well) farms. Gross income was highest in large farms (Rs.81415.50), followed by medium farms (Rs.77488.75) and small farms (Rs.72908.00) in Sprinkler irrigated farms. Similarly in surface irrigated farms the gross income was highest in large farms (Rs.71275), followed by medium farms (Rs.66786.50) and small farms (Rs.50283.49). This indicates there is increase in gross income with increase in land holdings.

From table-10 and 11, it can be concluded, the net income increased with the increase in size of holding in both categories. Thus, the net income per hectare was estimated higher on Sprinkler irrigated farms than on surface irrigated farms in each category of farm.

It is evident from the table 14 that on an average, the overall B: C ratio was 2.11 and 1.88 for sprinkler and surface irrigated farms respectively. B:C ratio in sprinkler irrigated farms was 2.15 on small, 2.16 on medium and 2.02 for large farms. While on the surface irrigated farms highest B: C ratio was on large farms (2.03), followed by medium (2.02) and small farms (1.60). Thus, the overall benefit-cost ratio in wheat production was higher in sprinkler farms than the surface irrigated farms in all categories of farm.

Conclusion

In general, on sprinkler irrigated farms, all cost components in both the selected crop (wheat) were greater than on surface irrigated farms. The higher cost of using the sprinkler system was attributable to the increased use of human labour in its operation; more watering, which raises electric rates, depreciation charges on fixed assets, and interest on debt and rental value of owned land. Farms with sprinkler irrigation were shown to be more profitable than those with surface irrigation. Sprinkler irrigated farms had higher productivity than surface irrigated farms for the selected crop. Sprinkler irrigated farms had higher gross income, farm business income, and net income from the selected crop than surface irrigated farms. Sprinkler irrigated farms had a greater benefit-to-cost ratio than surface irrigated farms for both of the selected crops. This demonstrated that irrigation provided by a sprinkler system was more effective at boosting revenue than irrigation provided by a surface system.

References

1. Bhatnagar, P., kaul, M.K., Singh, J., Manmohan, J.R. and Chauhan, P.S. (2011). Effect of micro- irrigation on growth of kinnow mandarin under silvihorti system. *Indian forester*. 137(12): 1391-1395.
2. Gangwar, A.C. and Agarwal, M.C. (1982). "Economic feasibility of sprinkler irrigation in desert areas of Haryana". *Haryana Agric. Univ. Jn. Res.*, 12(4) : 696-704.
3. Okunade, D.A., Olanusi, O.A. and Adekalu, K.O. (2009). Growth, yield and economics of okra under sprinkler irrigation. *International Journal of Vegetable*. 15(1): 28-43.
4. Rao, G.V. and Shankaran, N.L. (1976). Sprinkler for economic and efficient use of irrigation water". *Bhagirath*, 13: 7-9



Fuel Quality Assessment of Biodiesel Produced through Transesterification Process from Different Plant Oils

Atul Kumar Shrivastava, D.M. Kadam, R.K. Rathod and R.K. Dubey

Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, JNAU, Jabalpur-482004, M.P.

Email : atul_jnkvv@yahoo.com

Abstract

The study and optimization of biodiesel production are very important because of its renewable nature and environmentally beneficial attributes. The present study highlights methods related to the production and analytical characterization of biodiesel obtained from different plant oils for its fuel quality assessment. Biodiesel is obtained by reacting plant oils with alcohol (transesterification) in the presence of a basic catalyst to give the corresponding mono alkyl ester. The result of the investigation on methyl esters obtained by transesterification process from the Jatropha, Mahua, Karanja, Soybean and Rice bran oils are presented, analysed, compared with fuel diesel and are discussed in this paper. It is concluded from the properties study, that almost all the characteristics of biodiesels, prepared from different biodiesels, are similar to those of diesel. Therefore, it can be used as an alternate fuel in diesel engines.

Key words : Biodiesel, mahua oil, karanja oil, jatropha oil, plant oil, vegetable oil, extraction, transesterification process.

Introduction

Energy has always been an important aspect of man's activities. As demand energy is excessively increasing, there has been a relentless search for the different forms of energy that will meet up with his activities. Many countries in the world are resorting to biofuel technology to solve the problem of the gradually increasing rate of fuel and energy prices resulting from the depletion of the world's non-renewable fossil fuels. This has led to research for alternative fuels to replace conventional petroleum fuel.

There are more than a dozen alternatives and advanced fuels in production and use today of which biodiesel is one. Biodiesel refers to any diesel equivalent fuel made from renewable biological materials such as vegetable oils or animal fats. Biodiesel consists of alkyl esters of long chain fatty acids derived from vegetable oil or animal fats through a process called trans-esterification reaction (Van Gerpen, 2005). Biodiesel fuel is an alternative to conventional fossil fuel and belongs to ecological fuels because of its qualitative composition (carbon 77%, hydrogen 12% oxygen 11% and traces of sulfur and nitrogen). As the fuel of biological origin, it is recommended by most of the country and classified as a future fuel. The production of methyl esters of Karanja, Mahua, Rice Bran, Soybean and Jatropha oil are an interesting for the investigations. Biodiesel is worthy of continued study and production procedures optimization because of its renewable nature and favorable environmental attribute. It has attracted considerable

attention during the past decade as renewable, biodegradable and non-toxic fuel (Ibeto *et al.*, 2011).

The present study was carried out to highlighting analytical methods for the quality assessment of biodiesel obtained from plant oils (i.e. Karanja, Mahua, Rice Bran, Soybean and Jatropha oil) for its effective utilization as fuel.

Materials and Methods

The characteristics of biodiesel produced by transesterification process were determined for fuel quality assessment and same are discussed in this research article.

Determination of Characteristics of Biodiesel for fuel quality assessment : The final product quality for methyl esters is generally described by means of acid value. The density, viscosity, cloud point, pour point, acid number, flash point, fire point, copper strip corrosion test, carbon residue, ash content, gross heat value was estimated for assessment of fuel quality of produced biodiesel from vegetable oils.

Density : A density hydrometer was used to determine density of diesel and biodiesels. The sample was transferred to a cylinder of clear glass. The hydrometer was lowered into the sample and allowed to settle. A thermometer was also placed into the cylinder. Then the hydrometer and temperature reading were noted.

Kinematic Viscosity : Kinematic viscosity of sample was measured by using Redwood Viscometer No.1. During measurement of kinematic viscosity of prepared biodiesel

Table-1 : Copper strip classifications.

Classification	Designation	Description
1	Slight tarnish	Light orange, almost the same as a freshly polished strip, dark orange.
2	Moderate tarnish	Claret red, lavender, multicolored with lavender blue and/or silver over laid or claret red, silvery, brassy or gold
3	Dark tarnish	Magenta overcast or brassy strip, multicolored with red and green showing (peacock), but not gray
4	Corrosion	Transparent black, dark gray, or brown with peacock green barely showing graphite or lusterless black glossy or jet black

Table-2 : Fuel properties of different biodiesels of plant oil.

Plant Oil	Density (g/ml)	Viscosity (mm ² /s)	Cloud Point (°C)	Pour Point (°C)	Flash point (°C)	Fire point (°C)	Acid number Mg KOH/g	Copper Strip Copper test	Ash Content (% by mass)	Carbon Residue (wt %)	Gross Heat Value (MJ/Kg)
Jatropha	0.878	4.600	2.10	-6.1	176	199	0.38	1	0.0	0.014	38.450
Karanja	0.898	5.330	12.2	5.5	175	182	1.04	1	0.0	0.011	38.42
RRice Bran	0.895	6.750	10.0	-5.2	176	184	0.4	1	0.001	0.012	39.17
Mahua	0.882	4.607	5.50	-2.2	186	192	0.76	1	0.0	0.010	39.06
Soybean	0.897	6.400	1.10	-7.8	185	192	0.4	1	0.003	0.011	34.46
Diesel	0.845	3.441	5.50	-5.5	79	85	0.24	1	0.005	0.035	45.21

sample by using viscometer, the time of gravity flow of a fixed volume (50 ml) of fluid was measured. Apparatus was leveled by using a spirit level. Oil cup was cleaned, then filled with biodiesel up to the pointer mark inside the cup. The water in copper bath was heated and oil in the cup was brought to desired temperature by heating. The valve was removed and sample was allowed to flow from viscometer and collected in the flask kept just below the gate jet. The time for collection of 50 ml oil was noted with a stopwatch.

Flash Point : A cleave land apparatus was used to measure the flash point of samples. The sample was filed in a brass cup and was heated at a slow and constant rate. At the same time, a small test flame was diverted to the top of the cup at regular intervals after each 30C for one second only. The flash point was taken as the lowest temperature at which the flame caused the vapour above the sample to ignite momentarily.

Cloud and Pour Point : A container filled with an ice and sodium chloride mixture was insulated in order to achieve the low temperatures below the freezing point of water. The hole was provided on the top cover to insert the test tubes containing samples. A thermometer was placed in the tube coaxially. At every 1°C fall in temperature, tubes were taken out (for 3 seconds) for observing the cloudiness, and blow that temperature when sample ceases to flow when the jar tilted, record the temp for pour point.

Acid Number : It determines the acidic or basic constituents in petroleum products and lubricants. For biodiesels, the acid number is an indicator of the quality of

the product. Initially, 10 g of accurately weighted sample was collected in a conical flask, then add 50 ml each of alcohol and water. Shake thoroughly and titration against 0.5 N KOH, then by dropper, drops phenolphthalein till pink color was obtained, then calculate the acid number, by following equation :

$$\text{Acid Number} = (V \times 56) / W \quad \dots(1)$$

Where, W = Weight of fuel taken in gram; and

V = Volume of KOH used.

Copper Strip Corrosion Test : It measures the degree to which the fuel can have a corroding effect on copper. A polished copper strip was immersed in a known quantity of the sample and heated at a fixed temperature for a certain time. At the end of this period, the copper strip was removed, washed and compared with the copper strip corrosion standards.

Carbon Residues Test : This determines the amount of carbon residue left after evaporation and pyrolysis of fuel, indicating its relative propensity to form coke. This determined by Conradson Carbon Residue Apparatus, in which taken 10 gm of the sample in a silica crucible, then placed this in apparatus. Now placed ni chrome wire triangle on a suitable stand and putt on it the hollow sheet box. Then placed the sheet iron crucible in the block with its bottom on the top of triangle and covered the sheet iron hood. Then applied flame from gas burner at 10 minutes, when smoke appears from chimney. The following equations was used to determine the percentage of carbon residue on the sample.

$$\text{Percentage of carbon in the given oil} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad \dots(2)$$

Where, W_1 = Weight of the crucible in g;

W_2 = Weight of the crucible g + Fuel in g; and

W_3 = Weight of the crucible g + residue in g.

Ash Content : To determine the ash content of the sample, measured the amount of ash left after a sample was burned. The process of ash indicates undesirable impurities or contaminants. During procedure heated crucible to redness, allowed it to cool in a desiccator and weighed it. Weighed a small beaker containing the sample to the nearest 0.1 g and transferred successive portions of the sample to the crucible. Heated the crucible gently until the sample burns at the surface. Allowed the combustible matter to burn off slowly, and heated the residue strongly with a flame until the ash was free from carbon. Cooled the crucible and its contents in desiccators and weighed them. Repeated the heating until a constant weight was obtained. Per cent of ash in the given sample was obtained by using following equation :

$$\text{Percentage of ash in the given oil} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad \dots(3)$$

Where, W_1 = Weight of the crucible

W_2 = Weight of the crucible + Fuel

W_3 = Weight of the crucible + residue

Gross Heat Value : Gross Heat Value of samples was measured using a bomb calorimeter. The sample was placed in a gelatin capsule and then burnt in presence of oxygen in a bomb calorimeter. The total weight of the sample and the capsule was fed to the controller and the results, including the gross heating value, were taken on a printout. Knowing the weight and heat value of capsules, heat value of the sample was calculated, the formula is given below :

$$H_c = (W_e \times T) / M_s \quad \dots(4)$$

Where, H_c = Gross heat value of the fuel sample, cal/g

W_e = Water equivalent of the calorimeter assembly

T = Rise in temperature, $^{\circ}\text{C}$, and

M_s = Mass of sample burnt

Results and Discussion

The properties of esters of different edible & non-edible oils are shown in table 2. Experiment was designed to determine how variation in oil quality in comparison with diesel (variation shown in Fig. 1 to fig. 11).

The density of Karanja, Soybean and Rice bran biodiesel was found high i.e. 6.27%, 6.15% and 5.92%

respectively as compared to diesel, whereas in the case of Jatropha biodiesel it was found lower i.e. 3.90%. Density values of biodiesels and diesel have been presented in figure 1. It could be inferred from the figure that the density of different biodiesels i.e. Jatropha, Karanja, Rice bran, Mahua, soybean (0.878, 0.898, 0.895, 0.882 and 0.897 g/ml respectively) was quite close to that of diesel (0.845 g/ml). The density of different bio-diesel was 3.9 to 6.27 % higher than that of diesel. Biodiesels will have higher mass flow rate due to their high density. This will outweigh, to some extent, the lower heat values of the biodiesels.

It is obvious that method esters have a much lower viscosity than oil. The viscosity of biodiesel of Rice bran and Soybean was found higher i.e. 96.16% and 85.99% respectively as compared to diesel. Figure 2 shows that viscosity of biodiesel was quite high. It was in the range of 3 to 7 centistokes (cSt). Rice bran biodiesel had maximum viscosity followed by soybean biodiesel and Karanja bio-diesel, which was crossing the maximum limit of viscosity of biodiesel as per ASTM D 6751 (test code for bio -diesel). The viscosity affects the fuel atomization by the injector, engine deposits (increased viscosities associated with the increased deposits), and energy use (higher viscosity requires more energy by the fuel pump).

Cloud point of Karanja and Rice bran biodiesel was found higher i.e.121.81% and 81.81% respectively whereas it was found lower in case of Soybean and Jatropha i.e. 80.0% and 61.81% respectively. Cloud point shows the starting of clogging in fuel supply lines and filters because of the presence of saturated fatty acids. Figure 3 shows that cloud point of soybean and Jatropha biodiesel (i.e. 1.10 and 2.10 $^{\circ}\text{C}$ respectively) lowered than diesel (5.50 $^{\circ}\text{C}$) and other biodiesels i.e. Karanja, Rice bran, Mahua was 12.2, 10.0 and 5.5 $^{\circ}\text{C}$ respectively. Therefore, cloud points of biodiesels were quite close to that of diesel.

Pour point of Karanja biodiesel was found higher i.e. 200% whereas it was lower in the case of Soybean and Jatropha oil i.e. 41.81% & 10.91%. Pour point of biodiesel and diesel fuel are given in fig.4. It is clear from the figure that the pour point of Karanja biodiesel was very high (5.50C) followed by Mahua biodiesel (-2.2 0C) and rice bran biodiesel (-5.20C). Pour point reported by Gupta (1994) was -4.83 0C and Bhatt *et al.* (2001) was -50C. Table shows pour point of Jatropha, soybean was -6.10C and -7.80C respectively. These values differed little from that of diesel i.e. -5.50C. Therefore, these biodiesels will also not create a problem in engine operation at very low temperature, just like diesel.

It was observed that Flash point of Mahua and Soybean oil 135.44% and 134.17% higher than diesel

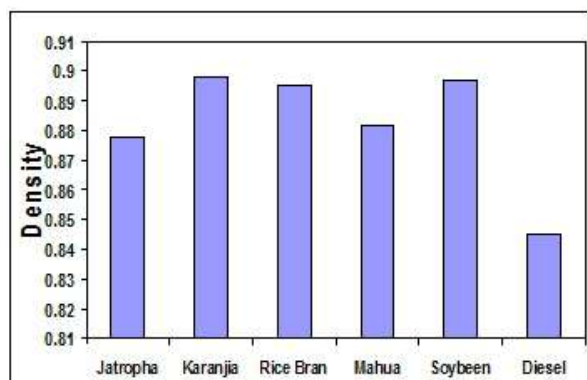


Fig-1 : Variation in density (g/ml) of different biodiesel of plant oil & diesel

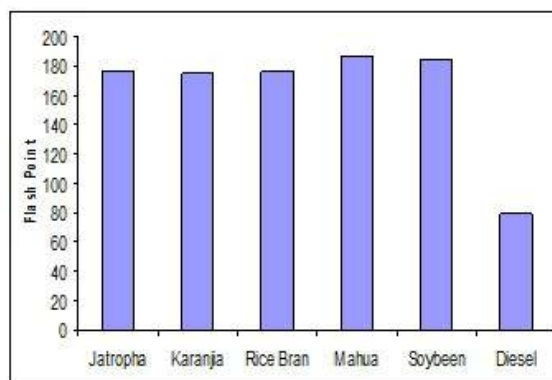


Fig-5 : Variation in flash point (°C) of different biodiesel plant oil & diesel

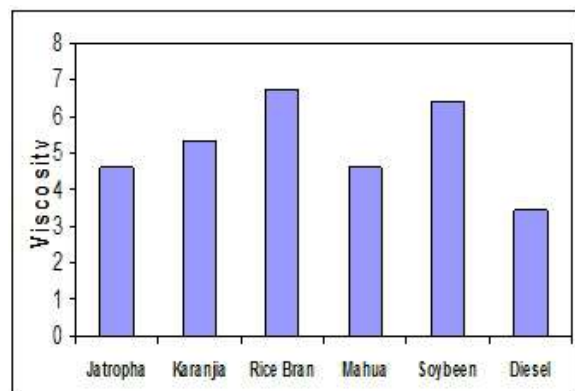


Fig-2 : Variation in viscosity (mm²/s) of different biodiesel of plant oil & diesel

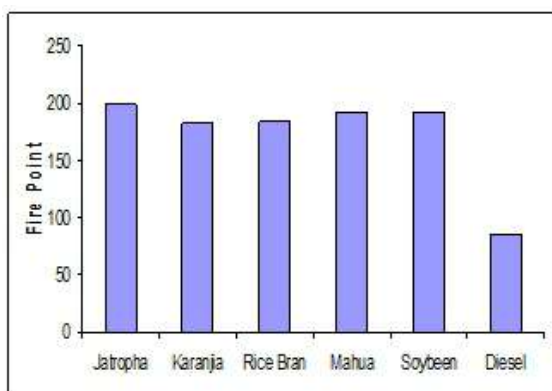


Fig-6 : Variation fire point (°C) of different biodiesel of plant oil & diesel

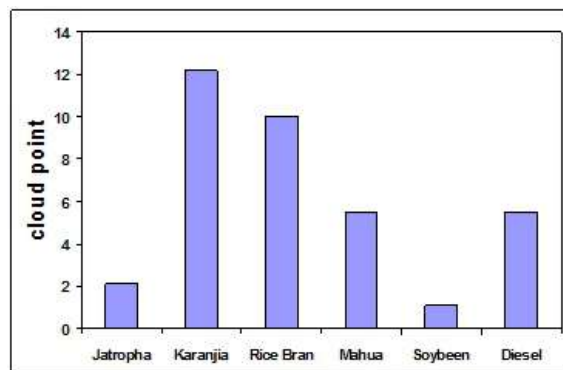


Fig-3 : Variation in cloud point (°C) of different biodiesel of plant oil & diesel

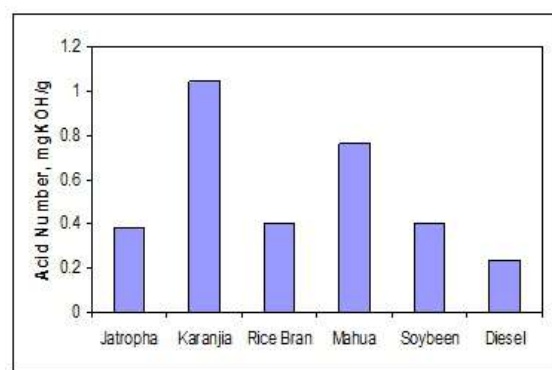


Fig-7 : Variation in acid number (Mg KOH/g) of different biodiesel of plant oil & diesel

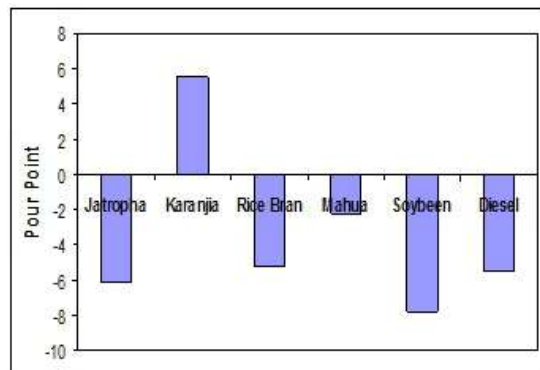


Fig-4 : Variation of pour point (°C) of different biodiesel of plant oil diesel.

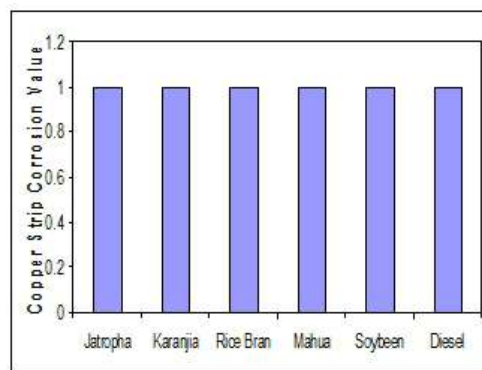


Fig-8 : Variation in copper strip corrosion value of different biodiesel of plant oil & diesel

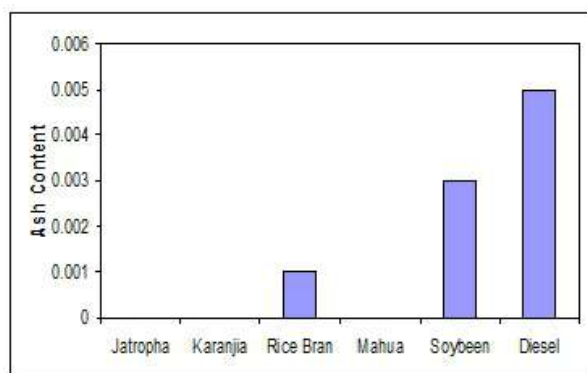


Fig-9 : Variation in ach content (% by mass) of different biodiesel of plant oil & diesel

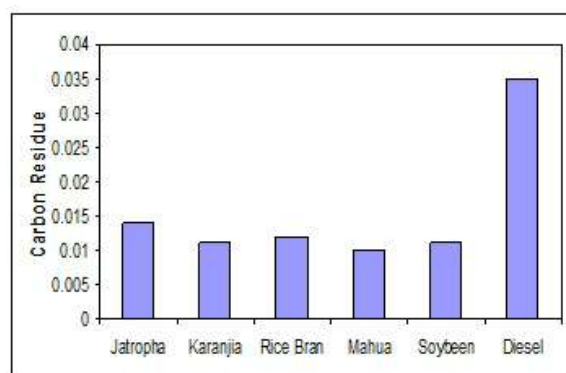


Fig-10 : Variation of carbon residues (wt %) of different biodiesel of plant oil & diesel

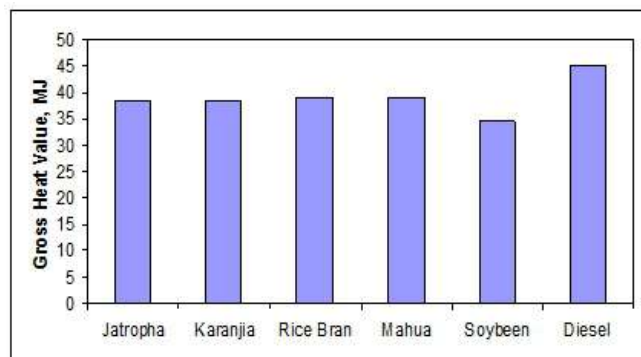


Fig-11 : Variation in gross heat value (MJ/Kg) of different biodiesel of plant oil & diesel

whereas it was lower in the case of Karanja oil. Whereas, flash point of diesel was 79°C. Thus, ensuring more safety during their transportation and handling. Verma (2003) reported that the higher value of flash point of biodiesels indicates that biodiesel is less likely to ignite accidentally. It is used to assess the overall flammability hazard of a material.

Fire point of all the biodiesel was found higher in range as compared to diesel, where fire point of Jatropha, Karanja, Ricebran, Mahua and Soybean was 199°C, 182°C, 184°C, 192°C and 192°C respectively.

Acid number of Karanja & Mahua was found 333.33% & 216.66% higher than diesel. The acid number of diesel and other biodiesels are shown in figure 7. It was also found that all the biodiesel had a higher acid number than diesel. The acid number of diesel was found to be 0.24 mg KOH/g. The acid number of soybean and rice bran was found to be similar i.e. 0.4 mg KOH/g whereas, for the Mahua and Karanja biodiesels, it was found to be 0.76 mg KOH/g and 1.04mgKOH/g respectively.

Table-1 shows that diesel and other biodiesels grouped one for Copper strip corrosion test. The values obtained with each of the biodiesels are the lowest level of corrosiveness and indicate that corrosion would not be considered a problem. The value of 1 is the lowest indication on the defined scale for this test. It should be noted that high levels of free fatty acids or residual levels of acids may results in lower values for this test. This test serves as a measure of possible difficulties with copper and brass or bronze parts of the fuel system. The presence of acids or sulfur-containing compounds can tarnish the copper strip, thus indicating the possibility for corrosion.

It was studied that there is a very negligible amount of ash content in Rice bran & Soybean oil and rest it was zero. Figure 9 shows a variation in Ach content of different biodiesel of plant oil & diesel.

The value of Carbon Residue (Fig.-10) was lower for biodiesels as compared to diesel. Carbon residue value was lower in each biodiesel & found lowest in case of Mahua and Soybean biodiesel (i.e. 23.78%) as compare to diesel.

Figure-11 shows the Gross Heating Value. The figure shows that biodiesels had less Gross heat value (34 -39.5 MJ/kg) compared to that of diesel (45.21 MJ/kg). This was because of oxygen present in the biodiesels. The gross heat value of Soybean biodiesel was about 76.37 % of that of diesel while the rice bran, Jatropha, Karanja, Mahua biodiesels had heat value of 86.64%, 85.04%, 84.98%, and 86.39% respectively. Table 2. Shows fuel properties of different biodiesel of Plant oil & diesel.

Conclusions

The properties study has shown that diesel and biodiesel obtained from different plant oils has almost same fuel qualities, its combustion products have lesser health hazards and particulate matter concentration. Therefore, biodiesel can be used as an alternate fuel in diesel engines without making much more modifications in the existing diesel engines.

References

1. Bhatt Y.C. and A.N. Mathur (2002). Biodiesel: An alternative diesel fuel. The Institute of Engineers (India), *Souvenir and Annual Bulletin*, 10: 29-31.
2. Dindorkar K. Swati, D.M., Mahalle, and S. Bhoyar (2008). Evaluation of cottonseed oil for biodiesel production. *International Journal of Agricultural Engineering*, Vol. 1, No. 2: 45-48.
3. Gupta, P.K., Rakesh Kumar, and B.S. Panesar (2008). Studies on characterization of selected plant oils and their bio-diesels. *Agricultural Mechanization in Asia, Africa, and Latin America*, Vol. 39, No. 2: 14-18.
4. Verma, P.K. (2003). The studies on generation of biodiesels & PTO performance evaluation of tractor energized with methyl esters of plant oil. Unpublished M. Tech. *Thesis*, College of Agricultural Engineering, JNKVV, Jabalpur.
5. Gupta et al (2008). Studies on characterization of selected plant oils and their biodiesels. *Agricultural Mechanization in Asia, Africa, and Latin America*, Vol. 39, No.: 14-18.
6. Van Gerpen, J., 2005. Biodiesel processing and production. *Fuel Process Technology*, 86:1097-1107.
7. Van Gerpen, J., B. Shanks, R. Pruszko, D. Clements and G., Knothe (2004). Biodiesel analytical methods. National Renewable Energy Laboratory, Midwest Research Institute, Battelle, Colorado, website: <http://www.nrel.gov/docs/fy04osti/36240.pdf>.
8. C.N. Ibeto, A.U. Ofoefule and H.C. Ezeugwu (2011). Fuel Quality Assessment of Biodiesel Produced from Groundnut Oil (*Arachis hypogea*) and its Blend with Petroleum Diesel.
9. American Journal of Food Technology, 6: 798-803.



Drying of Fenugreek Leaves Using Continuous Microwave Dryer

B.C. Khodifad^{1*}, N.K. Dhamsaniya² and P.J. Rathod³

¹Dept. of Processing and Food Engg., College of Agril. Engg. and Tech., JAU, Junagadh, Gujarat

²Polytechnic in Agro-Processing, Junagadh Agricultural University, Junagadh, Gujarat,

³Department of Biochemistry, Junagadh Agricultural University, Junagadh, Gujarat

*Email : bhargavkhodifad@gmail.com

Abstract

The present investigation was aimed to dry the fenugreek leaves using the continuous microwave dryer developed at Junagadh Agricultural University (India). The process variables viz., microwave power level and drying time were varied from 20 to 100% and 1.5 to 7.5 min, respectively using the response surface methodology. The obtained data were analysed for graphical representation, analysis of variance (ANOVA) and multiple regression using the software package Design Expert version 10.0.7.0 (State-Ease Inc., Minneapolis, MN, USA). The dried fenugreek leaves were analysed to obtain the changes in response of dependent variables of biochemical parameter viz., moisture content, total chlorophyll, ascorbic acid, crude fibre, total carotenoid and true protein due to varying the independent variables especially the microwave power level and drying time. The optimized microwave power level and drying time was found as 70% and 7.23 min for getting the better quality dried fenugreek leaves. At the optimized condition, the validated responses were recorded as moisture content 4.75% (wet basis), total chlorophyll 9.05 mg/g, ascorbic acid 535.30 mg/100g, crude fibre 22.95%, total carotenoid 125.45 mg/100g and true protein 23.70%. The leaves dried by continuous microwave dryer remained complete as whole and it can be easily crushed and converted in to a powder.

Key words : Fenugreek leaves; continuous microwave dryer; microwave power level; drying time

Introduction

Fenugreek (*Trigonella foenum Graecum* L.) belongs to the family of Leguminosae (Fabaceae) sub family Papilionaceae; also known as *Methi*. It is an important leafy vegetable-cum-condiment having excellent medicinal value. It is also known as nature's great boon. Its regular use helps in keeping the body healthy. The green tender leaves of fenugreek are rich source of minerals (Iron and Calcium), protein, vitamin A and vitamin C. It is used as vegetable alone or in combination with other vegetables. The seeds and dry leaves of fenugreek are used as a condiment and for medicinal purposes. Dried leaves and flowers are also used for flavouring of food [1]. Green leafy vegetables are highly perishable with shelf-life of only few days owing to higher moisture which spoils around 30% of the produce. This calls for preservation and processing to prevent losses as well as make them available in the lean season at remunerative price. Vegetable can be processed and preserved by various methods among which drying is considered to be an important property that is unmatched by any other preservation techniques [2, 3]. Drying is one of the oldest and traditional method of food preservation which is most widely used for food preservation. It converts the vegetable into light weight, easily transportable and storable product^[4, 5]. Major objective of drying is to remove moisture as quickly as possible at a

temperature that does not seriously affect flavour, texture and colour of the food [2]. Several techniques are available, based on evaporation or freeze concentration. Thermal evaporation is the most common industrial technique [6]. During microwave drying, these components are only exposed to low temperature and therefore suffer minimal thermal damage. It is, therefore, considered a mild concentration technique [7, 8]. Microwave drying has a potential for making superior quality produces while noticeably reducing drying duration^[9]. Microwave drying has numerous advantages over the conventional drying system such as less drying time, equal dissipation of energy all over a product, more energy efficient and offering qualitative product^[10]. Therefore, the present investigation was aimed to reduce the drying time and maintain the product quality of fenugreek leaves.

Materials and Methods

Raw material : The fresh well-matured leaves of fenugreek required for drying were procured from the Instructional Farm of College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh (Gujarat, India). The leaves were arranged in 0.5 kg batches for different drying treatments.

Experimental set-up : Microwave drying of fenugreek leaves was accomplished in continuous microwave dryer (2450 MHz microwave frequency and 3.7 kW power). The

equipment consisted of 2 m long drying chamber of 0.3 m width having Teflon conveyor mesh belt. The fenugreek leaves were dried in a single layer in continuous microwave dryer. A two-factor five-level Central Composite Rotatable Design (CCRD) with quadratic model was employed to study the combined effect of microwave power level and drying time on different response variables. A total of 14 combinations were carried out in random order according to a CCRD configuration for the two chosen variables with six centre points.

Quality characteristic : The dried fenugreek leaves were analysed for retaining the different biochemical attributes. The changes in response of dependent variables of biochemical parameters viz., moisture content, total chlorophyll, ascorbic acid, crude fibre, total carotenoid and true protein due to varying the independent variables especially the microwave power level and drying time were recorded.

Estimation of moisture content : The moisture content of dried fenugreek leaves was estimated by hot air oven method as described in AOAC [11]. The sample was put in a pre-weighed petri dish. The sample loaded petri dishes were placed inside the hot air oven at $105 \pm 1^\circ\text{C}$ till it attained constant weight. The samples were cooled in a desiccator and weighed. The initial and final weights were recorded and then used to calculate the moisture content on wet basis.

Estimation of Chlorophyll Content : The chlorophyll content in dried fenugreek leaf was determined by colorimetric method described by Sadasivam and Manickam [12]. According to this method, 0.2 g fenugreek leaf sample was ground by adding 80% acetone. After that it was centrifuged and collected the supernatant in 10 ml centrifuge tube. The absorbance was recorded at 645 and 663 nm against blank. The amount of chlorophyll present in extract was expressed in mg/g.

Ascorbic Acid Estimation : The indophenols method as described by Ranganna^[13] was used in the estimation of ascorbic acid in the dried fenugreek leaf. Ascorbic acid content was expressed as mg/100 g dry weight from.

Crude Fibre Estimation : Crude fibre is the organic residue that remains after the food sample which has been treated under standardized condition with petroleum spirit, boiling dilute sulphuric acid, boiling dilute sodium hydroxide solution and alcohol.^[11] Crude fibre content of fenugreek leaves was expressed in percentage (%).

Determination of Total Carotenoid : Total Carotenoids was determined according to the method of Harborne [14]. A sample of 0.5 g leaf was taken in a test-tube. In the sample, 10 ml of 80% acetone was added followed by

centrifuging at 3000 rpm for 10 minutes. Supernatant was taken in a separate tube and volume make up was done up to a known volume of 10 ml with 80% acetone. The optical density of supernatant was measured at 450 nm in UV spectrophotometer and total carotenoid was expressed in mg/100 g.

Estimation of True Protein : True protein content in the dried fenugreek leaf was estimated as per the method described by Sadasivam and Manickam [12]. A sample weighing 0.1 to 0.2 g was taken into test tube. In the sample, 10 ml of 0.1N NaOH was added and kept for 24 hours for extraction of sample. Supernatant was taken for analysis. BSA standard was used for set of standard run. Pipette out 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard into a series of test tube followed by Pipette out 0.2 ml from the supernatant of the sample in separate test tubes. Total volume was made up to 1 ml with distilled water. Then, added 5 ml of reagent C in each test tube. Mixed well and allowed to stand for 10 min. Then, added 0.5 ml of reagent D (FCR) in each test tube and mixed well and incubated at room temperature in the dark for 30 min and blue colour was developed. Then, optical density (O.D.) was read at 660 nm in spectrophotometer and true protein content was estimated in percentage (%).

Statistical analysis : The statistical analysis of the experimental data was carried out to observe the effect of selected process variables on the various responses. The obtained data were subjected to analyse for graphical representation, analysis of variance (ANOVA) and multiple regression using the software package Design Expert version 10.0.7.0 (State-Ease Inc., Minneapolis, MN, USA). Based on the validated predictive models, a numerical optimizer helps the user to determine the ideal values for each of the factors in the experiment. The software determines the main effects of each factor as well as the interactions between factors by varying the values of all factors in parallel. The three-dimensional (3D) response surface plots was generated using Design Expert software. The effect and regression coefficients of individual linear, interaction and quadratic terms were determined from the ANOVA Table [15].

Optimization and validation of process variables : The optimization of process variables was carried out by using Design Expert version 10.0.7.0 software. The optimum values of the selected variables were analysed by the response surface and also by solving the regression equation. Using these optimized conditions the experiments were again conducted to find out the variation in the different response variable. The closeness of the predicted and observed responses indicated the validity of developed model.

Results and Discussion

The effect of the microwave power level and drying time on the biochemical characteristics of fenugreek leaves during drying was investigated. The data of different responses during continuous microwave drying of fenugreek leaves are presented in Table 1. The regression coefficients for various responses and the corresponding R^2 and C.V. values are presented in Table-2 and Table-3. Analysis of variance indicated that the models are highly significant at $P < 0.05$ for all the responses (Table-2 and Table-3). The R^2 values for all responses were higher than 0.94, indicating the high accuracy and low proportion of the variability. Therefore, the models for all the responses were adequate. The general rule says that the coefficient of variation (C.V.) should not be more than 10%. In this investigation, the C.V. for all the responses were obtained lower than 10.0 (Table-2 and Table-3). The adequate precision value of all the responses indicated that the model can be used to predict the response within the design space as it was greater than 4.0 [16]. The similar results were also reported by Giri and Prasad [17] for microwave vacuum drying of button mushroom.

Moisture content : The moisture content of dried fenugreek leaves was obtained between 9.27% and 80.78% (w.b.) during different treatment combination. The minimum moisture content (9.27 %) was obtained at 60% power level and 7.5 min drying time in the developed continuous microwave dryer which was found about 8.71 times less than the maximum moisture content (80.78%) obtained at 20% power level and 4.5 min drying time (Table-1). Considering the criteria, following response model (Equation 1) was selected for representing the variation of moisture content for the further analysis.

$$\text{Moisture content} = +119.80 - 0.68 A - 2.13 B - 0.033 AB - 0.00016 A^2 - 0.68 B^2 \dots (1)$$

As increase in microwave power level and drying time may reduce moisture content of fenugreek leaves. It can be observed from ANOVA (Table-2), linear terms of power level and drying time and quadratic term drying time are extremely significant. It may be seen from Figure-1 (a) that moisture content of fenugreek leaves decreased with increase in microwave power level and drying time. It was happened due to increase in exposure time with increased drying time and also increase the magnitude of microwave energy (microwave power on time) with increase in microwave power level. Similar finding was observed for amaranth leaves dried by microwave energy at different microwave power level and drying time.^[18] Same trend was also reported by Walde et al.^[19] for wheat drying before grinding. Also, the increase in microwave power level resulted increase in drying

rates. Similar trend was observed by Maskan^[20] for drying of banana slices using the microwave.

Total chlorophyll content : Total chlorophyll content of dried fenugreek leaves was ranged between 1.81 to 8.78 mg/g (Table-1). The maximum total chlorophyll content was found 4.85 times more than the minimum total chlorophyll. Considering the criteria, following response model (Equation-2) was selected for representing the variation of total chlorophyll content for the further analysis.

$$\text{Total chlorophyll} = +0.50 + 0.035 A - 0.11 + B - 0.0087 AB + 0.00008 A^2 - 0.068 B^2 \dots (2)$$

The coefficients of model terms for power level and drying time are found positive and negative, respectively. This implies that the total chlorophyll content increased with increase in microwave power level and it is decreased with increase in drying time for fenugreek leaves. From Table-2, the model terms for total chlorophyll content as linear terms of power level and drying time are extremely significant. Whereas the interaction terms (AB) and square terms of (B^2) are less significant. Equation 2 shows that the linear term microwave power level, interaction term and quadratic terms were positively effected on total chlorophyll content of fenugreek leaves.

It clearly seen from Figure-1(b) that the total chlorophyll content of fenugreek leaves was increased with increases in microwave power level and drying time. It may be occurred due to increase in dry matter in the dried fenugreek leaves with increased in drying time and microwave power level. The same trend was also seen by Ankita and Prasad^[21] for fenugreek leaf powder.

Ascorbic acid content : The ascorbic acid content of dried fenugreek leaves was acquired from 200.00 to 533.33 mg/100g during different treatment combination (Table-1). Analysis of variance of Equation-3 and Table-2 indicate that the F values for linear terms of power level and drying time are extremely significant terms. Whereas the quadratic terms of A^2 and B^2 are less significant compared to linear terms.

$$\text{Ascorbic acid} = +208.33 - 0.66 A - 43.1 B + 0.28 + 0.029 A^2 + 7.87 B^2 \dots (3)$$

The coefficients of model terms for power level and drying time are found negative. This implies that the increase in microwave power level and drying time decreased the ascorbic acid content of fenugreek leaves. It may occurred due to higher microwave power level and high drying time. The coefficient of interaction model term is found positive. It may be due to combined effect of microwave power level and drying time. The quadratic terms microwave power level and drying time were positively affected on ascorbic acid of fenugreek leaves.

Table-1 : Biochemical and quality parameters of fenugreek leaves with different treatment combination.

Treatment No.	Microwave power level (%)	Drying time (min)	Moisture content (% wb)	Total Chlorophyll (mg/g)	Ascorbic acid (mg/100g)	Crude fibre (%)	Total caroteined (mg/100g)	True protein (%)
1.	80	6.0	13.30	8.31	483.33	19.47	116.80	21.84
2.	60	4.5	47.50	5.32	333.33	11.69	69.60	15.00
3.	60	7.5	9.27	8.78	533.33	22.53	124.80	23.47
4.	80	3.0	44.00	5.18	366.67	12.90	70.40	15.80
5.	60	4.5	46.07	5.09	316.67	10.26	68.00	15.36
6.	60	4.5	45.50	5.11	333.33	11.98	71.20	14.52
7.	40	6.0	47.70	4.52	300.00	9.71	62.40	15.44
8.	60	4.5	46.00	4.87	308.33	11.78	66.50	15.13
9.	60	4.5	46.82	5.05	316.67	12.06	69.60	14.78
10.	60	1.5	71.50	2.55	233.33	7.55	40.80	8.56
11.	100	4.5	11.50	8.62	516.67	21.83	120.80	22.86
12.	60	4.5	46.50	5.03	266.67	11.82	68.00	15.18
13.	20	4.5	80.78	1.81	200.00	5.66	24.00	5.87
14.	40	3.0	74.47	2.44	216.67	7.09	28.80	7.28

Table-2 : Analysis of variance for moisture content, total chlorophyll and ascorbic acid of dried fenugreek leaves.

Coefficients	Moisture content, (%)			Total chlorophyll, (mg/g)			Ascorbic acid, (mg/100g)		
	Coeff. Value	F	P	Coeff. Value	F	P	Coeff. Value	F	P
Model	+119.80	1056.00	< 0.0001	-0.50	274.53	< 0.0001	208.33	47.44	< 0.0001
Linear terms									
A-Power level	-0.68***	2905.12	< 0.0001	0.035***	764.91	< 0.0001	-0.66***	131.60	< 0.0001
B-Drying time	-2.13***	2323.67	< 0.0001	-0.11***	590.38	< 0.0001	-43.06***	90.13	< 0.0001
Interaction terms									
AB	-0.032	3.25	0.1089	0.0087*	6.22	0.0373	0.28	0.47	0.5126
Quadratic terms									
A ²	-0.00016	0.084	0.7797	0.000076	0.50	0.4990	0.029*	5.36	0.0492
B ²	-0.068***	45.97	0.0001	0.063*	11.13	0.0103	7.87**	12.81	0.0072
R ²	0.9985			0.9942			0.9674		
C.V. %	2.42			4.05			7.21		
Adjusted R ²	0.9975			0.9906			0.9470		
Adequate Precision	98.113			49.582			20.234		

Level of Significance : *P<0.05, **P<0.01, ***P<0.001, ns: not significant; df: degrees of freedom

It can be observed from Figure-1(c) that the ascorbic acid content of fenugreek leaves was increased with increased in microwave power level and drying time. It may be occurred due to increase in dry matter in the fenugreek leaves dried at higher drying time and microwave power level. Negi and Roy ^[22] had also observed higher ascorbic acid content in fenugreek leaves after drying. It may be due to increases in concentration of ascorbic acid as moisture content reduced.

The retention of ascorbic acid in higher amount by continuous microwave drying method was showed a comparatively high degree of safety for ascorbic acid than conventional drying methods. This might be credited to a quite lower drying temperature and smaller drying time, which can successfully prevent the oxidation of ascorbic acid. Similar kind of observation was reported by Xu et al. ^[23] for carrot drying in tunnel microwave drying.

Crude fibre content : The crude fibre content of dried fenugreek leaves was increased as moisture content decrease and it was found in the range of 5.66 to 22.53% (Table 1). The maximum crude fibre content was found at 60% power level and 7.5 min drying time and it was about 3.98 times more than the minimum crude fibre content at 20% power level and 4.5 min drying time.

$$\text{Crude fibre} = +10.75 - 0.10 A - 3.16 B + 0.0233 AB + 0.013 A^2 + 0.37 B^2 \dots (4)$$

From the ANOVA, (Table 3 and Equation (4)) it can be seen that the linear terms of power level and drying time are extremely significant terms. Whereas the square term A² is significant and B² is highly significant (Table-3). The coefficient of interaction model term and quadratic terms are positive. It shows that the increase in crude fibre content of fenugreek leaves with power level and drying time. It may due to lower moisture content was observed in leaves dried at higher microwave power level and

Table-3 : Analysis of variance for crude fibre, total carotenoid and true protein of dried fenugreek leaves.

Coefficients	Crude fibre, (%)			Total carotenoid, (mg/100g)			True protein, (%)		
	Coeff. Value	F	P	Coeff. Value	F	P	Coeff. Value	F	P
Model	10.75	58.91	< 0.0001	-12.13	374.32	< 0.0001	-12.13	464.22	< 0.0001
Linear terms									
A-Power level	-0.10***	164.57	< 0.0001	0.33***	1052.08	< 0.0001	0.33***	1267.58	< 0.0001
B-Drying time	-3.16***	109.86	< 0.0001	2.48***	771.54	< 0.0001	2.48***	1028.39	< 0.0001
Interaction terms									
AB	0.033	3.35	0.1044	-0.018*	6.17	0.0379	-0.018*	7.14	0.0283
Quadratic terms									
A ²	0.0013*	5.54	0.0465	-0.0004	2.27	0.1703	-0.0004	3.85	0.0854
B ²	0.37**	14.65	0.0050	0.11*	41.82	0.0002	0.11*	10.04	0.0132
R ²	0.9736			0.9966			0.9966		
C.V. %	8.56			3.60			2.63		
Adjusted R ²	0.9570			0.9944			0.9944		
Adequate Precision	22.627			66.057			66.057		

Level of Significance : * P<0.05, ** P<0.01, *** P<0.001, ns: not significant; df: degrees of freedom.

Table-4 : Optimized and validated of process variables for drying of fenugreek leaves.

Variables	Variables for targeted microwave power level					
	Goal	Importance	Optimum value	Goal	Importance	Optimum value
Microwave power level (%)	In the range	3	73.57	Targeted	3	70
Drying time (min)	In the range	3	6 min 57 s	In the range	3	7 min and 14 s
Responses	Responses for targeted microwave power level					
Constraints	Goal	Importance	Predicted value	Predicted value	Experimental value	Deviation (%)
Moisture content (%)	Minimum	3	5.01	4.49	4.75	5.79
Total chlorophyll (mg/g)	Maximum	3	9.27	9.28	9.05	2.47
Ascorbic acid (mg/100g)	Maximum	3	537.19	543.00	535.30	1.41
Crude fibre (%)	Maximum	3	23.04	23.16	22.95	0.91
Total carotenoid (mg/100g)	Maximum	3	131.057	131.93	125.45	4.91
True protein (%)	Maximum	3	23.78	24.03	23.70	1.37

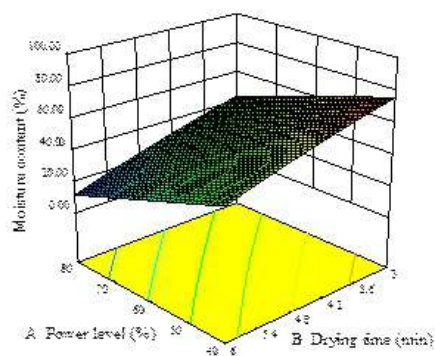
drying time. As the moisture content of leaves reduces simultaneously the crude fibre content was increased.

From the Figure-4(d), it can be seen that the crude fibre content in fenugreek leaves was increased with increase in microwave power level and drying time. The crude fibre content was observed inversely proportional with the moisture content of dried leaves. It may also due to crude fibre content was not greatly affected by range of drying temperature. Therefore higher amount of crude fibre content was observed in the treatment where lower moisture content was attained. Ankita and Prasad^[21] also reported higher crude fibre content in dried fenugreek leaves. Hence, the present findings are in agreement with the Ankita and Prasad.^[21]

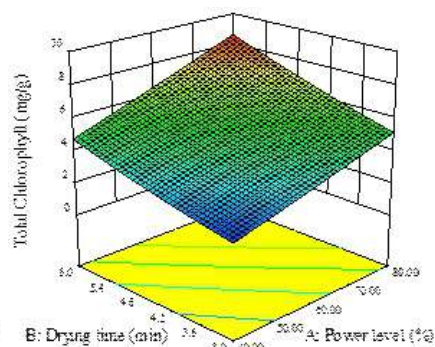
Total carotenoid content : The total carotenoid content of dried fenugreek leaves was obtained from 24.00 to 124.80 mg/100g during different treatment combinations. The maximum value was found at 60% power level and 7.5 min drying time.

$$\text{Total carotenoid} = -0.018 + 0.49A - 6.18B + 0.11AB - 0.0020A^2 + 1.15B^2 \dots (5)$$

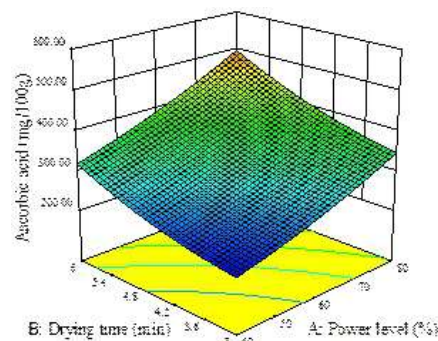
The effect of linear term microwave power level, interaction term AB and quadratic term B² are positively affected on total carotenoid (Equation-5). Also, the linear terms and quadratic term B² are extremely significant terms and interaction term AB is less significant (Table-3). It can be observed from Figure-1(e) that the total carotenoid content of fenugreek leaves was increased with increasing in microwave power level and drying time.



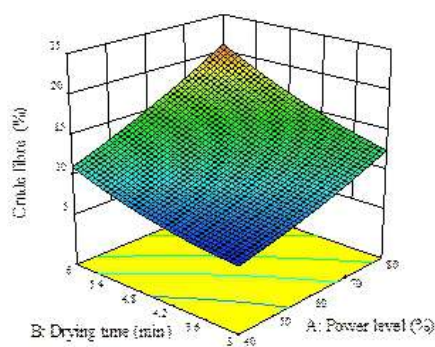
(a) Moisture content



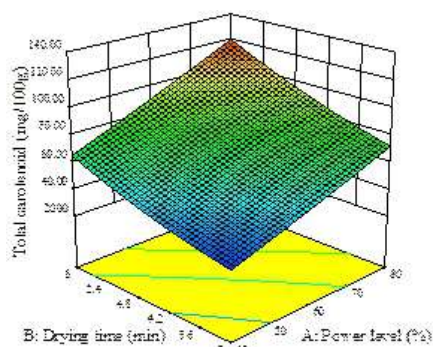
(b) Total chlorophyll



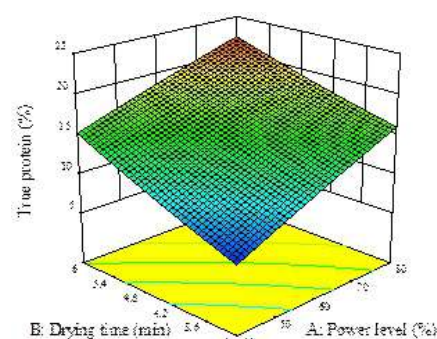
(c) Ascorbic acid



(d) Crude fibre



(e) Total carotenoids



(f) True protein

This may be due to increase in concentration of total carotenoid with reduction of moisture content. The higher amount of retention of chlorophyll and total carotenoid content was observed in continuous microwave dryer due to that the action of chlorophyllase and lipoxidase was critically reduced due to higher dehydration rate and shorter drying time. This was comparable with the report of Cui et al. [24] where they found that carotenoid retention of carrot slices and chlorophyll retention of chive leaves, dried by microwave assisted methods, was much better than those dried by conventional hot-air.

True protein content : The value of true protein content was observed between 5.87 to 23.47%. It was significantly affected by the linear terms and less significantly affected by interaction term and quadratic term B^2 (Table-3). The following response model was selected for representing the variation of true protein content for the further analysis.

$$\text{True protein} = -12.13 + 0.33A + 2.48B - 0.018AB - 0.0040A^2 + 0.11B^2 \dots (6)$$

Equation 6 shows that the linear terms of power level and drying time and quadratic term B^2 are positively affected on true protein content of fenugreek leaves. It means that, the true protein content increase with linear term and excessive increase in microwave power level. It

can also observed from the Figure-1(f) that the true protein content of fenugreek leaves was increased with increases in microwave power level and drying time. It may be due to increase in concentration of solid content with increasing the microwave power level and drying time. It may also due to the protein denaturation not take place during microwave drying because of mild temperature drying method. Walde *et al.* [19] also found that the microwave drying did not change the total protein content of wheat.

Optimization and validation of process variables : The desired goals for each variable and responses were chosen with equal importance for optimization of process variables (Table-4). According to the goals that were fixed for variables, the optimum treatment combination were found to be, 73.57% microwave power level and 6 min and 57 s drying time. With this optimized variables, the predicted responses are given in Table 4. But, in independent variable particularly the microwave power level can be adjusted by the interval of 10% power level. So the nearest value of microwave power level as 70% was selected for target value and according to that the predicted responses are given in Table 4. It might be possible to produce dried leaves with this treatment

combination as moisture content of 4.49%, total chlorophyll content of 9.28 mg/g, ascorbic acid of 543.00 mg/100g, crude fibre content of 23.16%, total carotenoid content of 131.93 mg/100g and true protein content 24.03% with a desirability of 1.0 (Table 4). Using these optimized conditions the drying experiment was again conducted to find the variation in the different responses. As per the results presented in Table 4, the experimental values of responses were very close to the predicted values (deviation < 10%). The closeness of the experimental and predicted responses indicated the validity of developed model.

These dried fenugreek leaves remained complete as whole leaves and easily crushed or blended to a powder. Similar kind of observation were reported by Mujaffar and Loy [18] for drying of amaranth leaves and Kathirvel *et al.* [25] for drying green leafy vegetables in batch type microwave oven. Deepika and Sutar [26] also obtained the quality product of the lemon slice with minimum specific energy consumption in microwave hot air drying due to lesser drying time.

Conclusion

The process variable for drying of fenugreek leaves optimized as microwave power level (70%) and drying time (7 min and 14 s). According to the optimized process variables, the validated responses were recorded as moisture content 4.75%, total chlorophyll 9.05 mg/g, ascorbic acid 535.30 mg/100g, crude fibre 22.95%, total carotenoid 125.45 mg/100g and true protein 23.70%. The drying of fenugreek leaves using continuous microwave dryer is the best to get best quality dried fenugreek leaves with maximum retention of biochemical parameter. The leaves dried by continuous microwave dryer remained complete as whole and it can be easily crushed and converted in to a powder. Thus, the drying with continuous microwave dryer at 70-80% microwave power level is recommended for drying fenugreek leaves.

Acknowledgements

The authors are thankful to the Junagadh Agricultural University to for providing all the required facilities for conducting the various investigations.

Disclosure statement

The authors have declared no conflict of interest.

References

- Katyal, S.L.; Chadha, K.L. Vegetable growing in India. Oxford and IBH Publishing Company, New Delhi, 1985.
- Rajeswari, R. Dehydration of green leafy vegetables and its effect on quality. *M.H.Sc. Dissertation, University of Agricultural Sciences, Dharwad, India*, 2010.
- Patil, G.D.; Pardeshi, I.L.; Shinde, K.J. Drying of green leafy vegetables using microwave oven dryer. *Journal Ready to Eat Food*. 2015, 2: 18-26.
- WoodRuff, J.G.; Luh, B. Commercial fruit processing, 2nd edition. *AVI Publishers*. USA. 1986.
- Chauhan, S.K.; Sharma, C.R. Development of instant dehydrated saag. *Beverages and Food World*. 1993, 20(4): 25-26.
- Sanchez, J.; Ruiz, Y.; Auleda, J. M.; Hernandez, E.; Raventos, M. Review. Freeze Concentration in the Fruit Juices Industry. *Food Sci. Technol. Int.* 2009, 15, 303–315. DOI: 10.1177/1082013209344267.
- Moreno, F.L.; Quintanilla-Carvajal, M.X.; Sotelo, L.I.; Osorio, C.; Raventos, M.; Hernandez, E.; Ruiz, Y. Volatile Compounds, Sensory Quality and Ice Morphology in Falling-Film and Block Freeze Concentration of Coffee Extract. *J. Food Eng.* 2015, 166, 64–71. DOI: 10.1016/j.jfoodeng.2015.05.018.
- Petzold, G.; Aguilera, J.M. Ice Morphology: Fundamentals and Technological Applications in Foods. *Food Biophys.* 2009, 4, 378–396. DOI: 10.1007/s11483-009-9136-5.
- Bourauoi, M.; Richard, P.; Durance, T. Microwave and convective drying of potato slices. *J Food Process Eng.* 2006, 17(3), 353-363. DOI: 10.1111/j.1745-4530.1994.tb00343.x
- Atong, D.; Ratanadecho, P.; Vongpradubchai, S. Drying of a slip casting for tableware product using microwave continuous belt dryer. *Dry. Technol.* 2006, 24(5), 589-594. DOI: 10.1080/07373930600626776
- AOAC. Official Methods of Analysis of the AOAC International, 18th ed., Gaithersburg, MD, USA. 2005.
- Sadasivam, S.; Manickam, A. Biochemical Methods for Agriculture Sciences, Wiley Eastern Limited. New Delhi. 1996.
- Ranganna, S. Handbook of analysis and quality control for fruit and vegetable products. (6th Edⁿ). New Delhi: *Tata McGraw-Hill Publishing Co. Ltd.* 2000.
- Harborne, J.B. Phytochemical Methods: A Guide to Modern Technique of Plant Analysis. Chapman A & Hall, London. 1973, 279.
- Whitcomb, P.J.; Anderson, M.J. RSM simplified: optimizing processes using response surface methods for design of experiments. CRC press. New York. 2004.
- Montgomery, D.C. Design and analysis of experiments (5th Edⁿ). New York: John Wiley. 2001, 455-492.
- Giri, S.K.; Prasad, S. Optimization of microwave-vacuum drying of button mushrooms using response-surface methodology. *Dry Technol.* 2007, 25(5): 901-911. DOI: 10.1080/07373930701370407
- Mujaffar, S.; Loy, A.L. Drying kinetics of microwave-dried vegetable amaranth (*Amaranthus dubius*) leaves. *J Food Res.* 2016, 5(6): 33-44. DOI: 10.5539/jfr.v5n6p33
- Walde, S.G.; Balaswamy, K.; Velu, V.; Rao, D.G. Microwave drying and grinding characteristics of wheat (*Triticum aestivum*). *J Food Eng.* 2002, 55(3): 271-276. DOI: 10.1016/S0260-8774(02)00101-2.
- Maskan, M. Microwave/air and microwave finish drying of banana. *J Food Eng.* 2000, 44(2): 71-78. DOI: 10.1016/S0260-8774(99)00167-3.

21. Ankita; Prasad, K. Chemical and physical characterization of dehydrated functional fenugreek leaf powder. *Asian J Chem.* 2015, 27(10): 3697-3703.
22. Negi, P.S.; Roy, S.K. Effect of blanching and drying methods on β -carotene, ascorbic acid and chlorophyll retention of leafy vegetables. *LWT-Food Science and Technology.* 2000, 33(4): 295-298.
23. Xu, Y.; Lang, X.; Xiao, Y.; Li, D.; Liu, C.; Song, J.; Zhou, C. (2020). Study on drying efficiency, uniformity, and physicochemical characteristics of carrot by tunnel microwave drying combined with explosion puffing drying. *Dry Technol.* 2020, 1-14. DOI: 10.1080/07373937.2020.1803351.
24. Cui, Z.-W.; Xu, S.-Y.; Sun, D.-W. Effect of microwave-vacuum drying on the carotenoids retention of carrot slices and chlorophyll retention of chinese chive leaves. *Dry Technol.* 2004, 22, 563–575. DOI: 10.1081/DRT-120030001.
25. Kathirvel K.; Naik K.R.; Gariepy Y.; Orsat V.; Raghavan G. S. V. Microwave drying-a promising alternative for the herb processing industry. In 2006 ASABE Annual Meeting 2006, (p. 1).
26. Deepika, S.; Sutar, P.P. Combining osmotic–steam blanching with infrared-microwave-hot air drying: Production of dried lemon (*Citrus limon* L.) slices and enzyme inactivation. *Dry Technol.* 2018, 36(14), 1719-1737. DOI: 10.1080/07373937.2017.1422744.



Assessment of Green Manuring and STV Based Nutrient Management in Mustard (*Brassica* spp.)

Debesh Singh, B.S. Kasana, Reena Sharma, S.P. Singh and S.V.S. Chauhan

RVSKVV-Krishi Vigyan Kendra, Morena (M.P.)

Abstract

Among the seven edible oilseed cultivated in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The productivity of mustard is declined due to deterioration in soil fertility levels. Green manuring has been well known to improve soil fertility. There are numerous benefits of green manuring. Present experiment was laid out in farmers field at ata and garikhera village of Morena district for assess the effect of green manuring on growth and yield of mustard crop. The most of farmers were practicing (S_1) fellow-mustard cropping system in referred villages. Krishi Vigyan Kendra Morena was demonstrated (S_2) green manuring with Dhaincha + 75 % RDF in these areas of mustard production system and (S_3) STV based Nutrient management in mustard under NICRA project during 2019-20 and 2020-21, with 5 replication. Each farmer's field was taken as replication. Data collected during the experiment were analysed in CRBD design. The results revealed that the application of green manuring + 75% RDF was beneficial in context of growth, yield and economics of mustard crop in comparison to farmers practice. However, it was at par to STV based Nutrient Management. The maximum yield (q/ha) was recorded with the application of green manuring with 75% RDF (22.28 q/ha) which was significantly at par with stv based nutrient management (21.40 q/ha) however, S_2 is significantly superior over S_1 (17.05 q/ha).

Introduction

Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. Among the seven edible oilseed cultivated in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The productivity of mustard is declined due to deterioration in soil fertility levels.

Green manuring has been well known to improve soil fertility. There are numerous benefits of green manuring. It increases soil organic matter, available nitrogen, concentration of nutrients near the soil surface in available form, and reduces the N losses through leaching and soil erosion (sultani *et al.* 2007). Increases organic matter in soil as a result of green manure improves soil physical properties by increasing the distribution and stability of soil aggregates and decreasing soil bulk density (McRae and Mehuys, 1988). Green Manuring in fellow soils is the most important way to influence topsoil and prevents the build-up of the aggregates, which could lead to the formation of surface crusts that reduce water infiltration. The vegetative cover reduces runoff as well as the concentration and the size of the transported sediment particles and thus, the rates of loss of both soil and moisture. It also influences the soil moisture and temperature dynamics.

Both legumes and non-legumes are used as green manures. However, legumes are superior green manure

crops as they fix atmospheric nitrogen and add it to the soil nitrogen pool (Carlson and Huss-Danell, 2003; Mayer, *et al.*, 2003). Keeping the facts in mind present study was designed to assess the green manuring with dhaincha to improve the fertility under fellow mustard cropping system.

Material and Methods

Present experiment was laid out in farmers field at ata and garikhera village of Morena district for assess the effect of green manuring on growth and yield of mustard crop. The most of farmers were practicing (S_1) fellow- mustard cropping system in referred villages. Krishi Vigyan Kendra Morena was demonstrated (S_2) green manuring with Dhaincha + 75% RDF in these areas of mustard production system and (S_3) STV based Nutrient management in mustard under NICRA project during 2019-20 and 2020-21, with 5 replication. Each farmer's field was taken as replication. Data collected during the experiment were analysed in CRBD design. The objective of these demonstration were to assess the effect of green manuring on soil properties of soil and ultimately on growth and yield of mustard crop. The demonstrations were also analysed for economic parameters during the experiments. During the experiment soil samples were collected from each farmer's field with help of soil auger at pre green manuring and post green manuring stage both the year. The collected soil samples were analysed at soil laboratory at KVK Morena. The mustard crop was sown 45 days after incorporation the green manure crop. The yield

Table-1 : Growth and yield as affected by various treatment in mustard crop during 2019-20 and 2020-21.

S. No.	No. of Branch/plant at 60 DAS	Plant Height (cm) at Harvest	No. of siliqua /plant	No. of Seed/ siliqua	Test weight (1000 seed weight) gm	Yield (q/ha)
S1	9.26	173.25	253.60	5.74	2.74	17.05
S2	13.51	190.19	285.80	6.36	3.98	22.28
S3	12.32	181.32	264.00	5.85	3.26	21.40
SEm	0.781	3.032	7.482	0.366	0.220	0.399
CD@5%	2.341	9.090	22.433	1.098	0.658	1.197

Table-2 : Economics of mustard crop as affected by various treatments during 2019-20 and 2020-21.

S. No.	Cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
S1	30850	76725	45875	2.48
S2	30050	100260	70210	3.33
S3	30500	96300	65800	3.15
SEm	-	-	-	-
CD@5%	-	-	-	-

and growth parameters were recorded as per recommended methods during the crop growth period.

Results and Discussion

The results of the experiment showed that the branch per plant was recorded maximum under (13.51) which was significantly superior over farmer's practice (9.26) however, it was significantly at par with STV based application of nutrients (12.32).

The plant height (cm) at harvest is recorded maximum under application of green manuring + 75% RDF 190.19 cm which was significantly superior over farmers practice (173.25 cm) and significantly at par with stv based nutrient management (181.32cm).

The number of siliqua per plant was also an important growth parameter in mustard crop. The number of siliqua was observed maximum with the application of green manuring + 75% RDF (285.80) which was at par to application of STV based nutrient management (264.00) and statistically superior over farmers practice (253.60).

Number of seed per siliqua observed minimum under farmers practice (5.74), which was statistically at par with both other treatment used in experiment. However the maximum number of seed per siliqua was recorded with the application of green manuring (6.36).

Test weight of mustard crop was also affected significantly due to various treatments. The maximum test weight (g) was recoded under application of green manuring (3.98) which was significantly superior over other treatments. However test weight (g) was significantly at par with each other. Kumari et al. (2010) also reported that the treatments with organic supplementation were more sustainable than those

supplied with sub optimal dose of inorganic fertilizers alone.

The maximum yield (q/ha) was recorded with the application of green manuring with 75% RDF (22.28 q/ha) which was significantly at par with stv based nutrient management (21.40 q/ha) however, S₂ is significantly superior over S₁(17.05 q/ha). Kasana *et al.* (2015) was also reported that total yield of cropping system was increased through incorporation of green manuring and there was significant increase in the grain yield of rice in plots receiving green manuring through dhaincha followed by 75% recommended dose of fertilizers-RDF in comparison to farmers practice. It has been widely documented that the inclusion of legumes in cropping system improved yields of both companion and subsequent crops and soil organic fertility (Bakht *et al.*, 2009).

Economics : Economics of any technology represent the viability of the technology. The maximum gross return (Rs.100260/ha), Net return (Rs.70210/ha) and B:C ratio (3.33) was recorded under the treatment S2 (application of green manuring with 75% RDF). However, the maximum cost of cultivation was also observed in same treatment (Rs.30850/ha). Which was followed by STV based Nutrient management and farmers practice respectively.

The experiment was concluded as the application of green manuring + 75% RDF was beneficial in context of growth, yield and economics of mustard crop in comparison to farmers practice. However, it was at par to STV based Nutrient Management. Here it was also stated that incorporation of Legume green manure crop in system can improve the soil fertility.

References

1. Bakht J, Shafi M, Jan MT and Shah Z, (2009). Soil C and N dynamics and wheat yield as affected by cropping systems and residue management in north western Pakistan. *Soil and Tillage Research* 104: 233-240.
2. Carlsson, G., Huss-Danell, K., (2003). Nitrogen fixation in perennial forage legumes in the field. *Plant Soil*, 253, 353-372.
3. Kasana, BS Tomar RKS, Tripathi MK and Tomar Surendra S (2015) Productivity and net return of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system as influenced by green manuring at farmers' field. *Current Advances in Agricultural Sciences* 7(2): 180-181 (December 2015) DOI : 10.5958/2394-4471. 2015. 00044.1
4. Kumari N, Singh AK, Pal SK and Thakur R, (2010). Effect of organic nutrient management on yield, nutrient uptake and nutrient balance sheet in scented rice. *Indian Journal of Agronomy* 55: 220-223.
5. Mayer, J., Buegger, F., Jensen, E.S., Schloter, M., (2003). Residual nitrogen contribution from grain legumes to succeeding wheat and rape and related microbial process. *Plant Soil*, 255, 541-554.
6. McRae, R.J., Mehuys, G.R., (1988). The effect of green manuring on the physical properties of temperate-area soils. *Adv. Soil Sci.*, 3, 71-94.
7. Sultani M. I., Gill M. A., Anwar M. M. and Athar M. (2007). Evaluation of soil physical properties as influenced by various green manuring legumes and phosphorus fertilization under rain fed conditions. *Int. J. Environ. Sci. Tech.*, 4 (1): 109-118, 2007



Influence of Microbial Inoculants on Biological Properties in the Rhizosphere of Capsicum (*Capsicum annuum* L.)

B.S. Nalini, L. Krishna Naik and R. Muthuraju

Department of Agricultural Microbiology, UAS, GKVK, Bengaluru-560 065, Karnataka, India

Corresponding Author : nalinibs90@gmail.com

Abstract

Capsicum is rich in beta carotene, capsaicin, vitamin A, vitamin C and antioxidant properties. Capsaicin is also known to help in restricting the binding of carcinogens with DNA. Microbial inoculants are used to improve plant nutrition while also promoting plant development by triggering the secretion of plant hormones. In a green house experiment, different combinations of microbial inoculants (*Azotobacter chroococcum* as nitrogen fixer, *Bacillus megaterium* as phosphate solubilizer and *Glomus fasciculatum* as phosphate mobiliser) were used at different levels of nitrogen, phosphorus, and potassium (50 per cent, 75 per cent, 100 per cent) along with recommended doses of farm yard manure and vermicompost. The results revealed viz., total bacteria, *Azotobacter* spp and total phosphate solubilizing bacteria enumerated from the rhizosphere soil of capsicum was found significantly the maximum in the treatment receiving *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* + 75% NP+100% K with vermicompost or FYM. Whereas, the total fungal population was maximum in the treatment involving *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* + 75% NP +100% K +FYM. Percent AM fungal root colonization was maximum in the treatment receiving *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* +75% NP+ 100% K+ vermicompost. Highest capsaicin content was observed in the treatment receiving only 100% NPK and among microbial inoculated treatments the capsaicin content found higher in the treatment with *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* +75% NP +100% K +FYM. Hence the application of microbial inoculants i.e., *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* will reduce the usage of inorganic fertilizer application and also helps in improving the soil fertility and sustainability.

Key words : Microbial inoculants, rhizosphere, biological properties, capsicum.

Introduction

Soil microorganisms have been differentiated by soil microbiologists and microbial ecologists, as beneficial and harmful according to their functions. Beneficial microorganisms are those that can stimulate plant growth by fixing atmospheric nitrogen, decomposing organic residues and enhance nutrient cycling, detoxifying pesticides, suppressing plant diseases, soil borne pathogens and by producing bioactive compounds such as vitamins, hormones, enzymes etc. Using some of these beneficial microorganisms, various microbial inoculants have been prepared for use in crop production to reduce the cost on chemical fertilizers and to minimize environmental pollution.

Capsicum (*Capsicum annuum* L.) belongs to the family Solanaceae, grown for its fruit. It is one of the most important vegetable crops and is widely cultivated throughout the warm, temperate, tropical and subtropical countries. *Capsicum* is a rich source of vitamin 'C' with plenty of minerals. Pungency in *Capsicum* is due to an alkaloid capsaicin, a benzylamine derivative. Biofertilizers play an important role for supplementing the essential plant nutrients for sustainable agriculture, economy and eco-friendly environment.

Mixed microbial inoculants interact synergistically which yields better and show quick results. Many researches have evidenced that development of plant growth promoting microbial consortium, could be a feasible technology for increasing the crop productivity with savings in chemical fertilizers application to an extent of 25 to 30 per cent. The constituent strains in the consortium not only out-compete with others for rhizospheric establishment but complement functionally for plant growth promotion (7). In the recent years, scientists have diverted their attention towards exploring the potentiality of these beneficial microorganisms for growth promotion and to obtain quality yields. In this context, this research study was initiated to study the plant growth promoting microbial inoculants effects on indigenous microflora of rizospheric soil of capsicum *Capsicum annuum* L.

Materials and Methods

The microbial inoculants of 24 hr old pure cultures of *Azotobacter chroococcum* and *Bacillus megaterium* with the population density of 48×10^9 cfu/ml and 35×10^9 cfu/ml respectively were transferred aseptically into flasks containing Waksman No. 77 broth and Sperber's broth respectively with the help of inoculation loop and

Table-1 : Effect of microbial inoculants on population density of total bacteria from the rhizosphere of *Capsicum* at different intervals.

Treat-ments	Bacteria (×10 ⁶ cfu/g dry weight of soil)			
	30DAT	60DAT	90DAT	Mean
T ₁	31.68	28.73	18.43	26.28
T ₂	42.06	39.33	29.03	36.81
T ₃	40.06	37.53	27.06	34.88
T ₄	32.43	29.43	19.53	27.13
T ₅	36.63	33.33	23.43	31.13
T ₆	38.63	35.53	25.73	33.30
T ₇	33.53	30.63	20.83	28.33
T ₈	35.43	32.23	22.23	29.96
T ₉	40.23	37.83	27.53	35.20
T ₁₀	31.34	28.13	18.35	25.94
T ₁₁	44.33	41.03	31.16	38.84
T ₁₂	38.33	35.43	25.53	33.10
T ₁₃	30.63	27.23	16.53	24.80
T ₁₄	30.35	27.63	16.06	24.68
T ₁₅	29.23	26.06	15.66	23.65
SE±	0.13	0.11	0.10	0.19
CD@5%	0.27	0.10	0.32	0.58

Table-2 : Effect of microbial inoculants on population density of total fungi from the rhizosphere of *Capsicum* at different intervals.

Treat-ments	Fungi (×10 ³ cfu/g dry weight of soil)			
	30DAT	60DAT	90DAT	Mean
T ₁	30.73	27.53	17.73	25.33
T ₂	31.53	28.86	18.53	26.31
T ₃	38.03	35.03	25.43	32.83
T ₄	30.53	27.23	17.26	25.01
T ₅	32.33	29.63	19.63	27.20
T ₆	36.73	33.73	23.73	31.40
T ₇	31.23	28.33	18.53	26.03
T ₈	32.93	29.33	19.43	27.23
T ₉	36.33	33.73	23.26	31.11
T ₁₀	30.68	27.83	17.53	25.35
T ₁₁	31.43	28.43	18.03	25.97
T ₁₂	34.53	31.53	21.03	29.03
T ₁₃	28.16	25.06	15.10	22.78
T ₁₄	29.10	26.63	16.43	24.06
T ₁₅	27.26	24.23	14.06	21.86
SE±	0.16	0.15	0.14	0.16
CD@5%	0.48	0.45	0.43	0.49

incubated on a mechanical shaker for 3 days for growth and mixed with carrier material. Effectiveness of these inoculants were tested on *Capsicum annum* L. (cv. *indira*) crop in a replicated pot culture study under glass house conditions and total microbial populations

Soil microbial load : The soil microbial load like total bacteria, total fungi, *Azotobacter* spp and *Bacillus* spp were enumerated from the capsicum rhizosphere at 30 days of interval. Air dried soil sample was serially diluted

by standard dilution plate count method. Bacteria, fungi, *Azotobacter* spp. and *Bacillus* spp. were enumerated in soil from specific dilution. The suitable agar media used were soil extract agar, Martin's rose bengal agar, Waksman No.77 and Sperber's media respectively. The inoculated plates were kept for incubation at 30 °C for 4 days and emerged colonies were counted.

Mycorrhizal spore count : The extrametrical chlamydospores in the root zone soil were determined by Wet sieving and decantation procedure as outlined by (3). For this, fifty gm soil sample was suspended in about 600ml water in 1 litre capacity conical flask and shaken thoroughly. After 20-30 seconds (for sedimentation of coarse sand) the suspension was decanted through a series of sieves arranged in descending order (1mm, 450, 325, 250, 105 and 45µ pore size). Then the content of the 105µ and 45µ sieves were carefully washed into a 100 ml conical flask before observation of the spores, the soil suspension in the flask was shaken and allowed to settle for 30 seconds and spores were trapped on a nylon mesh of 40 µm and placed on a sieve. the nylon mesh was then transferred on to a glass petriplate with parallel lines at distance of 1 cm made on the exterior of the base. The number of spores were then counted under the stereo microscope (40x magnification).

Per cent VAM colonization : The methodology followed for staining of root segments was developed by (8). The plant root segments were collected after uproot of the plant were immediately transferred to glass vials and fixed in FAA 5:5:90 solution (Formalin: Actic acid: Alcohol). Decanted FAA solution was decanted and 10% KOH was added and autoclaved at 121°C for 15 min to clear and soften the root bits. The root pieces were then rinsed in water and 1% HCL was added to neutralize the alkalinity due to KOH for five min. The roots were then washed with water to remove the acid. Staining was done by simmering the roots with 0.05% lactoglycerol with trypan Blue. The % root colonization was determined by grid line intersect method.

Treatments details

- T₁ – *Azotobacter* *hroococcum* (AC) + 75%N + 100%PK + FYM
T₂ – AC + *Bacillus megaterium* (BM) + 75%NP + 100%K + FYM
T₃ – AC + BM + *Glomus fasciculatum* (GF) + 75%NP + 100%K + FYM
T₄ – *Azotobacter chroococcum* (AC) + 50%N + 100%PK + FYM
T₅ – AC + *Bacillus megaterium* (BM) + 50%NP + 100%K + FYM
T₆ – AC + BM + GF + 50%NP + 100%K + FYM
T₇ – *Azotobacter* *hroococcum* (AC) + 75%N + 100%PK + vermicompost (VC)
T₈ – AC + *Bacillus megaterium* (BM) + 75%NP + 100%K + VC
T₉ – AC + BM + GF + 75%NP + 100%K + VC

Table-3 : Effect of microbial inoculants on population density of total *Azotobacter* spp. from the rhizosphere of *Capsicum* at different intervals.

Treat-ments	<i>Azotobacter</i> spp.($\times 10^3$ cfu/g dry weight of soil)			
	30DAT	60DAT	90DAT	Mean
T ₁	23.33	22.33	17.43	21.03
T ₂	20.63	18.73	15.83	18.40
T ₃	26.71	24.63	20.53	23.96
T ₄	23.83	21.63	17.63	21.03
T ₅	26.33	24.33	19.33	23.33
T ₆	24.63	22.03	18.53	21.73
T ₇	22.83	20.63	16.63	20.03
T ₈	23.33	21.53	17.63	20.83
T ₉	29.33	27.03	22.03	26.13
T ₁₀	22.33	20.43	16.03	19.60
T ₁₁	24.93	22.83	18.63	22.13
T ₁₂	22.53	20.33	16.33	19.73
T ₁₃	15.33	13.33	10.33	13.00
T ₁₄	15.73	14.03	10.90	13.55
T ₁₅	14.33	12.73	10.03	12.36
SE $\pm$	0.17	0.11	0.21	0.17
CD@5%	0.52	0.34	0.64	0.53

Table-4 : Effect of microbial inoculants on population density of phosphate solubilizing bacteria from the rhizosphere of *Capsicum* different intervals.

Treat-ments	Phosphate solubilizing bacteria ($\times 10^3$ cfu/g dry weight of soil)			
	30DAT	60DAT	90DAT	Mean
T ₁	17.03	15.67	14.03	15.58
T ₂	20.23	18.03	14.73	17.66
T ₃	24.63	22.73	21.73	23.40
T ₄	18.10	16.53	13.03	15.89
T ₅	22.33	20.43	16.43	19.73
T ₆	24.43	22.16	17.63	22.52
T ₇	16.73	14.53	11.53	14.26
T ₈	22.43	20.43	16.83	19.90
T ₉	25.06	23.33	22.83	21.41
T ₁₀	18.06	16.73	13.33	16.04
T ₁₁	20.63	18.63	14.06	17.77
T ₁₂	22.73	20.53	16.33	19.86
T ₁₃	13.16	11.67	8.63	11.15
T ₁₄	14.63	12.53	11.03	12.73
T ₁₅	12.33	10.03	9.06	10.47
SE $\pm$	0.12	0.11	0.10	0.12
CD@5%	0.37	0.34	0.31	0.38

Note : DAT-Days after transplanting.

T₁₀ – *Azotobacter chroococcum* (AC) + 50%N + 100%PK + VC

T₁₁ – AC + *Bacillus megaterium* (BM) + 50%NP + 100%K + VC

T₁₂ – AC + BM + GF + 50%NP + 100%K + VC

T₁₃ – 75%NP + 100%K

T₁₄ – 50%NP + 100%K

T₁₅ – 100%NPK

Capsaicin content : Capsaicin was estimated in the Department of Horticulture by using standard protocol suggested by (2). The following HPLC program was followed:

Pump mode : Low pressure gradient

Pump flow : 1 ml/min

Solvents : Methanol (100%)-70%

Methanol (10%)-30%

Oven temperature : 40°C

Detector : PDA @280nm

Process time : 15min

Weight of the sample : 1g

Volume of Acetonitrile : 20 ml

Process conditions: 80°C for 4hrs; swirled every 1hr

Statistical analysis : Statistical analysis of population data from laboratory experiment was done by two-way analysis of variance. Statistical analysis of data from glass experiment was done by using two way Completely Randomized Design (CRD).

Results and Discussion

Single, dual and consortium of *Azotobacter chroococcum*, *Bacillus megaterium*, and *Glomus fasciculatum* with different level of NPK fertilizers were tested in a glass house experiment to find out the effects of different microbial inoculants on total microbial population in *Capsicum* rhizosphere. The results thus obtained are discussed below. Before application of microbial inoculants, soil sample was collected and used for the enumeration of initial population of bacteria, fungi, *Azotobacter* spp. and PSB. The population of bacteria, fungi, *Azotobacter* spp. and PSB found was 13×10^6 cfu/gm of soil, 10×10^3 cfu/gm of soil, 8×10^3 cfu/gm of soil and 6×10^3 cfu/gm of soil respectively organisms were enumerated from rhizosphere soil of *Capsicum* at different stages of crop growth.

The results showed viz.. total bacteria (26.06×10^6 CFU/gm of soil), *Azotobacter* spp (19.33×10^3 CFU/gm of soil) and total phosphate solubilizing bacteria (23.33×10^3 CFU/gm of soil) enumerated from the capsicum rhizosphere soil was found maximum in the treatment receiving AC+BM+GF+75% NP+100% K with VC or FYM at 60DAT. Total fungal population (35.03×10^3 CFU/gm of soil) was maximum in the treatment involving AC+BM+GF+ 75% NP +100% K +FYM. The microbial population gradually reduced at 90th DAT. Increase in the microbial population in soil inoculated with different microbial inoculates could be due to modification of physico-chemical and nutritional properties of the soil.

Table-5 : Effect of microbial inoculants on arbuscular mycorrhizal spore numbers at different intervals from the rhizosphere of *Capsicum*.

Treatments	Chlamydospore count per 50gm of soil			
	30DAT	60DAT	90DAT	Mean
T ₁	35.44	33.63	29.43	32.83
T ₂	39.67	37.33	33.50	36.83
T ₃	74.33	72.53	68.60	71.82
T ₄	35.33	33.50	29.50	32.78
T ₅	43.66	41.53	37.63	40.94
T ₆	67.60	65.66	61.66	64.97
T ₇	41.00	38.53	34.43	37.99
T ₈	44.67	43.00	38.73	42.13
T ₉	59.63	57.56	53.70	56.96
T ₁₀	36.83	34.73	30.33	33.96
T ₁₁	50.33	48.76	44.66	47.92
T ₁₂	67.33	65.33	61.33	64.66
T ₁₃	34.33	32.56	28.33	31.74
T ₁₄	35.50	33.56	29.33	32.80
T ₁₅	32.56	30.33	26.50	29.80
SE±	0.34	0.25	0.23	0.27
CD@5%	1.03	0.74	0.68	0.80

Table-6 : Effect of microbial inoculants on per cent arbuscular mycorrhizal (VAM) colonization.

Treatment	% VAM colonization
T ₁	22.33
T ₂	26.00
T ₃	54.66
T ₄	20.33
T ₅	24.33
T ₆	50.00
T ₇	24.00
T ₈	26.00
T ₉	56.00
T ₁₀	24.00
T ₁₁	23.00
T ₁₂	53.33
T ₁₃	16.33
T ₁₄	19.00
T ₁₅	16.00
SE±	0.63
CD@5%	1.89

The results obtained in the study are in confirmation with the results highlighted by (9). The addition of microbial inoculants has been proved to improve soil biological properties. Also, (11) found increase in soil bacterial colonies and declined fungal colonies on the 40th day with the application of PSB. Similarly, (5) revealed that the maximum population of fungi and actinobacteria were attained at 60 DAS. The soil microbial population of soybean crop was also increased with *Rhizobium* and

Table-7 : Effect of microbial inoculants on capsaicin content of *Capsicum* fruit under glass house condition.

Treatments	Scovelli Heat Units (SHU)	Pungency level
T ₁	8603.63	Moderate
T ₂	8887.73	Moderate
T ₃	10200.16	Moderate
T ₄	8620.20	Moderate
T ₅	8706.37	Moderate
T ₆	10003.10	Moderate
T ₇	6077.58	Moderate
T ₈	7662.23	Moderate
T ₉	9032.60	Moderate
T ₁₀	6004.32	Moderate
T ₁₁	7541.36	Moderate
T ₁₂	9262.69	Moderate
T ₁₃	11600.53	Moderate
T ₁₄	11360.36	Moderate
T ₁₅	12310.51	Moderate
SE±	0.16	
CD@5%	0.47	

[Non-pungent (0-700SHU); Midly pungent(700-3000SHU); Moderately pungent (3000-25000 SHU); highly pungent (25000-75000 SHU); Very highly pungent (>80000 SHU) Ref: Othman et al., 2011, Nwokemet al., 2010].

PSB along with recommended dose of fertilizers (6). In contrast, (10) reported increase in actinobacteria and *Azotobacter* at harvesting time with inoculation of biofertilizers.

Arbuscular mycorrhizal sporulation (spore load/50gm soil) in rhizosphere soil was found to be highest in the treatment *Azotobacter chroococcum* + *Bacillus megaterium*+ *Glomus fasciculatum* + 75%NP + 100%K + FYM (72.53/50g of dry soil). Whereas percent VAM root colonization was maximum in the treatment with AC+BM+GF+75% NP+ 100% K+ VC. Highest capsaicin content was observed in the treatment receiving only 100% NPK and among microbial inoculated treatments the capsaicin content found maximum (12310.51SHU) in the treatment with AC+BM+GF+75% NP +100% K +FYM. Maximum VAM spores were recorded with the treatment (T₃) receiving *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* + 75%NP +100%K + FYM at different stages of crop growth. The mycorrhizal fungi in symbiosis with major crop plants make available phosphorus from soil to plants (4). The root exudates which contain minerals, vitamins and hormones encourage the multiplication of spore. The present results are in accordance with the results obtained by (1).

Conclusion

Findings of the study indicated that the *Azotobacter* spp and phosphate solubilizing bacterial population in the rhizosphere soil was maximum in the treatment

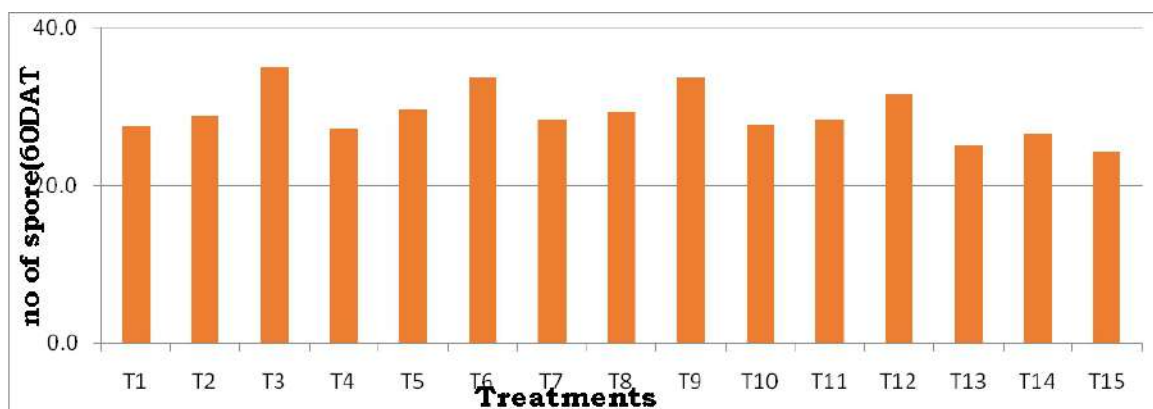


Fig-1 : Effect of microbial inoculants on arbuscular mycorrhizal spore numbers at 60DAT in the rhizosphere of *Capsicum* (spore count per 50g of soil).

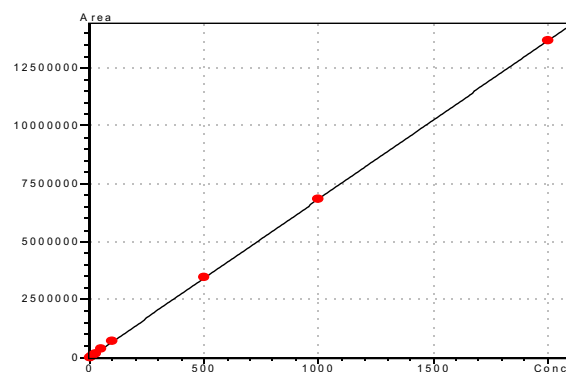
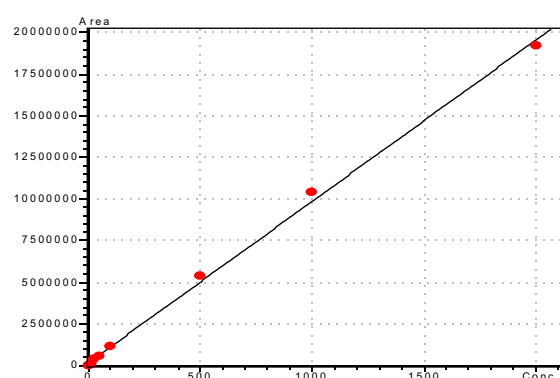
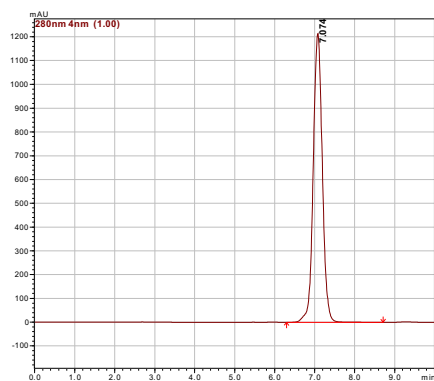
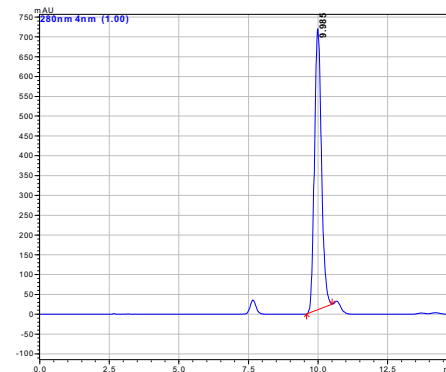


Fig-3 : HPLC Chromatograms.



Capsaicin Standard

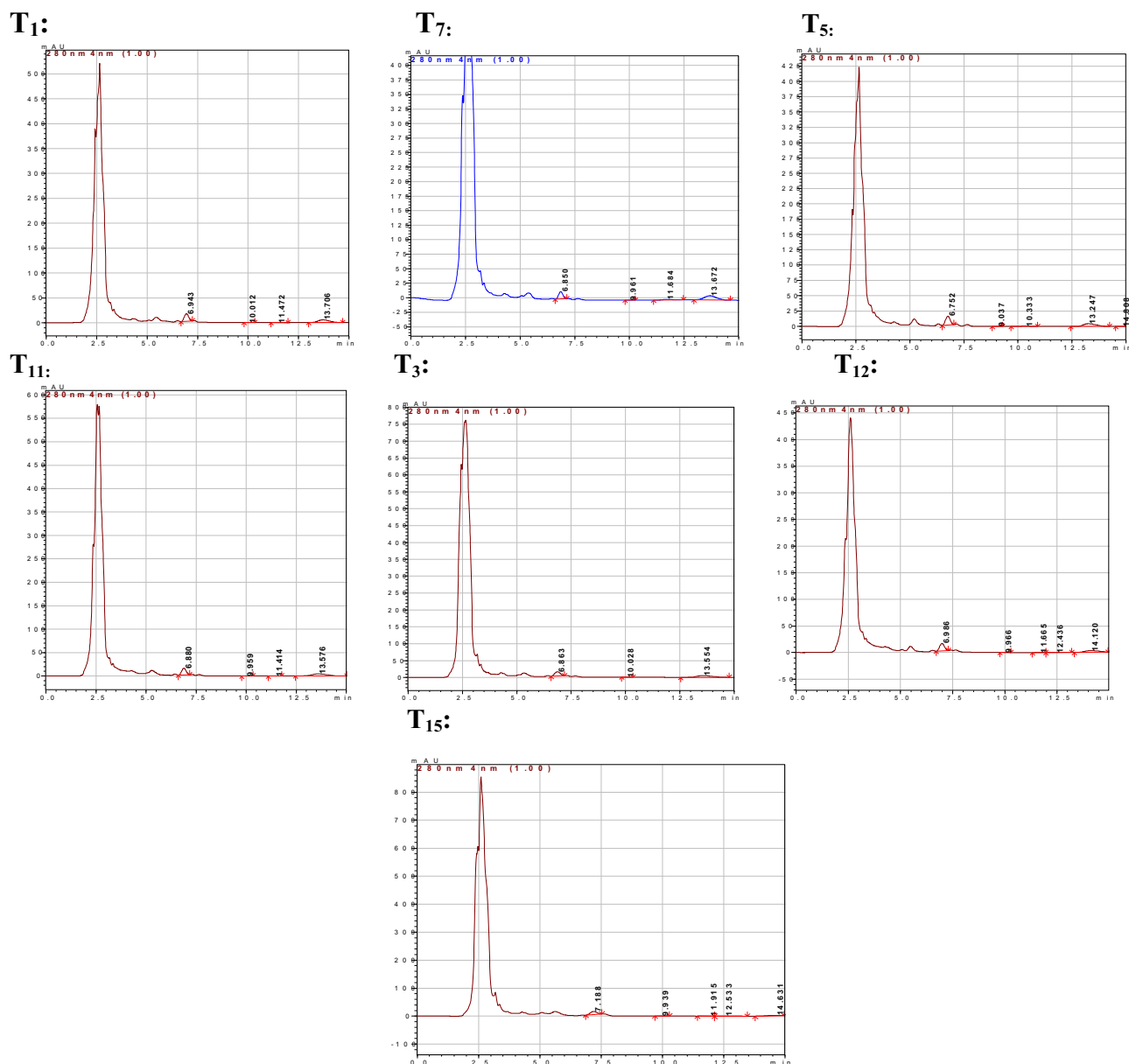


Dihydro Capsaicin Standard

Fig-4 : HPLC Chromatograms.

Azotobacter chroococcum + *Bacillus megaterium* (BM) + 50%NP+100%K+Vermicompost. The fungal population in the rhizosphere soil was maximum in *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* + 75%NP +100%K +Farm yard manure. AM fungal spore number was highest in the rhizosphere soil of the treatment having *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum*+75%NP +100%K+ Farm yard manure. The capsaicin content was

found highest 100% NPK (12310.51SHU).Among microbial inoculated treatments, plants treated with *Azotobacter chroococcum* + *Bacillus megaterium* + *Glomus fasciculatum* + 75%NP + 100%K + FYM(T₃) (10.200. 16SHU) recorded maximum capsaicin content. The result of the present study clearly showed that, the triple microbial inoculants of *Azotobacter chroococcum*, *Bacillus megaterium* and *Glomus fasciculatum* with 75% of nitrogen, phosphorus and 100% potassium with



vermicompost which help in accelerating the indigenous microflora in the soil and also was found as best treatment for Capsicum sustainable cultivation for eco friendly sustainable agriculture.

Acknowledgement

This work was carried out in collaboration among all the authors. Authors Mrs. Nalini, B. S. MSc scholar conducted this research work at Department of Agricultural Microbiology, UAS, GKVK, Bangalore, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Author Dr. L. Krishna Naik¹ Professor and Dr. Muthuraju, R Associate Professor, Department of

Agricultural Microbiology, UAS, GKVK, Bangalore edited the whole draft. All authors read and approved the final manuscript.

References

1. Cathy L. Cripps and Grimme. (2011). Inoculation and successful colonization of White bark pine seedlings with native Mycorrhizal fungi under greenhouse condition. Dept. plt. Sci. and plant pathology, Montana state Univ., Bozeman.
2. Collins, M.D., Wasmund, L.M. and Bosland, P.W. (1995). Improved method for quantifying capsaicinoids in capsicum using high performance liquid chromatography. *Hort. Sci.*, 30(1): 137-139.

3. Gerdemann, J.W. and Nicholson (1963). Vesicular-arbuscular mycorrhiza and plant growth. *Annual Review of Phytopathol.*, 6: 397-418.
4. Gray, L. E. and Gerdemann, J.W. (1967). Influence of vesicular-arbuscular mycorrhizas on the uptake of phosphorus-32 by *Liriodendron tulipifera* and *Liquidambar styracifina*. *Nature*, 213: 106-107.
5. Gupta, R.D. And Bharadwaj, K.K.R. (1992). Phosphatases and urease enzymatic activities in some soil profiles of North-West Himalayas. *J. Ind. Soc. Soil. Sci.*, 38: 756 - 759.
6. Kumar, B.K. and Ismail, S. (2017). Influence of different microbial inoculants on biological health of soil and economics in Soybean crop grown on Vertisol. *J. Pharmacognosy Phyto. Chem.*, 6: 198-201.
7. Pandey, P. and Maheshwari, D.K. (2007). Two species microbial consortium for growth promotion of *Cajanus cajan*. *Curr. Sci.*, 92: 1137-1141.
8. Philips, J.M. and Heyman, D.S. (1970). Improved procedures for clearing roots and staining parasitic and vesicular-arbuscular mycorrhizal fungi for rapid assessment of infection. *Transactions of the British Mycological Society*, 55(1): 158-161.
9. Ros, M., Garcia, C. and Hernandez, T. (2006). A full-scale study of treatment of pig slurry by composting kinetic changes in chemical and microbial properties. *Waste Manage.*, 26: 1108-1118.
10. Talwar, D., Singh and Walia, S.S. (2017). Influence of biofertilizers on microbial count and nutrient uptake of kharif onion (*Allium cepa* L.). *Int. Agric. Environ. Biotechnol.*, 10: 289-294.
11. Wang, R., Zong, L., Yan, J., Luo, M. and Hu, Y. (2014a). Simulation experiment of organic farming system: Changes of soil organic carbon and microbial communities by organic fertilization. *Antonie Van Leeuwenhoek*, 81: 357-364.



Impact of Pusa Hydrogel and Different Growing Media on Growth and Flowering of Pot Chrysanthemum (*Dendranthema grandiflora* Ramat.)

B.V. Thumar, Trupti Dodiya, N.S. Joshi, Prof. P.V. Maheta and N.V. Chovatia

Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat

Corresponding Author Email : nimeshchovatia@gmail.com

Abstract

The present experiment entitled "Impact of Pusa hydrogel and different growing media on growth and flowering of pot chrysanthemum (*Dendranthema grandiflora* Ramat.)." was carried out at the Jambuvadi Farm, Department of Horticulture, J. A.U., Junagadh (Gujarat) during 2019 to 2020. The results of the study indicated that treatment H₃ significantly improved all the growth and flowering parameters. Plant grown along with M₂ increased plant height, plant spread E-W and N-S direction, number of branches per plant, minimum days to initiation of flowering, flower stalk length and flower stalk thickness. While, plant grown with growing media M₃ resulted in increased length of branches, duration of flowering. The plant grown with treatment H₃M₂ significantly increased plant height, plant spread E-W and N-S direction, number of branches per plant and flower stalk length. While, plant grown with treatment H₃M₃ was significantly increased length of branches.

Key words : Pusa hydrogel, growing media, pot chrysanthemum.

Introduction

Chrysanthemum, the golden flower is derived from two Greek words (Chryos meaning golden and anthos meaning flower), is one of the most beautiful and perhaps the oldest flowering plants commercially grown in different parts of the world. *Chrysanthemum* belongs to the family Asteraceae. Chrysanthemum is an herbaceous perennial and grouped as sub-shrubby plants. The chrysanthemum plant has fibrous root system (shallow rooted plant), growing to 50-150 cm tall with deeply lobed leaves and heads of white, yellow pink and other colours. Its flower actually belongs to a group of many small flowers called florets borne on a receptacle called head or capitulum. Chrysanthemum is versatile; it can be planted in the bed, cultured in the pot, used for garland making also as cut-flower for flower arrangement. In India, large flowered varieties are grown for exhibition purpose while small flower varieties are grown for cut flowers, making garland, wreaths, veni and religious offerings. The utility and popularity of the chrysanthemum have increased greatly with the technique of year-round blooming habit based on the research in the field of photoperiodism and genetics. The chrysanthemum has fibrous root system (shallow rooted plant), herbaceous perennial plant growing to 50-150 cm tall, with deeply lobed leaves and large flower heads, white, yellow or pink. It requires long day for good vegetative growth and short day for flowering.

Materials and Methods

The present investigation was carried out at the Jambuvadi farm, Department of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat) during

2019-2020. Junagadh is situated in Saurashtra region of Gujarat state. Geographically, this place is situated at 21.50 N latitude and 70.50 E longitudes with an altitude of 60 meters above the mean sea level and 80 kilometers away from Arabian sea. The soil of this region is classified as Vertic Ustochrepts. Physical and chemical properties of the soil of the experimental field were determined with pH 7.85. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with three replications and twelve treatment combinations. The treatment comprised of four levels of Pusa hydrogel viz., Without Pusa hydrogel (Control) (H₀), Pusa hydrogel @ 0.4% W/W (H₁), Pusa hydrogel @ 0.5% W/W (H₂), Pusa hydrogel @ 0.6 % W/W (H₃) and three different growing media i.e. Soil + FYM + Sand (1:1:1) (M₁), Soil + FYM + Sand + Cocopeat (1:1:1:1) (M₂) and Soil + FYM + Sand + Vermicompost (1:1:1:1) (M₃) were considered as treatments.

Results and Discussion

Impact of Pusa hydrogel and different growing media on growth parameters : **Impact of Pusa hydrogel on growth parameters :** The result indicates that the levels of Pusa hydrogel had produced significant effect on growth parameters viz., plant height (cm), plant spread (cm) (E-W & N-S), number of branches per plant, length of branches (cm).

Plant height : The significant effect of Pusa hydrogel on plant height presented in Table-1. The highest plant height (18.06 cm) obtained with treatment of H₃ [Pusa hydrogel @ 0.6 % W/W]. This might be attributed to the fact, due to increase the level of Pusa hydrogel is increase the cell turgidity, cell growth, cell

Table-1 : Impact of Pusa hydrogel and different growing media on growth parameters.

Treatments	Plant height (cm)	Plantspread (cm)		No. of branches/ plant	Length of branches (cm)
		E-W	N-S		
Pusa hydrogel (H)					
H ₀ -Without Pusahydrogel (Control)	11.17	11.17	10.62	06.44	07.31
H ₁ -Pusa hydrogel @ 0.4% W/W	15.41	14.95	14.46	08.02	10.50
H ₂ -Pusa hydrogel @ 0.5% W/W	17.89	17.67	17.04	08.11	10.71
H ₃ -Pusa hydrogel @ 0.6 % W/W	18.06	18.50	17.45	11.11	14.72
S.Em.±	0.292	0.292	0.324	0.192	0.231
C.D. at 5%	0.85	0.85	0.95	0.56	0.67
Growing media(M)					
M ₁ -Soil+FYM+Sand (1:1:1)	13.04	13.04	12.26	06.75	08.67
M ₂ -Soil+FYM+Sand+Cocopeat (1:1:1:1)	17.19	17.10	16.47	10.00	12.05
M ₃ - Soil+FYM+Sand+Vermicompost(1:1:1:1)	16.49	16.51	15.95	09.61	16.42
S.Em.±	0.252	0.253	0.280	0.167	0.198
C.D. at 5%	0.73	0.74	0.82	0.47	0.58

Table-2 : Impact of Pusa hydrogel and different growing media on flowering parameters.

Treatments	Days to initiation of flowering (days)	Duration of flowering (days)	Flower stalk length (cm)	Flower stalk thickness (mm)
Pusa hydrogel (H)				
H ₀ -Without Pusahydrogel (Control)	54.33	52.56	02.49	01.25
H ₁ -Pusa hydrogel @ 0.4% W/W	51.44	57.78	02.92	01.30
H ₂ -Pusa hydrogel @ 0.5% W/W	45.49	62.44	03.62	01.39
H ₃ -Pusa hydrogel @ 0.6 % W/W	43.67	67.00	04.31	01.45
S.Em.±	0.667	0.837	0.067	0.024
C.D. at 5%	1.95	2.44	0.20	0.07
Growing media(M)				
M ₁ -Soil+FYM+Sand (1:1:1)	51.17	56.75	03.02	01.28
M ₂ -Soil+FYM+Sand+Cocopeat (1:1:1:1)	47.42	60.63	03.68	01.40
M ₃ -Soil+FYM+Sand+Vermicompost (1:1:1:1)	48.67	62.67	03.31	01.35
S.Em.±	0.577	0.725	0.059	0.021
C.D. at 5%	1.68	2.12	0.17	0.06

volume and number of cells within the stem are increase the plant height via reduction of drought stress. Similar results have been reported by Kumar *et al.* (2018) in ginger, Abdul *et al.* (2017) in colius, Anupama *et al.* (2007) in chrysanthemum and Al-Harbi *et al.* (1996) in cucumber.

Plant spread : The highest plant spread in E-W direction (18.50 cm) and N-S direction (17.45 cm) were obtained with treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. This may be ascribed the fact that these plants could get sufficient time for putting up more vegetative growth in more plant spread. The present study is in agreement with the results obtained by Madhu (2018) in foliage plant, Abdul *et al.* (2017) in coleus.

Number of branches per plant : The number of branches per plant is vital parameter of growth as stated in Table-1. The highest number of branches per plant (11.11) were obtained with treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. Number of branches significantly increased with

increased concentration of Pusahydrogel which may be due to significant amount of water in Pusahydrogel structure and subsequently, putting the absorbed water into the growing media around plant roots, thereby increasing media water holding capacity and providing a buffer against the product loss during the time of moisture stress, (Johnson and Woodhouse, 1991). Similar results were also reported by Abdul hamid (2019) in date palm, Rakshith *et al.* (2018) in ginger and Kumar *et al.* (2018) in ginger.

Length of branches : The data indicated that the maximum length of branches was found significant (Table-1). The data indicated that the maximum length of branches (14.72 cm) was recorded in treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. This increase the length of branches was due to more retention of moisture and indirectly the availability of nutrients provided by Pusa hydrogel, where it might have helped to increase the

Table-3 : Interaction effect of Pusa hydrogel and different growing media on growth and flowering parameters.

Treatments	Plant height (cm)	Plant spread (cm)		No. of branches/plant	Length of branches (cm)	Flower stalk length (cm)
		E-W	N-S			
H ₀ M ₁	11.07	07.80	07.40	03.33	04.93	02.08
H ₀ M ₂	14.50	12.70	12.09	08.67	07.22	02.28
H ₀ M ₃	13.57	12.85	12.37	07.33	09.80	03.11
H ₁ M ₁	12.93	15.79	14.54	08.20	07.87	02.57
H ₁ M ₂	13.48	14.63	13.87	08.56	11.78	02.96
H ₁ M ₃	14.10	15.80	14.99	06.23	11.87	03.32
H ₂ M ₁	14.60	13.95	13.25	05.45	06.83	03.35
H ₂ M ₂	15.10	18.76	17.73	08.24	09.60	03.60
H ₂ M ₃	18.23	20.95	20.14	10.43	16.12	03.39
H ₃ M ₁	14.50	14.62	13.85	09.47	15.07	04.10
H ₃ M ₂	19.92	22.68	22.21	14.33	17.20	04.23
H ₃ M ₃	17.45	16.86	16.30	09.53	11.90	03.70
S.Em.±	0.505	0.506	0.561	0.333	0.402	0.178
C.D. at 5%	1.48	1.48	1.64	0.97	1.17	0.34
C.V. %	5.61	5.61	6.52	6.86	6.43	6.11

activity of cell division, expansion and elongation, ultimately leading to increased length of branches. Similar results have been reported by Verma *et al.* (2013) in gerbera, Sivalapan (2001) in soybean and Al-Harbi *et al.* (1996) in cucumber.

Impact of growing media on growth parameters : The result indicates that the different growing media had produced significant effect on growth parameters viz., plant height (cm), plant spread (cm) (E-W & N-S), number of branches per plant, length of branches (cm).

Plant height : The significant effect of growing media on plant height presented in Table-1. The maximum plant height (17.19 cm) was obtained with treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. It might be due to ability of this growing media to provide good aeration to plants in order to sustain the development and growth of roots and shoots. Results are similar with the observations of Bisht *et al.* (2010) in chrysanthemum, Younis *et al.* (2008) in dahlia and Kiran *et al.* (2007) in chrysanthemum.

Plant spread : Data revealed that the plant spread was found significant in E-W and N-S direction due to different growing media in Table-1. The largest plant spread in E-W direction (17.10 cm) and N-S direction (16.47 cm) were obtained with treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. It is due to the fact that N is an essential constituent of protein and more availability of N, P and K in the substrate lead to increase in cell number and cell size. Maximum plant spread may be due to increased synthesis of protein as nitrogen is an essential part of nucleic acid which plays vital role in promoting plant growth (Kaur, 1992). The present study is in agreement with the results obtained by Kameshwari *et al.* (2014), Bala and Singh (2013) in chrysanthemum, Chauhan *et al.* (2014), Panj (2007) in gerbera.

Number of branches per plant : The result indicates that the number of branches was found significant due to different growing media. The highest no. of branches per plant (10.00) was obtained with treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This might be due to the fact that Cocopeat and FYM stimulate nutrient uptake and assimilation, have colloidal and buffering activity and positive effect on plant growth. These results are in agreement with findings of Rajsekhar *et al.* (2015) in rose, Kameshwari *et al.* (2014) in chrysanthemum.

Length of branches : The significant effect of growing media on length of branches presented in Table-1. The data indicated that the maximum length of branches (16.42 cm) was recorded in treatment M₃ [Soil + FYM + Sand + Vermicompost (1:1:1:1)]. However, their detrimental effect was reduced when sand was included in the media. Vermicompost contain higher nutrients besides reducing the C: N ratio of the soil, these increase the water holding capacity of the soil and improve the tilth and aeration. The activity of microorganisms that make the plant food elements in soil readily available to the plants. These results are in agreement with findings of Akintoye *et al.* (2013) and Bisht *et al.* (2010) in chrysanthemum.

Impact of Pusa hydrogel and different growing media on flowering parameters

Impact of Pusa hydrogel on flowering parameters : The data from investigation revealed that by levels of Pusa hydrogel exerted to be significant influence on flowering parameters viz., days to initiation of first flowering (days), duration of flowering (days), flower stalk length (cm), flower stalk thickness (mm).

Days to initiation of flowering : The data revealed that the days to initiation of flowering was significantly affected

by Pusa hydrogel (Table-2). The data indicated that the minimum days to initiation of first flowering (43.67 days) was recorded in treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. Which may be due to the growing media containing hydrogel is improve the better aeration and water retentive capabilities as it helps in giving quick hold of plants and triggers faster growth. This result was in line with findings of Kumar *et al.* (2016) in chrysanthemum.

Duration of flowering : The duration of flowering was significantly influenced by Pusa hydrogel (Table-2) and data indicated that the maximum flowering duration (67.00 days) was recorded in treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. This could be due to significant amount of water in hydrogel structure is the uninterrupted water availability, plant obtained continuous supply of water and nutrients and thereby resulted in prolonged flowering period compared to without Pusa hydrogel. Similar results were also obtained by Kumar *et al.* (2016) in chrysanthemum, Verma *et al.* (2013) in gerbera and Anupama *et al.* (2007) in chrysanthemum.

Flower stalk length : The data revealed that flower stalk length was significantly influenced by Pusa hydrogel (Table-2). The data indicated that the maximum flower stalk length (4.31 cm) was recorded in treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. This might be due to the increase vegetative growth is increase accumulation of more assimilates. This result is in line with findings of Kumar *et al.* (2016) in chrysanthemum.

Flower stalk thickness: The data (Table-2) showed that the number of flower stalk thickness was significantly influenced by Pusa hydrogel. The maximum flower stalk thickness (1.45 mm) was recorded in treatment H₃ [Pusa hydrogel @ 0.6 % W/W]. This might be due to the increase vegetative growth is increase accumulation of more assimilates. Similar findings were also reported by Kumar *et al.* (2016) in chrysanthemum.

Impact of growing media on flowering parameters : The data from investigation revealed that different growing media exerted to be significant influence on flowering parameters viz., days to initiation of first flowering (days), duration of flowering (days), flower stalk length (cm), flower stalk thickness (mm).

Days to initiation of first flowering : The data indicated that the minimum days to initiation of first flowering (47.42 days) was recorded in treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This is also attributed to accumulation of more photosynthate in this media might have induced early flowering. This result are in line with findings of Karthikeyan and Jawarhalal (2015) in chrysanthemum, Kalirana and Dubey (2009) in anthurium, Kiran *et al.* (2007) in dahlia, Gupta *et al.* (2004) in gerbera.

Duration of flowering : The duration of flowering was significantly influenced by different growing media (Table-2) and result indicated that the maximum flowering duration (62.67 days) was recorded in treatment M₃ [Soil + FYM + Sand + Vermicompost (1:1:1:1)]. This could be due to significant amount of water is the uninterrupted water availability, plant obtained continuous supply of water and nutrients and thereby resulted in prolonged flowering period. Similar results were also obtained by Sujatha and Ushabharti (2015) in chrysanthemum, Chauhan *et al.* (2014) in gerbera, Dubey *et al.* (2012) in petunia.

Flower stalk length : The data revealed that flower stalk length was significantly influenced by different growing media (Table-2). The data indicated that the maximum flower stalk length (03.68 cm) was recorded in treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This might be due to the increase vegetative growth is increase accumulation of more assimilates. This result is in line with findings of Kalirana and Dubey (2009) in anthurium, Kale *et al.* (2009) and Gupta *et al.* (2004) in gerbera.

Flower stalk thickness : The data (Table-2) showed that the number of flower stalk thickness was significantly influenced by different growing media. The maximum flower stalk thickness (1.40 mm) was recorded in treatment M₂ [Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This might be due to the increase vegetative growth is increase accumulation of more assimilates. Similar findings were also reported by Chauhan *et al.* (2014) in gerbera.

Interaction effect of Pusa hydrogel and different growing media on growth parameters : The data revealed that application of Pusa hydrogel and growing media had produced significant effect on growth parameters viz., plant height (cm), plant spread (E-W and N-S direction) (cm), number of branches per plant and length of branches (cm).

Plant height : The result indicates that the plant height was found significant due to interaction effect of Pusa hydrogel and growing media (Table-3). The highest plant height (19.92 cm) was obtained with treatment combination H₃M₂ [Pusa hydrogel @ 0.6 % W/W + Soil + FYM + Sand + Cocopeat (1:1:1:1)]. Application of polymers, addition with growing media improving aeration and water storage capacity enhanced the moisture and nutritional supply, thereby favored the increased plant height. Results were similar with the observations of Deenavarman *et al.* (2018) in *Syngonium podophyllum*, Singh *et al.* (2005) in chrysanthemum.

Plant spread : Data revealed that the plant spread was found significant in E-W and N-S direction due to interaction effect of Pusa hydrogel and growing media

(Table-3). The largest plant spread in E-W direction (22.68 cm) and N-S direction (22.21 cm) were obtained with treatment combination H₃M₂ [Pusa hydrogel @ 0.6 % W/W + Soil + FYM + Sand + Cocopeat (1:1:1:1)]. Maximum plant spread may be due to increased synthesis of protein as nitrogen is an essential part of nucleic acid which plays vital role in promoting plant growth. The present study is in agreement with the results obtained by Deenavarman *et al.* (2018) in *Syngonium podophyllum* and Madhu (2018) in foliage plant species.

Number of branches per plant : The result indicates that the number of branches was found significant due to interaction effect of Pusa hydrogel and growing media (Table-3). The highest number of branches per plant (14.33) was obtained with treatment combination H₃M₂ [Pusa hydrogel @ 0.6 % W/W + Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This might be due to the fact that application of hydrogel along with the growing media supply the more water and nutrient to the plant which may lead to more vegetative growth. These results were in agreement with findings of Singh *et al.* (2005) in chrysanthemum.

Length of branches: Data revealed that the length of branches was affected significantly by interaction effect of Pusa hydrogel and growing media (Table-3). The data indicated that the maximum length of branches (17.20 cm) was recorded in treatment combination H₃M₂ [Pusa hydrogel @ 0.6 % W/W + Soil + FYM + Sand + Cocopeat (1:1:1:1)]. These results are in agreement with findings of Madhu (2018) in foliage plant species, Verma *et al.* (2013) in gerbera.

Interaction effect of Pusa hydrogel and different growing media on flowering parameters : The data from investigation revealed that application of Pusa hydrogel different growing media exerted to be significant influence on flowering parameters *viz.* flower stalk length (cm).

Flower stalk length : The data revealed that flower stalk length was significantly influenced by interaction effect of Pusa hydrogel and growing media (Table-3). The data indicated that the maximum flower stalk length (04.23 cm) was recorded in treatment combination H₃M₂ [Pusa hydrogel @ 0.6 % W/W + Soil + FYM + Sand + Cocopeat (1:1:1:1)]. This might be due to the increase vegetative growth is increase accumulation of more assimilates. This result was in line with findings of Kumar *et al.* (2016) in chrysanthemum and Verma *et al.* (2013) in gerbera.

Conclusions

The observations recorded from the present investigation revealed that among the four different levels of Pusa hydrogel, the application of Pusa hydrogel @ 0.6 % W/W

(10 g/kg) results an effective and balanced plant growth and improved flowering parameters. Pot chrysanthemum grown along with growing media Soil + Sand + FYM + Cocopeat (1:1:1:1) improves growth and flowering. In the light of these findings, it can be concluded that the pot chrysanthemum grown in media of Soil + Sand + FYM + Cocopeat (1:1:1:1) along with application of Pusa hydrogel @ 0.6 % W/W (10 g/kg) is found better for various vegetative growth and flowering.

References

1. Abdul, S.D.; Jayanthi, R. and Saidajan, A.A. 2017. Efficacy of graded doses of Pusa hydrogel on growth and quality of coleus (*Coleus blumei* L.) under polyhouse condition. *International Journal of Agriculture and Environmental Science*, 4: 32-36.
2. Abdulhamid, M. 2019. Effects of superabsorbent on growth and physiological responses of date palm seedling under water deficit conditions. *International Journal of Horticultural Science and Technology*, 6(1): 77-88.
3. Akintoye, H.A.; Akinkunmiand, O.Y. and Adeoluwa, O.O. 2013. Influence of media on establishment and growth of *Chrysanthemum morifolium*. *Nigerian Journal of Horticultural Science*, 17: 146-156.
4. Al-Harbi, A.R.; Al-Omran, A.M.; Choudhary, M.I.; Wahdan, H. and Mursi, M. 1996. Influence of soil conditioner on seed germination and growth of cucumber. *Journal of Science Research*, 14(1): 129-142.
5. Anupama, M.C.; Kumar, R.; and Parmar, B.S. 2007. Performance of a new superabsorbent polymer on seedling and post planting growth and water use pattern of chrysanthemum grown under controlled. International Conference and Exhibition on Soilless Culture Ed. K.K. Chow. *Acta Horticulture*, 7(42): 43-50.
6. Bala, M. and Singh, K. 2013. Effect of different potting media for pot mum production in Chrysanthemum grown under open and polyhouse conditions. *Journal of Ornamental Horticulture*, 16(1&2): 35-39.
7. Bisht, D.; Kumar, A. and Kumar, P. 2010. Standardization of media composition for pot mum production in open field under Tarai conditions. Abstract book, National Symposium on Life style Floriculture Challenges and Opportunities, 19- 21 March, 105.
8. Chauhan, R.V.; Varu, D.K.; Kava, K.P. and Savaliya, V.M. 2014. Effect of different media on growth, flowering and cut flower yield of gerbera under protected condition. *The Asian Journal of Horticulture*, 9(1): 228-231.
9. Deenavarman, M.; Lourdasamy, D.K.; Thangaselvabai, T. and Venkatesan, K. 2018. Effect of different media incorporated with Pusa hydrogel on growth and watering frequency of potted foliage plant, arrowhead (*Syngonium podophyllum* Schott.). *Journal of Agriculture and Ecology*, 6: 71-76.
10. Dubey, R.K.; Singh, S.; Kukal, S.S. and Kalsi, H.S. 2012. Evaluation of different organic growing media for growth and flowering of petunia. *Commercial Soil Science and Plant Analysis*, 44: 1777-85.
11. Gupta, Y.C.; Dein, L.E.; Dhiman, S.R. and Jain, R. 2004.

- Standardization of growing media under protected environment for gerbera in mid hill of Himachal Pradesh. *Journal of Ornamental Horticulture*, 7(1): 99-102.
12. Johnson, M.S. and Woodhouse, J. 1991. Effect of superabsorbent polymers on survival and growth of crop seedlings. *Agricultural Water Management*, 20: 63-70.
 13. Kale, R.D.; Jagtap, K.B. And Badgujar, C.D. 2009. Effect of different containers and growing media on yield and quality parameters of gerbera under protected cultivation. *Journal of Ornamental Horticulture*, 12(4): 261-264.
 14. Kameswari, L.P.; Girwani, A. and Padmavathamma, A.S. 2014. Effect of different potting media mixtures on growth and flowering of chrysanthemum (*Dendranthema grandiflora*). *Progressive Horticulture*, 46(2): 314-318.
 15. Kaur, K. 1992. Effect of Biofertilizers and nitrogen on the yield and quality of pearl millet fodder. *Annales Biology*, 8: 29-32.
 16. Kiran, M.K.; Bloch, J.; Waseem, K.; Jilani, M.S. and Khan, M.Q. 2007. Effect of different growing media on the growth and development of dahlia (*Dahlia pinnata*) under the agro-climatic condition of Dera Ismail Khan. *Pakistan Journal of Biological Sciences*, 10(22): 4140-4143.
 17. Kumar, R.; Nadukeri, S.; Kolakar, S.S.; Hanumanthappa M.; Shivaprasad M. and Dhananjaya B.N. 2018. Effect of hydrogel on growth, fresh yield and essential oil content of ginger (*Zingiber officinale* Rosc.). *Journal of Pharmacognosy and Phytochemistry*, 30(7): 482-485.
 18. Kumar, T. A.; Kameswari, P. L. and Girwani, A. 2016. Impact of Pusa hydrogel incorporated growing media on floral characters and yield of pot mums (*Dendranthema grandiflora* L.) under various irrigation regimes. *International Journal of Agricultural Science and Research*, 6(3): 195-200.
 19. Madhu B. 2018. Effect of potting media incorporated with Pusa hydrogel on growth and production of quality foliage plants of *Philodendron Xanadu*. *Bulletin of Environment, Pharmacology and Life Sciences*, 8(1): 95-98.
 20. Panj, F.G. 2007. Standardization of growing media for gerbera (*Gerbera jamesonii* Bolus Ex. Hooker. F). A Ph. D. thesis submitted to NAU, Navsari.
 21. Rajsekhar, P.; Suresh, R. and Rajadurai, K.R. 2015. Effect of potting media composition for flower bud length in pot grown rose (*Rosa chinensis* Jacq.). *Research in Environment and Life Sciences*. 8(1): 477-480.
 22. Rakshith, K.R.; Sadashiv, N.; Shashikala, S.K.; Hanumanthappa, M.; Shivaprasad, M. and Dhananjaya, B.N. 2018. Effect of hydrogel on growth, fresh yield and essential oil content of ginger (*Zingiber officinale* Rosc.). *Journal of Pharmacognosy and Phytochemistry*, 3: 482-485.
 23. Singh, A.M.; Singh, K.P.; Singh, D.P. and Sirohi, N.P.S. 2005. Response studies in chrysanthemum (*Dendranthema grandiflora* Tzevlev) plugs as self rooted cuttings grown in gel-amended media under greenhouse nursery. *Journal of Ornamental Horticulture*, 3(8): 225-227.
 24. Sivalapan, S. 2001. Effect of polymer on growth and yield of soybean (*Glycine max* L.) grown in a coarse textured soil, in Proceeding Irrigation, Regional Conference, Toowoomba, Queensland, Australia, pp. 93-99.
 25. Sujatha, N.A. and Ushabharthi, T. 2015. Influence of potting media composition on pot mum production. *The bioscan*, 10(1): 73-76.
 26. Verma, A.K.; Sindhu, S.S.; Janakiram, T.; Singh, M.C.; Sharma, R.R.; Anupama, S. and Bhupinder, S. 2013. Influence of vermi-products and Pusa hydrogel on growth and flowering of landscape gerbera under greenhouse condition. *International Journal of Agriculture Environmental Biotechnology*, 6(1): 109-115.
 27. Younis, A.; Ahmad, M.; Riaz, A. and Khan, M.A. 2008. Effect of different potting media on the growth and flowering of *Dahlia coccinea* cv. Mignon. *Acta Horticulture*, 804: 191-196.



Problem Faced by Mushroom Growers in Adoption of Mushroom Production Technology in Chhattisgarh

Bharti Shriwas, K.K. Srivastava and M.A. Khan

Department of Agricultural Extension, College of Agriculture, IGKV, Raipur-492012, C.G.

Email : preetishriwas10@gmail.com

Abstract

Indian mushroom industry exported 1054 quintals of white button mushroom in canned and frozen form and produced revenue of Rs. 7282.26 lakh. The present investigation of 80 respondents of Raipur and Durg district of Chhattisgarh state was conducted during 2019-2020. The study is focused on knowledge, income, education, mass media exposure and motivation. The identified package and practices may help to give direction to mushroom farmers to manipulate the appropriate factors so as to enhance their knowledge and adoption level. An attempt has also been made to find the constraints faced by the mushroom growers, there by efforts should be made to obtain the suggestions from mushroom growers to improve the production and eliminate constraints of mushroom production technology. The data reveals that majority of the respondents had suffered from irregular market in village area with 88.75 per cent and 93.75 per cent had suggested avoid high temperature and ventilation problems.

Key word: Problems and suggestions, mushroom production.

Introduction

Mushroom is a fungal growth that typically has flat and rounded shape on a stalk, with gills on the underside of the cap. It belongs to the class Basidiomycetes. They are saprophytes (They cannot synthesis their own food as they lack chlorophyll in them) There are large numbers of edible and non-edible species of mushroom present in all over world. Production of mushroom in the world is about 40 MT contributed by china, followed by USA, Poland, Netherland, Spain, France, Italy, Ireland, Canada, and UK. India hardly produces 0.18 Million tons of Mushroom. (M.P. Thakur 2020). According to recent news the mushroom production has been reached up to 2, 10,000MT by 2019 which was 40,000MT in 1994. (Anonymous) white button mushroom is the maximum producing mushroom (73%) followed by oyster mushroom production (16%), then paddy straw mushroom production (7%) and lastly milky mushroom production (3%). According to a study when comparison made with other vegetables, data shows that in India per person mushroom consumption is less than 100 grams per year. In the year 2016-2017, Indian mushroom industry exported 1054 quintals of white button mushroom in canned and frozen form and produced revenue of Rs. 7282.26 lakh.

In Chhattisgarh the total spawn production is around 50 tonne per annum and accordingly mushroom production is about 250-300 tonne per annum. IGKV Mushroom laboratory at Raipur has been producing an approximated 5-6 tonnes of spawn per year and Paddy

straw mushroom spawn around 10 tonne which gives about 20 tonne mushroom per year. (H.K. Singh *et al* 2018). In Raipur and Durg the production rate of spawn is about 260 q/ annum. (M.P. Thakur 2020). In Chhattisgarh state mushroom is known by different names such are "futu", "patharchatta" and "kukurmutta" in different regions. Due to good adaptive climatic condition, it can grow all over Chhattisgarh, commercially it grows in Raipur, Durg, Janjgir-Champa, Bilaspur, Dhamtari, Ambikapur districts. Oyster and paddy straw mushrooms variety are commercially grown varieties in Chhattisgarh. Generally tropical and subtropical region are most favorable for normal growth of mushroom.

Oyster mushroom is commonly known as the wood fungus and in India it is called as "dhingri". Firstly, it was cultivated in Germany. It is the most popular edible mushrooms and belongs to the genus *Pleurotus* and the family Pleurotaceae. Oyster mushroom famous for its high nutritive value as it contains 90% moisture, 20-35% protein, low fat, low starch, high fiber, sodium-potassium ratio and 4-5% carbohydrate on a wet weight basis. They contain a good amount of Vitamin C and B complex (Thiamine, Riboflavin, and niacin). Some minerals like, Iron (Fe), Phosphorus (P), Potassium (K) and Sodium (Na) also present in this mushroom. (Chang and Miles, 1992). In India, different edible mushroom species are produced species like *Pleurotus*, (oyster mushroom) *Volvariella* (Paral/Paddy straw/straw mushroom), *Lentinus* (shiitake mushroom) *Calocybe* (dudhia/Milky mushroom) and *Agaricus bisporus* (White button mushroom) is covered about 80% of the total mushroom

Table-1 : Problem expressed by the mushroom growers in adoption of mushroom production Technology. n=80

S.N.	Problems	Frequency	%	Rank
1.	Contamination during spawn production	66	82.50	III
2.	Equipment related problems	34	42.50	IX
3.	Problems in maintaining optimum temperature and ventilation	65	75.00	IV
4.	Irregular and discontinue production	41	51.25	VIII
5.	Are you facing problems like insects and house flies during mushroom production	54	67.50	V
6.	Irregular market	71	88.75	I
7.	Lacking of information about value-added products	70	87.50	II
8.	Excess of initial expenses	27	33.75	XI
9.	Lack of knowledge of villagers about mushroom nutrients	45	56.25	VII
10.	Hesitation in accepting new varietal	50	62.50	VI

*Data are based on multiple responses.

Table-2 : Suggestions obtained from the mushroom growers to overcome the problems faced by them during the adoption of mushroom production technologies. n=80

S. No.	Suggestions	Frequency	%	Rank
1.	For preventing contamination formalin treatment can be used for insect control	50	62.50	V
2.	Fungicide like Bavistin is helpful to prevent fungus infection	56	70.00	IV
3.	To avoid high temperature and ventilation problem mushroom production should be done in kaccha house.	75	93.75	I
4.	The people should be aware about the mushroom production technology	65	81.25	III
5.	The knowledge should be given about the nutritive value of mushroom	66	82.50	II
6.	For better production of mushroom Scientific knowledge should be given by scientist.	45	56.25	VI
7.	Training should be conducted for all information about mushroom production.	34	42.50	VII

*Data are based on multiple responses.

production. *Volvariella* spp, *Calocybe indica*, *Pleurotus* spp. *Agaricus bisporus* these varieties have been recommended for production in all over the country throughout the year. The Chhattisgarh is an ecological habitat for many natural wild edible species of macro-fungi which has been surveyed on large scale, recognised, categorized and recorded as dry and wet sample from many agro-ecological areas. *Termitomyces clypeatus*, *Russula* spp, *Cantharellus* spp, *Rhizopogon*, edible *Amanita*, *Lentinus* spp, *Pleurotus* spp, *Macrocybe* spp, *Tricholoma* spp, and *Volvariella volvacea* are the dominant forest mushrooms, which are observed as food. The aseptic cultivation of edible mushroom species, their spore prints and dried sample are submitted yearly at Directorate of Mushroom Research, Chambaghat, Solan H. P and is also being maintained at IGKV, Raipur. The growing technology of many species of oyster mushroom like *Pleurotus eous*, *Pleurotus djamor*, *Pleurotus florida*, *Pleurotus flabellatus*, *Pleurotus sajor-caju*, *Hypsizygous* and *Calocybe indica* has been standardized with regard to their growing temperature throughout the year. Similarly, different production systems have been identified for *Volvariella volvacea* cultivation. Open cultivation of *Volvariella* in mango orchards, bamboo plantations, border rows of green houses in protected cultivation sheds and indoor cultivation in growing rooms have been popularized across Chhattisgarh.

Due to its indoor activity mushroom production is beneficial and advantageous for small and marginal farmers. It can be grown within a limited space, it only uses a vertical space of land, and hence waste land area can be easily used for mushroom production. mushroom farming is one of the agricultural activities in which women can play a very important role without sacrificing their home responsibilities, which is a big blessing for any Indian women and also provides full or part time employment to rural and urban small and marginal farmers.

Research Methodology

The present study was carried out in Raipur and Durg district of Chhattisgarh state during the year 2019-20. Two blocks from Raipur district (Dharsiwa and Arang) and two blocks from Durg district (Durg and Patan) was selected randomly for this study. Out of total villages of the block, 5 villages were randomly from each block and selection of respondents were identified on the basis of total mushroom growers from each block. From each selected village four mushroom growers were selected randomly i.e., 20 villagers from each block, in this way the total no. of respondent were 80 for this study. An interview schedule was prepared to collect the information from the selected mushroom grower. For the tabulation and analysis of

collected data, appropriate statistics tools and methods are used.

Results and Discussion

There are many factors that affect mushroom production. The Problems faced by the mushroom growers in the adoption of recommended mushroom production technology are show in these tables.

Multiple responses were chosen to find out the problems encountered by the farmers during adoption of mushroom production technology. Various problems regarding selected practices are presented in Table-1. The data reveals that majority of the respondents had suffered from irregular market in village area with 88.75 per cent, 87.50 per cent of the respondents had problem like lack of information about value addition of mushroom like dry mushroom, capsule of mushroom powder, powder of mushroom and pickles also, 82.50 per cent of the respondents facing problem due to contamination of pathogen, fungus, here dirty hand can be a reason of infection in spawn production as spawn is very sensitive to fungal, bacterial and other infection and these kinds of contamination may deteriorate the quality of spawn, which will give rise poor quality of mushroom. 75.00 per cent of the respondents had facing problem in maintaining temperature during mushroom production because initial 2-20 days are most critical for mycelial growth which require optimum temperature for growth. 67.50 per cent of the respondents had facing problem like insect and fly, these were observed as the most common insects of mushroom. 56.25 per cent of the respondents had lack ok knowledge of nutrients of mushroom. 51.25 per cent of the respondents facing the problem like irregular production of mushroom, it may be due to untreated medium with formalin and Bavistin and due to improper mixing of spawn in the medium. 42.50 per cent of the respondents had equipment related problem most of the farmers was ready for spawn production but they were un-succeed due to high cost of equipment with high rate of maintenance charge, which was not affordable by farmers. 40.00 per cent of the respondents had facing problem in maintaining ventilation for exhaustion of used air outside and taking fresh air inside. 33.75 per cent of the respondents had faced problem of initial expenses.

The findings regarding suggestions from respondents are compiled in table 2. The data reveals that majority 93.75 per cent of the respondents had suggested to avoid high temperature and ventilation problem, mushroom production should be done in kaccha house. 82.50 per cent of the respondents had suggested that the knowledge should be given about the nutritive value of mushroom. 81.25 per cent of the respondents had

suggested that people should be aware about the mushroom production technology, 70.00 per cent of the respondents had suggested fungicide like Bavistin is helpful to prevent fungal infection. About 62.50 per cent of the respondents had suggested formalin treatment for preventing contamination like insect control, 56.25 per cent of the respondents had stated that for better production of mushroom, scientific knowledge should be given by scientist. 42.50 per cent of the respondents had suggested that training should be conducted for all information about mushroom production.

Conclusions

The data reveals that majority of the respondents had suffered from irregular market in village area with 88.75 per cent, 87.50 per cent of the respondents had problem like lack of information about value addition of mushroom like dry mushroom, capsule of mushroom powder, powder of mushroom and pickles also reported by the respondents, the important one were as follows : 93.75 per cent of the respondents had suggested to avoid high temperature and ventilation problem, mushroom production should be done in kaccha house. 82.50 per cent of the respondents had suggested that the knowledge should be given about the nutritive value of mushroom.

References

1. Karthick, K. and Hamsalakshmi. 2016. Marketing problems of mushroom cultivators with special reference to Nilgiris District. *International Journal of Applied Research*; 2(5): 1033-37.
2. Kumar, P., Shruti, R.K. Singh, Kumar, K. and Nidhika, Rani. 2018. Impact of Oyster Mushroom (*Pleurotus ostreatus*) Training on Socio- Economic and Knowledge of Tribal Woman of Hazaribagh, Jharkhand, India. *Int. J. Cur. Microbiol. App. Sci.* Special Issue-7: 1106-1111 1106.
3. Kushwah, S. and Chaudhary, S. 2015. Adoption Level and Constraints in Scientific Oyster Mushroom Cultivation among Rural Women in Bihar. *Indian Res. J. Ext. Edu.* 15 (3), pp 11-16.
4. Sharma, D., Kumar, A. and Guleria, J.S. 2016. Economic viability, technological gap and problems of mushroom cultivation in Mandi district of Himachal Pradesh. *Himachal Journal of Agricultural Research.*, 42(1): 47-54.
5. Singh, B.D., Verma, M., Kumar, R., Gupta, P.C. and Aditya. 2018. Economic Empowerment of Rural Farm Women through Mushroom Production – A Case Study of Patna District, India. *Int.J.Cur.Microbiol.App.Sci* 7(5): 348-351.
6. Singh, HK., Shukla, C.S. 2018. Spawn production at small scale and cottage level in villages. *Special National Symposium on Extension Plant Pathology* :153-154.
7. Thakur, M.P. 2014. Present status and future prospects of tropical mushroom cultivation in India: A review. *Indian Phytopath.* 67 (2): 113-125.



Insect Pollination

Viji C.P.*, Phani Kumar K.¹, Sudha Vani V. and Divya Bharathi V.

College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, A.P.

¹Maize Research Centre, Vijayarai, Andhra Pradesh

*Email : vijiento@gmail.com

Abstract

Without insect pollinators, many plants fail to reproduce. Knowledge of insects that aid in pollination is important for obtaining higher yields. Beetles, flies, honey bees, wasps, ants, butterflies, moths and thrips play a key role in pollinating various crops. The major beetle families that commonly or exclusively contain anthophilous species are the Buprestidae (jewel beetles), Cantharidae (soldier beetles), Cerambycidae (longicorn or longhorn beetles), Cleridae (checkered beetles), Dermestidae, Lycidae (net-winged beetles), Melyridae (soft winged flower beetles), Mordellidae (tumbling flower beetles), Nitidulidae (sap beetles) and Scarabaeidae (scarabs). Major pollinator taxa in Brachycera (Diptera) are the Bombyliidae (bee flies), Syrphidae (hoverflies), Calliphoridae (blowfly/ blue bottle fly) and muscoid families. Nematoceran (Diptera) belonging to family Ceratopogonidae, Bibionidae and Culicidae also play a major role in pollination. Among hymenopterans, long tongued bees (Apidae, Megachilidae) and short tongued bees (Andrenidae, Colletidae, Halictidae, Melicidae) play an important role in pollination. Moth families (Sphingidae, Noctuidae, Geometridae, Pyralidae Oecophoridae) and butterfly families (Danidae, Nymphalidae, Papilionidae, Pieridae, Hesperidae) of Lepidoptera are reported to be involved in pollination. Thrips visit the flowers during anthesis and transfer pollen to stigma during movement.

Key words : Entomophily, cantharophily, myophily, melittophily, spheosophily, myrmecophily, phalenophily, psychophily, thripophily.

Introduction

Pollination is the act of transferring pollen grains from the male anther of a flower to the female stigma enabling fertilization and the production of seeds. The process of pollination requires pollinators as agents that carry or move pollen from anthers to receptive part of the stigma. Entomophily or insect pollination is a form of pollination whereby pollen of plants is distributed by insects. The major anthophilous (flower frequenting) taxa among insects are the beetles (Coleoptera), flies (Diptera), honey bees, wasps, and ants (Hymenoptera), butterflies and moths (Lepidoptera) and thrips (Thysanoptera). Pollination by different groups of insects is given below.

Beetle Pollination (Cantharophily) : The flowers that are visited by beetles are typically unspecialized or bowl-shaped with sexual organs exposed, white to dull white or green in colour, heavily scented (strongly fruity, spicy, or similar to decaying organic material), moderate nectar producers with lots of pollen grains and open during the day. The major beetle families that commonly or exclusively contain anthophilous species are the Buprestidae (jewel beetles), Cantharidae (soldier beetles), Cerambycidae (longicorn or longhorn beetles), Cleridae (checkered beetles), Dermestidae, Lycidae (net-winged beetles), Melyridae (soft winged flower

beetles), Mordellidae (tumbling flower beetles), Nitidulidae (sap beetles) and Scarabaeidae (scarabs).

Beetle pollination is common in the families of Palmae (palm trees), Nymphaeaceae (water lilies) and Araceae. Palms are pollinated by wind and insects like beetles, wasps, flies and bees where, beetles play a major role in pollination. The pollinating weevil, *Elaeidobius kamerunicus* (EK) was introduced from Africa into the oil palm growing regions of Asia and the Pacific and into the oil palm plantations of India during 1985 to increase the fruit set which dramatically raised the yield of oil palm.

Nitidulids pollinate commercially grown sugar apples (*Annona squamosa* L.) and atemoyas (*A. squamosa* X *A. cherimola*). It is reported that, *Carpophilus mutilatus* was the most important pollinator in terms of efficacy and abundance, followed by *C. fumatus* and *Haptoncus luteolus*. The *Annona* flowers, which are protogynous, are entered by the beetles usually during the female phase with peak entry in morning and evening. The beetles remain inside up to 22 h, until the flowers senesce and the stamens fall. The pollen grains are transferred to the neighbouring flowers. Percentage of fruit set is positively correlated with numbers of nitidulids in the flowers.

Anthurium, *Philodendron*, *Alocasia*, *Amorphophallus*, *Colocasia*, *Spathiphyllum*, *Monstera* and other aroid genera (family Araceae) are pollinated by

beetles. Flowers of arums are borne on a type of inflorescence called a spadix organized with female flowers towards the bottom and male flowers towards the top. Spadix is partially enclosed in, a spathe or leaf-like bract. The stigma is not receptive when the pollen is released, thus preventing self-fertilization. Many plants in this family are thermogenic (heat-producing). Their flowers can reach up to 45°C even when the surrounding air temperature is much lower. One reason for this unusually high temperature is to attract insects (usually beetles) to pollinate the plant, rewarding the beetles with heat energy. The spathe of the inflorescence opens in the evening. Beetles fly to the inflorescence in darkness where they are trapped for 24 hours. Beetles remain in the inflorescence eating protein rich staminodia that surround the stigmas and fertilizing the flower with pollen brought from another flower. On the third day evening, the anthers dehisce and the beetles become covered with pollen and crawl up the spadix and leave transferring the pollen to nearby plants.

Fly Pollination (Myophily) : Flies are pollinators or regular visitors of thousands of species of flowering plants. Some plants are completely dependent on flies for pollination. Even flies that are generalists in their floral visits can contribute to plant reproductive success as many are effective pollinators of plants. Pollinators are more numerous in the Brachycera, in which at least 30 families are known to contain anthophilous species. Major pollinator taxa are the Bombyliidae (bee flies), Syrphidae (hoverflies), Calliphoridae (blowfly/blue bottle fly) and muscoid families. Nematoceran belonging to family Ceratopogonidae, Bibionidae and Culicidae also play a major role in pollination. Plants that are pollinated by flies include members of *Euphorbiaceae*, *Crassulaceae*, *Brassicaceae*, *Iriaceae* and *Orchidaceae* families.

Typical fly pollinated flowers do not bloom regularly and are simple with very little depth. They do not emit a strong scent. They are typically purple, violet, blue, and white, and have open dishes or tubes. Nectar guides are not present. Nectar is open or easily available and the male and female parts of the flower are well exposed. Adult flies feed on pollen and nectar.

Bee flies or humbleflies belong to the family Bombyliidae, and are considered as important pollinators. Adults generally feed on nectar and pollen whereas larvae are generally parasitoids of other insects. Bee flies visit numerous taxa of different families, but prefer groups with hypocrateriform, tubular, disk and lip flowers, while other floral types, such as keel and funnel flowers, receive less attention. The preferred colours of the flowers visited are purple, violet, blue and white.

Yellow flowers, and still more reddish or pink flowers are much less attractive. Bee flies show low flight activity in shade and avoids shade. They significantly contribute to cross pollination of plants, becoming the main pollinators of some plant species of desert environments. For example, greater bee fly, *Bombylius major*.

Hoverflies also called flower flies or syrphid flies, belong to the family Syrphidae. Adults are seen hovering or nectaring at flowers mainly feeding on nectar and pollen, while the larvae (maggots) are insectivores and prey on aphids, thrips and other plant sucking insects. Adults are reported as effective pollinators of strawberry and members of Umbelliferae. Some examples are *Episyrphus balteatus*, *Eupeodes latifasciatus*, *Eristalis tenax*.

Blowfly/Bluebottle fly, *Calliphora vomitoria* (Calliphoridae) are fairly large flies, nearly twice the size of the housefly. They can be easily identified by their shiny, blue bodies. Adult flies feed on nectar and are especially attracted to flowers that have strong odours, such as those that have adapted to smell like rotting meat. Blowflies are reported as a main pollinator of mangoes as they visit the flowers in large numbers and disperse between different trees. They are successfully used to pollinate vegetable crops including onions, carrots, radishes, cauliflower, broccoli, lettuce, allium, buckwheat, sunflowers, garlic, peppers and canola.

Muscidae are the leading group of pollinators of open blossoms. They are also recorded as efficient pollinators of umbelliferous plants.

In cocoa, *Theobroma cacao* pollination is almost exclusively performed by various species of midges, *Forcipomyia* and *Euprojoannisia* (Ceratopogonidae, Diptera). The trees flowers grow directly from the trunks and lower branches. The flowers are small (1-3 mm), white, convoluted, face downwards, and require tiny pollinators. These midges (2-3 mm) are active in their pollination duties at dusk and dawn in synchrony with the cocoa flowers and pollinate these intricate flowers. Microscopic nectaries found on the stems and base of the flowers attracts this little fly.

Adults of Bibionidae (*Bibio* and *Dilophus*) are important pollinators in orchards and are the exclusive pollinators of some species of Orchidaceae, Iridaceae and Umbelliferae.

Honey Bee Pollination (Melittophily) : Pollination by honey bees is called Melittophily. Bees are known to forage flowers for pollen and nectar for their hives. Some plants are nectarless and contain floral glands or oil secreting bodies or elaiophores that secrete non-volatile oils as a reward for their pollinators. While foraging, they

pollinate hundred and thousands of flowering plants and assure setting of seed or fruit. Honey bees perform more than 80 percent of all pollination of cultivated crops. More than 100 important crops are pollinated by honey bees. This includes many of the fruits and vegetables that we eat, but also a number of important crops such as nuts, herbs, spices, oilseed crops, forage for cattle as well as medicinal and numerous ornamental plants. The potential benefits due to bee pollination in the form of increase in yields of various crops including fruits and vegetables, oilseeds, pulses and others varies from 5% to 33,150%.

Long tongued bees (Apidae, Megachilidae) and short tongued bees (Andrenidae, Colletidae, Halictidae, Melicidae) play an important role in pollination.

Bees have a number of specialised adaptations that help them to be great pollinators. The body of bee is clothed with hairs. Each hair is branched (plumose), enabling it to trap pollen grains more effectively. They also have thousands of unbranched hairs covering their body which are for sensory purposes. It is also reported that the bodies of bees also carry an electrostatic charge that attracts pollen. The hind legs of bees are modified for pollen collection (foraging type of legs).

At least 74 of the 508 recognized genera of bees (comprising 58% of all bee species) sonicate flowers to extract pollen, but many species, including the honey bee, cannot perform buzz pollination. Floral sonication typically consists of a female bee biting poricidal anthers or corollas with her mandibles and rapidly contracting her indirect flight muscles, generating vibrations that release pollen from the tube-like structures. The anthers of buzz pollinated plant species are typically tubular, with an opening at only one end, and the pollen inside is smooth-grained and firmly attached. These poricidal anthers are only able to release pollen when vibrated at a specific frequency. The stigmas of these flowers are often located below the anthers. In order to release the pollen, solitary bees are able to grab onto the flower and move their flight muscles rapidly, causing the flower and anthers to vibrate, dislodging pollen. Examples of buzz pollinating bee species are *Bombus terrestris*, *Xylocopa frontalis*, *Euglossa* sp., *Melipona* sp., *Protandrena* sp., *Nomia* sp., *Oxea* sp.

Wasp Pollination (Sphegophily) : Wasps function as generalist pollinators, transferring pollen between flowers they visit for nectar collection. Wasps look like bees, but are generally not covered with branched hairs. As a result, they are much less efficient in pollinating flowers, because pollen is less likely to stick to their bodies and to be moved from flower to flower. In some higher wasps, mouth parts have been modified into tube-like structures, 5-10 mm long, through which nectar can be sucked up. In their

ability to utilize blossoms, these wasps approach bees. Wasp pollinated flowers are common among figs and deceptive orchids but rare in nectar rewarding plants.

Vespid wasps (Hymenoptera : Vespidae) have been reported as pollinators of *Oxyptalum* species, *Asclepias* sp., *Blepharodon nitidum* and *Cynanchum* species. Tiphid wasps and sphecids (Hymenoptera : Tiphidae and Sphecidae) is reported to pollinate species of *Asclepias*.

Ant Pollination (Myrmecophily) : Ants (Formicidae, Hymenoptera) form a great group of social insects that are great lovers of nectar. Ants are commonly anthophilous (flower loving) and visit flowers to collect energy rich nectar. Ants are wingless and crawl into each flower to reach their reward. The flowers that are visited by ants are typically low growing, have small inconspicuous flowers positioned close to the stem. In most cases of ant pollination, the ants are one of multiple pollinators i.e., the plants are not completely dependent on ants for pollination. Ant (*Azteca chartifex*) as one of the multiple pollinators is reported to increase the pollination of cocoa plants in Brazil. However, the hare orchid, *Leporella fimbriata* can only be pollinated by its winged male ant partner (*Myrmecia urens*). Onion orchid, *Microtis parviflora* is effectively pollinated by flightless worker ants of *Iridomyrmex gracilis*.

Ants are not considered as efficient pollinators because, due to their small size, are able to exploit nectar without touching the anthers or stigmas of a flower and thus act as nectar thieves. The smooth cuticle and frequent grooming by ants also prevent pollen attachment. Researchers discovered that the most likely reason for the paucity of ant pollination is the presence of metapleural gland secretion on the integument of many ant species. The secretion derived from these paired glands is actively distributed over the bodies of adults and larvae, and due to its antimicrobial properties, protects ants from pathogenic fungi and bacteria. This secretion also kills pollen grains very rapidly when it comes in contact with this natural antibiotic and has a strong impact on the viability of pollen grains. Such a strong reduction of pollen viability cannot be found in honeybees and wasps.

Moth Pollination (Phalaenophily) : To feed on nectar, lepidopterans have a long and slender proboscis formed by two greatly elongated galeae of maxilla which are kept together by interlocking spines and hooks. When the butterfly moves to feed upon the nectar of a flower, the proboscis unfurls to extend downward into the flower's centre. Lepidopterans use their proboscis to collect nectar only, they do not feed on pollen. The pollen sticks to the head and proboscis and also collected on the body hairs

during their visit to flowers, which is carried to fertilize another plant.

Most of the moths are nocturnal and are active during night time. Moth pollinated flowers have nocturnal or crepuscular anthesis, are pale or white in colour (moths can see them at dusk), nectar guides absent (as colour vision does not work at night), heavy with fragrance (moths find plants by scent), long tubed (to accommodate the moths' long tongues), usually radially symmetrical, may or may not have landing platform (as some moths feed while hovering), contain copious dilute nectar to attract these pollinating insects..

Olfactory attraction plays a greater part in moth blossoms. Moths have feathered antenna (pectinate/bipectinate) with scent receptors to locate flowers at night. They can detect scent several miles away. Moth pollinated flowers are heavily scented such as gardenias, jasmine, evening primrose, tuberose, lilies, pseudodatura, night queen, tobacco (*Nicotiana glauca*), yucca, honey suckle, morning glory, orchids etc. Moths don't pollinate any of food crops, however, they do pollinate many native and garden plants. Moth families viz. Sphingidae, Noctuidae, Geometridae, Pyralidae, Oecophoridae play an important role in pollination.

Butterfly Pollination (Psychophily) : Butterflies have a long and slender proboscis characteristic of Lepidoptera. While foraging at the flowers for nectar, the pollen grains adhere to the various butterfly body parts such as proboscis, head, thorax, legs, wings etc. The pollen thus adhered is transferred on the stigmatic surface when the butterfly moves to another conspecific flower, thus performing pollination. All species of members of *Danaidae*, *Nymphalidae*, *Papilionidae*, *Pieridae*, *Hesperiidae*, the majority of male *Lycaenidae* are reported to be involved in pollination.

Butterfly pollinated flowers have diurnal anthesis, open in daylight, are large, have showy upright flowers and is usually scented. Butterflies rely on floral colour for locating, identifying and feeding from the flower. Most species have innate colour preference. They can distinguish colours of yellow, red and blue. The members of Nymphalids and Pierids are sensitive to both yellow/orange and red. Since most butterflies do not digest pollen, more nectar is offered by plants than pollen. The flowers have simple nectar guides with concealed nectaries usually hidden in narrow long tubes or spurs, reached by the long tongue of the butterflies. As butterflies are sun lovers that like to perch while feeding, the flowers pollinated by butterflies frequently have a landing area with flat-topped corollas. Butterflies alight on the blossom, generally sitting on the margin of funnel or trumpet shaped blossoms or flowers arranged

aggregately on the inflorescence. They prefer sucking nectar out of narrow tubes, frequently florets of Compositae, flowers of Verbenaceae (*Lantana* sp.), Apocynaceae (periwinkle, *Catharanthus roseus*), Rubiaceae (jungle flame, *Ixora javanica*), Apocynaceae (blood flower, *Asclepias curassavica*), Scrophulariaceae (Himalayan butterfly bush, *Buddleja crispa*), Caprifoliaceae (red valerian, *Centranthus ruber*).

Thrips Pollination (Thripophily) : Thrips originated in Paleozoic era (Permian) when gymnosperms ruled the world. Modern gymnosperms like gnetaleans and cycads are insect pollinated. For cycads, thrips are specialized pollinators. The rewards associated with thrips pollination include pollen, nectar, and possibly other epidermal cell contents, brood sites, heat, protection and mating opportunities. The pollen feeding habit of thrips make them to visit the flowers during anthesis and carry appreciable number of pollen grains and incidentally transfer them on to the stigma during their inter and intra movement between the flowers/ florets/ inflorescence.

However, the role of thrips in pollen transfer dynamics has been overlooked by many researchers due to their small size and weak flying ability, lack of specialized organ to carry pollen etc. Their aggregation within the flower generally indicates them as pest rather than its status as a pollinator. But, during the last century a number of observations have been made on diverse plant species to establish the pollination potential of thrips.

Thrips detect colour and scent in flight and actively fly short distances in response to these. Location of hosts over long distances is achieved by using a combination of active and passive dispersal on wind currents. By virtue of their pollen feeding habit, they attend the flowers during anthesis and carry at least a minimum load of 15 to 30 pollen grains per individual and transfer them on to the stigma during their inter and intra movement. The body setae of thrips favour for fine attachment of pollen.

Microsatellite DNA analysis of single pollen adhering to pollinators, density of thrips within the flowers, vector potentials of thrips and viable seed production after pollination further justify their dynamic role in pollen transfer.

References

1. Ajay Kumar Chauhan, Umesh Chandra and Gupta, P.K. 2018. Study of pollinator's diversity on mango (*Mangifera indica* L.) var. Amrapali. *Journal of Entomology and Zoology Studies*, 6(3): 974-975.
2. Amaya Márquez Marisol, 2009. Floral Constancy in Pollination. *Revista colombiana de entomología*, 35(2): 206-216.

3. Catherine E.A. Gresty, Elizabeth Clare, Dion S. Devey, Robyn, S. Cowan, Laszlo Csiba, Panagiota Malakasi, Owen T. Lewis and Katherine J. Willis, 2018. Flower preferences and pollen transport networks for cavity nesting solitary bees: Implications for the design of agri-environment schemes. *Ecology and Evolution*, 8(15): 7574–7587.
4. Chartier, M., Gibernau, M. and Renner S.S.. 2014. The evolution of pollinator-plant interaction types in the Araceae. *Evolution*, 68(5): 1533-43. doi: 10.1111/evo.12318. Epub 2013 Dec 19.
5. Christoph Kastingner and Anton Weber, 2001. Bee-flies (*Bombylius* spp., *Bombyliidae*, *Diptera*) and the pollination of flowers. *Flora*, 196(1): 3-25.
6. Dafni, A., Ivri, Y. and Brantjes, N.B.M. 1981. Pollination of *Serapias vomeracea* Briq. (*Orchidaceae*) by imitation of holes for sleeping solitary male bees (*Hymenoptera*). *Acta Botanica Neerlandica*, 30: 69–73.
7. Dhileepan, Kunjithapatham. 1994. Variation in populations of the introduced pollinating weevil (*Elaeodius kamerunicus*) (Coleoptera : Curculionidae) and its impact on fruitset of oil palm (*Elaeis guineensis*) in India. *Bulletin of Entomological Research*, 84: 477 - 485. 10.1017/S0007485300032703.
8. Dylan Hodgkiss, Mark, J.F. Brown and Michelle T. Fountain, 2018. Syrphine hoverflies are effective pollinators of commercial strawberry. *Journal of Pollination Ecology*, 22(6): 55-56.
9. Emily M. Dutton and Megan E. Frederickson, 2012. Why ant pollination is rare: new evidence and implications of the antibiotic hypothesis. *Arthropod-Plant Interactions*, 6(4): 561–569.
10. Erhardt, A. 1989. Pollination of *Dianthus gratianopolitanus* (*Caryophyllaceae*). *Pl. Syst. Evol.*, 170: 125–132. doi:10.1007/BF00937854
11. George, A.P., Nissen, R.J. Ironside, D.A. and Anderson, P. 1989. Effects of nitidulid beetles on pollination and fruit set of *Annona* spp. hybrids. *Scientia Horticulturae*, 39(4): 289-299.
12. Geraldine A. Wright, Susan W. Nicolson and Sharoni Shafir, 2018. Nutritional Physiology and Ecology of Honey Bees. *Annual Review of Entomology*, 63(1): 327-344.
13. Helen J. Young, 1986. Beetle Pollination of *Dieffenbachia longispatha* (Araceae). *American Journal of Botany*, 73(6): 931-944.
14. Hölldobler, B. and Wilson, E.O. 1990. The ants. Harvard University Press, Cambridge, MA, 732 pp.
15. Juha Tuomi, Juho Lamsa, Lauri Wannas, Juha Tuomi, Juho Lamsa, Lauri Wannas, Thomas Abeli and Anne Jakalanemi, 2015. Pollinator Behaviour on a Food-Deceptive Orchid, *Calypso bulbosa* and Coflowering Species. *The Scientific World Journal*, Article ID 482161, 9 pages.
16. Peter Goldblatt, John C. Manning and Peter Bernhardt, 2005. The Floral Biology of *Melasphaerula* (Iridaceae: Crocoideae) : Is This Monotypic Genus Pollinated by March Flies (Diptera: Bibionidae)? *Annals of the Missouri Botanical Garden*, 92(2): 268-274.
17. Shuttleworth, A. and Johnson, S. D. 2009. A key role for floral scent in a wasp-pollination system in *Eucomis* (Hyacinthaceae). *Annals of Botany*, 103(5): 715–725.
18. Sophie Cardinal, Stephen L. Buchmann and Avery L. Russell, 2018. The evolution of floral sonication, a pollen foraging behavior used by bees (Anthophila). *Evolution – International Journal of Organic Evolution*. <https://doi.org/10.1111/evo.13446>
19. Tan, K.H., Nishida R. and Toong, Y.C. 2002. Floral synomone of a wild orchid, *Bulbophyllum cheiri*, lures *Bactrocera* fruit flies for pollination. *Journal of Chemical Ecology*, 28(6): 1161-72.
20. Whittall and Hodges, 2007. Pollinator shifts drive increasingly long nectar spurs in columbine flowers. *Nature*, 447: 706-709.
21. Varatharajan, Ramaiyer, 2016. Pollination Potential of Thrips (Insecta: Thysanoptera) – an overview. *Zoo's Print*, XXXI: 6-12.



Cost and Return of Mango Fruit in Kanker District of Chhattisgarh

Chanchal and B.C. Jain

Department of Agricultural Economics, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, C.G.

Email : chanchal.sahu.0991998@gmail.com

Abstract

The study conducted “cost and return of mango in Kanker district of Chhattisgarh”. Kanker and Charama blocks were selected for study. Three villages were selected from each block and totally 20 fruit growers selected from villages by using random sampling technique. The study is based on primary data. Primary data was collected from the selected fruit growers through questionnaires schedule. The total establishment cost of overall farms (initial investment cost and maintenance cost) during gestation period was observed as Rs. 50352 and per quintal cost of production of selected fruit during bearing period (5th year onward) was Rs. 1013.47, Rs. per hectare for mango. The per hectare net profit at input cost for mango was Rs. 62163.24. Benefit-cost ratio of mango was 2.45 rupees on invest of one rupee, while Input – output ratio of mango was 3.45 rupees.

Key word : Mango, establishment cost, cost of production, BCR, input-output ratio.

Introduction

Mango (*Mangifera indica* L.) is the most important fruit in India and is known as the “King of fruits”. India’s mango production rank first in the world. Horticultural crops contributed about 8% of total area contributing nearly 20% of the gross agricultural output of the country. Nearly 50 different types of mangoes are produced in the country (Srinivasan, 2005). Mango is cultivated in many tropical regions and distributed widely in the world. It is also the national fruit of India, Pakistan and Philippines (Abdelazium *et al.*, 2011). Andhra Pradesh is the leading producer of mango in the country, with a total area of 363 thousand hectares and a total production of 4373.61 thousand tons. The total area of fruit crops in the Chhattisgarh state is 2, 58, 630 hectares, and the production in 2019-20 was 25, 48,930 tons, which 76.57 thousand hectare of produce mangoes; contribute for 17.0% of the state’s total fruit production. The major fruits grown in Chhattisgarh are mango, guava, lime, litchi, cashew etc. The total area of fruit crops in the Kanker region is 1, 00,190 hectares, and the output in 2019-20 is 7, 61,581 tons. Raipur, Gariyaband, Mahasamund, Dhamtari, Durg, Rajnandgaon, Balod, Bemetara, Kabirdham, Mungeli, Bilaspur, Janjgir Champa, Raigarh, Sarguja, Korba, Balrampur, Surajpur, Koriya, Jashpur, Bastar, Kondagaon, Narayanpur, Dantewada and Kanker are the main mango growing areas in the state. According to the 2019-20 data, the area of the Kanker mango production area in the state is 2017 hectares and the output is 8673.1MT. (Source - Assistant Director of Horticulture Kanker).

Research Methodology

The present study conducted was Chhattisgarh state, Kanker district was selected for the study purpose because the maximum fruit cropping area is in Bastar division, which 2 block (Kanker and Charama) were selected purposively for the study. Sample of six villages were randomly selected for the study viz: Bhiroud, Aawri, Bharritola, Devri, Lalmatwada and Khartha. Three villages selected to each blocks. A multi-stage sampling method was adopted in the selection of fruits growers. Total 20 respondents selected to both block. Ten farmers selected to each block. The data was collected using personal interview method and prepared questionnaire schedule.

Analytical Tools

Estimation of cost and return : The total cost of cultivation were divided into, (i) Establishment costs and (ii) Maintenance costs.

Establishment costs : It was the cost incurred during the establishment of a fruits plantation. This cost comprised of land preparation, digging of pits, planting material and its transportation, weeding , manures and fertilizers, plant protection chemicals and all other after care operation during the establishment period (up to 4th years from the data planting of the crop).

Maintenance costs : It includes all the costs incurred annually for the maintenance and production in the fruits plantation from the 5th year onward till the end of life span (productive year). It consisted of (a) annual fixed cost and (b) annual variable cost. The annual fixed cost included apportioned annual share of establishment cost, land tax, repairs and maintenance of building and machines, depreciation and interest on fixed capital. The annual

Table-1 : Establishment cost of mango orchard (Rs./ha).

S. No.	Operation	Establishment cost				Overall Percent
		Initial investment cost	Maintenance cost			
			2 nd year	3 rd year	4 th year	
1.	Field preparation	1555.00	-	-	-	1555.00 (3.09)
2.	Labor cost	5119.00	3892.00	3954.00	3256.00	16221.00 (32.21)
3.	Planting material	12750.00	-	-	-	12750.00 (25.32)
4.	Application of fertilizers and manure	1383.00	1507.00	1560.00	1660.00	6110.00 (12.13)
5.	Irrigation	500.00	500.00	550.00	650.00	2150.00 (4.27)
6.	Fencing	5430.00	-	2500.00	-	7930.00 (15.75)
7.	Plant protection chemical	334.00	352.00	373.00	377.00	1436.00 (2.86)
8.	Miscellaneous charges	500.00	550.00	550.00	600.00	2200.00 (4.37)
	Total cost	27571.00 (54.76)	6801.00 (13.50)	9487.00 (18.84)	6493.00 (12.90)	50352.00 (100)

Table-2 : Cost and return of mango production (Rs./ha).

S. No.	Particulars	Value (Rs.)	Percent (%)
	Annual fixed cost		
1.	Depreciation cost	425.43	86.25
2.	Land revenue	15.00	3.04
3.	Interest on fixed capital @12%	52.85	10.71
	Sub Total	493.28	1.94
	Annual variable cost		
4.	Human labor cost	15665.56	63.05
5.	Manure and fertilizers	3780.78	15.21
6.	Plant protection chemical	2135.34	8.60
7.	Fencing	500.00	2.01
8.	Irrigation charges	100.00	0.40
9.	Interest on working capital @12%	2661.80	10.73
	Sub Total	24843.48	98.05
	Total cost (TFC + TVC)	25336.76	
	Yield (qt/ha.)	25	
	Price (per kg.)	35	
	Gross income (Rs.)	87500.00	
	Net income(Rs.)	62163.24	
	Cost of production (Rs./qt.)	1013.47	
	Input – output ratio	3.45	
	Benefit-cost ratio	2.45	

variable cost included of human labor cost, cost of machine power, material cost (plant protection chemicals, manures and fertilizers, etc) and interest on working capital. The data collected from the fruit growers are used for estimating cost and returns structure by using fixed and variable cost.

(a) Total cost = Total fixed cost + Total variable cost

(b) Gross income (Rs.) = Total Yield (kg) Market Price of the crop (Rs. /kg)

(c) Net income (Rs.) = Gross income – Total cost

(d) Cost of production (Rs. / qt.) = $\frac{\text{Total Cost}}{\text{Yield}}$

(e) Input – output ratio = $\frac{\text{Total Return}}{\text{Total Cost}}$

(f) Benefit – Cost ratio = $\frac{\text{Net Return}}{\text{Total Cost}}$

Results and Discussion

The outcome of the present study yielded many useful finding cost and returns of mango fruits of selected fruit growers.

Initial investment cost (1st year) : In Kanker district, cost of establishment of mango orchard of overall farms per hectare for four years was Rs. 50352. Initial establishment costs such as planting material, gap filling and fencing account for 54.76 per cent of total establishment cost. Total investment cost of mango was found to be Rs. 27571.

Maintenance cost during gestation period (from 2nd year to 4th year) : The maintenance cost incurred by the mango growers during the gestation period is presented in the Table-1. The results revealed that in Kanker district, total maintenance cost during gestation period (up to fourth year) accounted to Rs. 22781 of which cost of Rs. 6801, Rs. 9487, and Rs. 6493 occurred during second, third and fourth years respectively. Hence the total establishment cost was accounted to Rs.50352.

Cost of cultivation of mango orchard (5th year onwards) : The cost of cultivation of mango in Kanker district is presented in table. In Kanker district, total cost incurred in cultivation of mango orchard was found to be Rs. 25336.76 of which variable cost accounts Rs. 24843.48 (98.05% of the total cost) and fixed cost accounts Rs. 493.28 (1.94% of the total cost). Among labour cost, harvesting cost was found to be highest accounting Rs. 15665.56 followed by manure and fertilizers Rs.3780.78 and depreciation of fixed capital Rs. 1562.43.

Total cost of production of overall farms was Rs. 25336.76. The prevailing rate in the market during the period under study was Rs.35 per kg. The gross income received from mango was observed to be Rs. 87500 per hectare. The net profit at total cost was Rs. 62163.24 per hectare. Input-output ratio was 3.45 and benefit-cost ratio of mango was 2.45 rupees. The per quintal production cost of mango was Rs 1013.47.

Conclusion

The initial investment cost of mango orchard during first year in Kanker district was Rs. 27571 ha. Total maintenance cost of mango orchard (second, third and fourth year) in Kanker district was Rs. 22781 ha. The annual total cost of production of mango orchard during fifth year of establishment of orchard in Kanker district was Rs.26610.20 ha. In Kanker district total yield obtained overall farms was 25 quintal of mango per ha. Average price per kg of fruit obtained Rs. 35. Farmer realized higher gross return of Rs. 87500 and net return of Rs. 60889.80. Input – Output ratio of mango was Rs. 3.28.

References

1. Anandaraj, P., and Chinniah, V. 2012. A study on capital productivity analysis of mango cultivation with special reference to Madurai district. *SMART Journal of Business Management Studies*, 8: 48-58.
2. Anonymous. 2020. Assistant Director of Horticulture, Kanker. Government of Chhattisgarh.
3. Bhat, A. R. S., Kachroo, J. and Kachroo, D. 2011. Economic appraisal of kinnow production and its marketing under north-western Himalayan region of Jammu. *Agricultural Economics Research*, 283-290.
4. Bhosale, S.S., Sonawane, K.G. and Shinde, V. A., 2016. Economics of kesar mango production in plain zone of western Maharashtra. *International Journal of Agriculture Sciences*, 8: 1912-1915.
5. Datarkar, S. B., Darekar, A. S., Dangore, U. T. and Parshuramkar, K. H. 2014. Economic of production and marketing of mango in Gadchiroli district of Maharashtra. *International Research Journal of Agricultural Economics and Statistics*, 5(2): 278-283.
6. Kulkarni, A.K., Tingre, A.S. and Sanap, D.J. 2019. Economics of production and constraints in pomegranate cultivation in Vidarbha region of Maharashtra. *Journal of Pharmacognosy and Phytochemistry*, 8(2): 2153-2159.
7. Kumar, R., Kumar, N., Dhillon, A., Bishnoi, D. K., Kavita, and Malik, A. K. 2019. Economic analysis of guava (*Psidium guajava* L.) in Sonapat district of Haryana. *Indian journals. com* 64: 747-752.
8. Loganathan, M., Mani, K., Mariappan, G. and Kumar, K. T. 2016. Cost, returns and economic viability of cashew plantation in Tamil Nadu. *International research Journal of Agricultural Economics and Statistics*, 7: 76-85
9. Ramani, M., Tarpara, V.D., Swaminathan, B., Manasi, P. and Pokiya, N.M. 2019. Cost of cultivation and profitability of kesar mango cultivation in Saurashtra region of Gujarat, India. *International Journal of Science, Environment and Technology*, 8(6): 1153-1160.
10. Thorat, V.A., Hake, A.D. and Kambale, S.K. 2016. Economic analysis of mango plantation under EGS linked horticultural development programme in Konkan region. *Journal of Agriculture Research and Technology*, 41(2): 286-291.
11. Yadav, S., Shukla, A., Rai, J. and Mishra, R. 2018. Economics of mango production and constraints in district Lucknow, U.P. *Journal of Pharmacognosy and Phytochemistry*, 7(3): 1398-1402.



Growth and Foliage Production of Kasuri Methi (*Trigonella corniculata*) under the Influence of Different Types and Doses of Organic Manures at Temperate Region of Bharsar, Uttarakhand

Chand P.¹, Singh K.C.^{2*} and Chauhan R.S.¹

¹College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar-246123 U.K.

²Department of Natural Resource Management, College of Horticulture, VCSG UUHF, Bharsar-246123 U.K.

*Corresponding Author Email : chandrakumarkh@gmail.com

Abstract

On a field trial conducted to investigate the influence of different types and doses of certain types of organic manures at temperate region of Bharsar, Uttarakhand, comprising of varying doses of FYM, Compost and Vermicompost, it was apparently seen that application of different types and doses were helpful in boosting the foliage production. However, the degree of enhancement of production were variable among the different types and doses of organic manures. It was further seen that application of Vermicompost @ 15 t/ha witnessed an intense and significant impact on growth and foliage yield in Kasuri Methi. The results of experiment showed that minimum days to germination (14.000 ± 1.155), tallest plant height (21.767 ± 0.145 cm), maximum number of branches per plant (5.667 ± 0.333), number of leaves per plant (43.667 ± 0.333), fresh foliage biomass (10.400 ± 0.100 q/ha), dry foliage biomass (1.100 ± 0.000 q/ha), fresh leaf yield (7.047 ± 0.023 q/ha), dry leaf yield (0.757 ± 0.013), fresh straw yield (3.390 ± 0.092 q/ha) and dry straw yield (0.357 ± 0.013 q/ha) were recorded under treatment Vermicompost @ 15 t/ha whereas, minimum was recorded under control T₁. The highest cost of cultivation (Rs.125900.00) gross return (Rs.77485.00) was recorded in Vermicompost @ 15 t/ha. Compost @ 5 t/ha, having lower nutrient than vermicompost but higher than FYM, in this experiment resulted in the highest net return (Rs. 23500.00) as well as greatest BCR (1.76) because of its lower per unit application cost than vermicompost. The findings indicated that increasing doses in all the three types of organic manures resulted in greater foliage production of Kasuri Methi. According to present investigation, even though Vermicompost @ 15 t/ha provided the greatest foliage yield of Kasuri Methi, it couldn't provide a good net return (Rs. -48415.00) resulting a BCR of 0.62 only. Further, compost @ 5 t/ha, even though it provided moderate foliage yield of Kasuri Methi, resulted in the greatest net return (Rs.23500.00) with BCR of 1.76. Hence, the dose of compost @ 5 t/ha could satisfactorily be recommended for getting maximum foliage production of Kasuri Methi at temperate region of Bharsar, Uttarakhand.

Key words : Kasuri methi, organic manures, foliage yield, BCR.

Introduction

Kasuri Methi (*Trigonella corniculata*) is an annual herb reaching a height of about 0.9m which belongs to family Fabaceae and is a native of South Eastern Europe and West Asia. The crop is cultivated as leafy vegetable, condiment and as a medicinal plant and for fodder as well. The crop is particularly considered important for its high medicinal value like preventing constipation, removing indigestion, stimulating spleen and liver and is appetizing and diuretic. The fresh tender leaves and stem are consumed as curried vegetable and the seeds are mainly used as spice for flavouring almost all dishes which are in fact rich in iron, calcium, vitamins and essential amino acids, like lysine, leucine and phenylalanine. The seeds are used in treatment of flatulence, dysentery, diarrhoea, dyspepsia, chronic cough, dropsy, enlargement of liver and spleen, rickets, gout, diabetes and arthritis [13].

Because of the increasing concern of deteriorating soil health as a result of prolonged use heavy

doses of inorganic fertilizers it has been of paramount importance to develop different organic cultivation packages including Vermicompost, Compost, FYM and other organic manures for Kasuri Methi production for different climatic conditions. The use of Vermicompost is one of the fundamentals of raising crops organically in the various field crops. Also, many researchers suggested the implementation of the use of vermicompost as organic fertilizer and substitute for chemical as a valuable part of organic farming. The application of vermicompost not only add plant nutrients and growth regulators to the soil but also improves physical, chemical and biological properties of the soil. Besides, the application of Vermicompost has the advantages of reduced soil erosion, deodorification of obnoxious smell, destruction of pathogens and detoxification of soil pollutant etc. Also, the application of vermicompost is believed to have encouraged desirable microbial population in the root zone [13]. Vermicompost improves yield components of Fenugreek due to vegetative and reproductive growth led to higher seed yield [1 & 10] which consequently

Table-1 : Influence of different types and doses of organic manures on various growth attributes of Kasuri Methi (*Trigonella corniculata*).

Treatment details		Number of days taken to germination Mean±S.E.	Plant height (cm) Mean±S.E	Number of branches per plant Mean±S.E	Number of leaves per plant Mean±S.E	Fresh foliage biomass yield (q/ha) Mean±S.E	Dry foliage biomass yield (q/ha) Mean±S.E.
T ₁	Control	24.667±0.882	13.500±0.289	2.333±0.333	32.667±0.333	5.267±0.033	0.433±0.033
T ₂	Farmyard Manure @ 5 t/ha	23.667±0.882	14.800±0.115	2.667±0.333	33.667±0.333	7.067±0.088	0.533±0.033
T ₃	Farmyard Manure @ 10 t/ha	22.667±0.667	15.067±0.233	3.000±0.000	35.000±0.577	7.167±0.033	0.633±0.033
T ₄	Farmyard Manure @ 15 t/ha	21.667±1.202	15.800±0.115	3.333±0.333	36.000±0.577	7.767±0.240	0.667±0.033
T ₅	Compost @ 5 t/ha	18.333±2.028	16.267±0.233	3.667±0.333	38.000±0.577	7.900±0.058	0.733±0.033
T ₆	Compost @ 10 t/ha	18.333±0.882	17.133±0.186	4.000±0.000	39.333±0.333	8.133±0.088	0.867±0.033
T ₇	Compost @ 15 t/ha	20.667±0.333	18.100±0.208	4.333±0.333	40.667±0.882	8.667±0.145	0.900±0.000
T ₈	Vermicompost @ 5 t/ha	16.000±1.155	19.500±0.289	4.667±0.333	42.333±0.333	9.200±0.100	1.000±0.000
T ₉	Vermicompost @ 10 t/ha	14.667±1.333	20.900±0.208	5.333±0.333	43.333±0.333	9.767±0.067	1.067±0.033
T ₁₀	Vermicompost @ 15 t/ha	14.000±1.155	21.767±0.145	5.667±0.333	43.667±0.333	10.400±0.100	1.100±0.000
S.E(d)		1.611	0.271	0.419	0.650	0.147	0.038
C.D. (0.05)		3.411	0.573	0.886	1.376	0.311	0.079

* Significant at 5% level of significance as compared to control

Table-2 : Influence of different types and doses of organic manures on some yield attributes of Kasuri Methi (*Trigonella corniculata*).

Treatment details		Fresh leaf yield (q/ha) Mean±S.E	Dry leaf yield (q/ha) Mean±S.E	Fresh straw yield (q/ha) Mean±S.E	Dry straw yield (q/ha) Mean±S.E
T ₁	Control	2.700±0.017	0.280±0.010	2.590±0.020	0.180±0.010
T ₂	Farmyard Manure @ 5 t/ha	4.443±0.059	0.333±0.020	2.610±0.010	0.190±0.010
T ₃	Farmyard Manure @ 10 t/ha	4.543±0.030	0.400±0.017	2.633±0.020	0.210±0.010
T ₄	Farmyard Manure @ 15 t/ha	5.037±0.186	0.457±0.030	2.733±0.038	0.210±0.010
T ₅	Compost @ 5 t/ha	5.133±0.038	0.533±0.020	2.777±0.029	0.220±0.010
T ₆	Compost @ 10 t/ha	5.367±0.069	0.587±0.030	2.777±0.039	0.257±0.013
T ₇	Compost @ 15 t/ha	5.763±0.120	0.620±0.010	2.910±0.049	0.290±0.010
T ₈	Vermicompost @ 5 t/ha	6.110±0.059	0.680±0.010	3.057±0.070	0.310±0.010
T ₉	Vermicompost @ 10 t/ha	6.533±0.052	0.720±0.010	3.247±0.039	0.333±0.020
T ₁₀	Vermicompost @ 15 t/ha	7.047±0.023	0.757±0.013	3.390±0.092	0.357±0.013
S.E(d)		0.107	0.019	0.067	0.013
C.D. (0.05)		0.227	0.041	0.143	0.038

*Significant at 5% level of significance as compared to control.

Table-3 : Economic study of different treatments imposed on organic production of Kasuri Methi.

Treatment details		Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B : C ratio
T ₁	Control	20900	28900	8000	1.38
T ₂	Farmyard Manure @ 5 t/ha	30900	34250	3350	1.11
T ₃	Farmyard Manure @ 10 t/ha	40900	41050	150	1.00
T ₄	Farmyard Manure @ 15 t/ha	50900	46750	-4150	0.92
T ₅	Compost @ 5 t/ha	30900	54400	23500	1.76
T ₆	Compost @ 10 t/ha	40900	59985	19085	1.47
T ₇	Compost @ 15 t/ha	50900	63450	12550	1.25
T ₈	Vermicompost @ 5 t/ha	55900	69550	13650	1.24
T ₉	Vermicompost @ 10 t/ha	90900	73665	-17235	0.81
T ₁₀	Vermicompost @ 15 t/ha	125900	77485	-48415	0.62

increased seed and straw yields. Keeping the above facts in due consideration, the present investigation was being framed with the objective to develop and a cost-effective organic cultivation package for profitable Kasuri Methi production at temperate region.

Materials and Methods

The present investigation was conducted during February 2020 to June 2020 at the Medicinal and Aromatic Plants Block, College of Horticulture, VCSG, Uttarakhand University of Horticulture and forestry, Bharsar, Pauri Garhwal, Uttarakhand - 246123. The entire experiment was framed with Completely Randomized Block Design consisting of ten treatments viz., Control (T₁), FYM @ 5 t/ha (T₂), FYM @ 10 t/ha (T₃), FYM @ 15 t/ha (T₄), Compost @ 5 t/ha (T₅), Compost @ 10 t/ha (T₆), Compost @ 15 t/ha (T₇), Vermicompost @ 5 t/ha (T₈), Vermicompost @ 10 t/ha (T₉) and Vermicompost @ 15 t/ha (T₁₀) in triplicates. Seeds were sown on 12th February 2020 maintaining 30cm × 10cm spacing at a depth of 2cm. The seeds were properly covered with a thin layer of soil and the plots were irrigated lightly after sowing. Thinning was done manually at 30 days after sowing as per treatment to maintain recommended spacing so as to retain healthy vigorous seedling. The different types of organic manures viz., FYM, Compost and Vermicompost with different doses were applied in the field on dry weight basis 10 days prior to sowing and mixed properly. The plots were kept free from weeds by hand weeding at 30 and 45 days after sowing (DAS) and were irrigated by rose can after sowing and thereafter at 3 days interval for 10 days and subsequent irrigation was applied at an interval of 4-7 days in initial growth period. The plants were then harvested at 75 DAS and brought to laboratory for processing and further analysis. The harvested parts were divided into two grades namely leaves (for grade A quality) and straws (for grade B quality). The respective observations on growth, yield and economic parameters like days to germination, plant height (cm), number of branches per plant, number of leaves per plant, foliage

biomass (g), leaves yield per plant (g), leaves yield per hectare (q/ha), straw yield per plant (g), straw yield per hectare (q/ha), cost of cultivation, gross return, net return and benefit cost ratio were critically observed at 45, 75 DAS and statistically analyzed using the method of variance as described by Gomez and Gomez [5] given in standard book "Statistical Procedure for Agriculture Research". The soils of the experimental site fall under inceptiol order with sandy loam texture having 1.31 – 2.57 % oxidizable organic carbon, 384.8 – 722.6 Kg ha⁻¹ available nitrogen, 23.6 – 57.2 Kg ha⁻¹ available P₂O₅ and 24.1 – 53.1 Kg ha⁻¹ available K₂O. The soils are slightly acidic in reaction (5.84 pH) with optimum electrical conductivity (0.35 - 0.40 %).

Results and Discussion

Growth attributes : The data presented in Table-1 revealed that the minimum number of days (14.000 days) taken for germination, tallest plant height (21.767 cm), maximum number of branches per plant (5.667), maximum number of leaves per plant (43.667), fresh foliage biomass (10.400q/ha) and dry foliage biomass (1.100q/ha) were being recorded in T₁₀ i.e., vermicompost @ 15 t/ha. Vermicompost being a well decomposed organic manure which provides plants with essential nutrients and aids in the suppression of plant diseases as it contains different hormones etc. might have resulted in such a promising performance. Also, vermicompost accelerates germination, plant growth, and crop yield and also improves root growth and structure. Vermicompost is being claimed to contain 3% N, 1% P and 1.5 % K [9]. The present findings are in accordance with the reports of [6] who reported earliest seed germination, maximum plant height, no. of branches, number of pods and seeds, higher grain yield etc. by using three organic modules (M₁, M₂ and M₃) Organic module-1 (M₁) comprising of soil application of Vermicompost @ 5t/ha+ foliar spray of 5% garlic extract @ 2.0 kg/ha+ 2% neem oil @ 5litre/ha + soil application of neem cake @ 150 kg/ha and *Trichoderma* @ 2.5 kg/ha, seed treatment with *Rhizobium* @ 100ml/kg

seed, PSB @ 100 ml/kg seed and *Trichoderma* @ 10 g/kg seed and two fenugreek varieties (AFg-1 and RMt-305) with four replications. Similar results were also reported by [8] that the urban organic wastes and their compost and vermicompost showed significant positive effects on the growth of different traits of both plants. Also, they reported a significant positive correlation between the number of leaves and dry biomass of both plants. The shoot length, number of leaves, number of branches, and dry biomass of both the plants increased significantly.

Yield attributes : The data on the effect of different treatments on leaf and straw yield (fresh and dry weight of leaves and straw) of Kasuri Methi are depicted in Table-2. The leaf yield to the tune of 7.047q/ha (fresh) and 0.757q/ha (dry) along with 3.390q/ha of fresh straw yield and 0.357q/ha of dry straw yield were being recorded as highest in T₁₀ i.e., Vermicompost @ 15 t/ha which were analyzed statistically significant at p=0.05 level. Superior performance of plants under T₁₀ is believed to be the reason behind resulting greatest yield attributes in this treatment. Among all the organic manures, highest dose of Vermicompost (15 t/ha) provided the greatest amount of fresh as well as dry leaf yield and straw yield. [13] also reported significantly increased seed and straw yields to the tune of 29.10 and 24.03 percent over control with the increasing application of vermicompost up to 4 t ha⁻¹. Similar findings were reported by [11] also. Further, compost is seen to have provided better result than FYM, however, lesser than vermicompost. Vermicompost is a nutritive organic fertilizer enriched with plant available forms of macro (Nitrogen, Phosphorus and Potassium) and micro (Iron, Copper, Zinc, etc.) nutrients, beneficial microbes; nitrogen-fixing and phosphate solubilizing bacteria, actinomycetes etc. and also improves plant health due to which plant show better height, leaves, pods and seed [4, 13]. It also contains biologically active substances such as plant growth regulators [12]. The enhanced crop growth might be due to improved soil physical condition, prolonged availability of macro and micro nutrients to crop during entire growing season as well as increased microbial activity. Our findings are in conformity with the findings of [2] who claimed that application of vermicompost results improvement in growth parameters such as plant height, herbage yield and dry weight of leaves. [7] also found significantly higher growth traits and seed, straw yield in fenugreek with the application of vermicompost.

Economic studies : The data pertaining to economic studies as shown in Table 3 revealed that the highest total cost of cultivation per hectare (Rs. 125900.00) and gross return (Rs. 77485.00) were estimated in T₁₀ i.e., vermicompost @ 15 t/ha. However, contrastingly, the greatest net return per hectare (Rs. 23500.00) was

estimated in T₅ i.e., compost @ 5 t/ha as shown in Table 4. Some of the treatments are seen to have resulted in negative net return viz., T₄ (Rs. -4150.00), T₉ (Rs. -17235) and T₁₀ (Rs. -48415.00), indicating the occurrence of loss in these cultivation packages. Further, it is also seen that some of the treatments viz., T₂ (Rs. 3350.00), T₃ (Rs. 150.00), T₄ (Rs. -4150.00), T₉ (Rs. -17235.00) and T₁₀ (Rs. -48415.00) performed even poorer in comparison with T₁ (Rs. 8000.00) Control, so far net return from the entire cultivation package is concerned. Consequently, the greatest benefit cost ratio (BCR) was estimated in T₅ (1.76) i.e., Compost @ 5 t/ha. The rest of the treatments viz., T₂ (1.11), T₃ (1.00), T₄ (0.92), T₇ (1.25), T₈ (1.24), T₉ (0.81), and T₁₀ (0.62) were seen to have resulted in poorer performance in terms of benefit per unit cost invested.

However, [3] claimed highest grain yield, gross return, net return and BCR with the application of Vermicompost followed by Poultry manure which were reported better for maintaining good soil health and sustainable higher yield levels in fenugreek. Similar findings were also reported by [13] who claimed that the application of vermicompost upto 4 t ha⁻¹ significantly increased the net return. The variation in the BCR values of our experiment and the values reported by other researchers might possibly be partially due to cheaper cost of vermicompost at their location and partially due to the inclusion of other economic parts of the crop i.e., seeds which is the worthiest part of the crop. In our experiment, we observed the crop up to only 75 DAS.

Conclusion

Based on the experimental results, it is concluded that under organic production of Kasuri Methi, the leaf yield of this crop could effectively be improved by application of different organic manures over the untreated control. Among the different organic manures, vermicompost appeared to have greatest positive influence on foliage production of the crop. It is also appeared that increasing doses in all the three types of organic manures (FYM, compost and vermicompost) resulted in greater foliage production. The dose of vermicompost @ 15 t/ha provided the greatest yield of Kasuri Methi in this experiment and could be recommended for enhanced foliage production of this crop. However, from the point of view of benefit earned per unit cost invested, vermicompost @ 15 t/ha is proven to give the least return as it incurred the highest cost of cultivation and shall not be recommended. Further, it is worth to mention that compost @ 5 t/ha, even though it produces lesser foliage yield (lesser than vermicompost but greater than FYM and control), resulted in providing highest net return (Rs. 23500.00/ha) earned per unit of cost invested making the most beneficial in terms of B:C ratio (1.76). Being a leguminous crop, cultivation of this

crop along with application of different organic manures like Vermicompost, Compost, FYM and other organic manures would be a great move towards organic cultivation of Kasuri Methi which ensures the maintaining of sustainable soil fertility as well as sustainable and should be advocated to the farmers to replace the use of chemical fertilizers. As Kasuri Methi has many medicinal and nutraceutical properties which are rich in several important phytochemicals with positive impacts on human health, thrust should be given on developing different organic cultivation packages of this crop in future.

Aknowledgement

The authors are thankful to College of Horticulture, VCSG, UUHF, Bharsar, Uttarakhand for providing laboratory and field facilities for conducted the experiment.

References

1. Chaturvedi, S. and Chandel, A.S. (2005). Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (*Glycine max* L.). *Ind. J. Agron.* 50 (4): 311-313.
2. Deora, N.S.; Singh, J. and Reager, M.L. (2009). Studies on nutrient management and seed rate on growth and herbage yield of fenugreek (*Trigonella corniculata* L.) cv. Kasuri in Rajasthan. *J. Spice. Aro. Crops.* 18(1): 19-21.
3. Dubey, P.K.; Pandey, C.S.; Khanday, A.S. and Mishra, G. (2012). Effect of integrated nutrient management on nutrient uptake, protein content and yield of fenugreek. *Int. J. Food Agri. Vet.* 2(1):1-12.
4. Edwards C.A. and Burrows, S. (1988). The potential of earthworm compost plant media. *In: F dwards, C.A. and Neuhauser, E. Eds. Earthworms in waste and environmental management SPB Academicprocss.* Hauge Netherlands. pp. 21-32.
5. Gomez K.A. and Gomez A.A. (1984). Statistical Procedure for Agricultural Research. *John Wiley and Sons, Inc.* New York. 357-427.
6. Lal, G.; Singh, R.; Mehta, R.S.; Sharma, Y.K.; Krishna, K. and Maheria, S.P. (2017). Standardization of organic module for sustainable production of fenugreek. *Leg. Res.- Int. J.* 40(1):144-149.
7. Lunagariya, D.; Zinzala, D.; Barvaliya, V.J.; Mital, M. and Dubey, P.K. (2018). Effect of organics on growth, yield, quality and economics of fenugreek grown under organic farming system. *J. Pharma. Phytochem.* 7(3):2420-2424.
8. Reddy, V.M. and Pattnaik, S. (2010). Effects of Urban Organic Wastes, their Composts and Vermicomposts on the Growth Traits of Fenugreek (*Trigonella foenum-graceum* L.) and Tomato (*Lycopersicum esculentum* Mill.) under Field Conditions. *Global Science Books.* 113-122.
9. Singh, J. (2014). Soil fertility management. *In: basic Horticulture. Kalyani Publishers, New Delhi.* 4: 208-209.
10. Suman; Dahma, A.K. and Poonia, S.L. (2007). Effect of balanced fertilization on growth and yield of greengram [*Phaseolus radiates* (L.) Wilczek]. *Har. J. Agron.* (1&2):118-119.
11. Thanunathan, K.; Arumugan, K.; Kuruppswami, G. and Ravichandran, M. (2002). Effect of vermicompost on growth and yield of soybean (*Glycine max* L.) cv. CO-1. *Madras Agric. J.* 89(10-12): 613-616.
12. Tomatic, U.; Grappelli, A. and Gill, E. (1987). The presence of growth regulator in earthworm worked wastes. *In: bauvicies pagnot A. M. Chodeo P. (Eds.) on Earthworms, Modena Italy.* pp. 423-436.
13. Verma, S.R.; Shivran, A.C.; Bhanwaria, R. and Singh, M. (2014). Effect of vermicompost and sulphur on growth, yield and nutrient uptake of Fenugreek (*Trigonella foenum-graceum* L.). *Bioscan.* 9(2): 667-670.



Linkage Map Construction Using SSR Markers and QTL Mapping for Some Productivity and Fiber Quality Traits in Desi Cotton

Chetankumar N. Banakar¹, Rajendragouda Patil² B. M, Khadi¹ and I.S. Katageri^{1*}

¹Department of Genetics and Plant Breeding UAS Dharwad, Karnataka India

²School of Agricultural Sciences and Technology (SAST), NMIMS, Shirpur Maharashtra India

*katageriis@uasd.in and chetan3823@gmail.com

Abstract

Desi or Diploid cottons had been under commercial cultivation in sizable area in India, which can never be replaced by tetraploid upland cotton in environmentally harsh regions. However, conversion of poor quality diploids into superior quality cottons are remunerative. Molecular linkage maps provide essential tools for plant genetic research which facilitate quantitative trait locus (QTL) mapping, marker-assisted selection (MAS) and map-based cloning (MBC). In the present study, a genetic linkage map was constructed with 40 markers. The total map length was 343.29cM with average distance of 8.58 cM between the markers. In total, 8 putative QTLs were detected, among these highest number of QTLs were for seed cotton yield (4). The linkage groups 2 (seed cotton yield and lint yield) and 4 (seed cotton yield and uniformity ratio) harboured QTLs for more than one trait.

Key words: *Desi* cotton, SSR markers, QTL mapping.

Introduction

Cotton (*Gossypium* spp.) is considered as the foremost natural fiber and oil source worldwide, with an estimated production and utilization of ~115 million bales (in India, ~30 million bales) (Annon. 2015). It is indigenous to tropical and sub-tropical regions and being cultivated on every continent excluding Antarctica. The economic impact of the cotton industry throughout the world is about ~\$500 billion per year (Zhang *et al.*, 2013). Cotton belongs to genus *Gossypium* and family Malvaceae. The genus *Gossypium* has 45 diploid and 5 allotetraploid species and occurs in semiarid and arid areas of Africa, Central and South America, Galapagos, Indian sub-continent, Australia, Arabia, and Hawaii (Frixel, 1992). Currently, cotton has 4 cultivated species, among which two are tetraploid species [*G. hirsutum* L. (AADD) and *G. barbadense* L. (AADD)] and two are diploid species [*G. arboreum* L. (A₂A₂), and *G. herbaceum* L. (A₁A₁)], (Iqbal, *et al.*, 2001). *G. hirsutum* (Upland cotton or Mexican cotton) contributes to 90%; *G. barbadense* (Sea Island cotton or Egyptian cotton) produces 8% (Zhang *et al.*, 2005), *G. herbaceum* (Levant cotton) and *G. arboreum* (Tree cotton) together provide 2% of the World's cotton (Zhang *et al.*, 2008). Perhaps, India is the only country in the World where in all the four cultivated species are grown on commercial scale. In India, diploid cottons are grown from time immemorial. During pre-independence era, about 95 per cent of the area under cotton cultivation is under Asiatic (*desi*) cotton and only three per cent of the area under American cotton (*G. hirsutum*). Now, upland cotton and its intra and inter specific hybrids cover 90 per

cent area in the country and the remaining cotton area under Asiatic cotton. Among these, *G. hirsutum* only contributes 90 per cent of the total cotton production.

Diploid cottons *G. herbaceum* and *G. arboreum* have been under the commercial cultivation in sizable area, which can never be replaced by tetraploid upland cotton because those areas which are considered to be environmentally very harsh. Conversion of poor quality diploids into superior quality cottons are remunerative (Katageri *et al.*, 2004). The *Desi* cottons are having very high yield potential along with the resistance to biotic and abiotic stresses. The yield potentials of some *desi* cotton varieties is noticed upto 40 q/ha which is much higher than *G. hirsutum* (Meena *et al.*, 2004).

In 1994, the first molecular genetic map of cotton was published (Reinisch *et al.*, 1994). However, even with all possible potential molecular markers, studies using markers for genetic mapping are too incomplete to be useful for breeding are still only attempts by researchers and that the development of an efficient breeding program using genetic maps requires additional dialogue among breeders regarding this technology (Bandyopadhyay, 2011).

A genetic map of cotton is extremely important because it provides fundamental information about the genetic content and genome organization of this species. In addition, it allows for the development of a strategy for improving cotton production. The research that has been conducted thus far has not mapped all cotton genes, and scientists have prioritized genes associated with traits of

interest, especially those related to fiber quality. Moreover, no record of an ideogram of the species was found in the literature, only the genetic map of some chromosomes.

The regions in genomes to have genes linked with a quantitative trait are known as quantitative trait loci, QTLs (Collard *et al.*, 2005) and the process of developing linkage maps and performing QTL analysis is referred to as QTL mapping (Paterson, 1996a and 1996b). QTL analysis stands on the principal of identifying a connection among phenotype and genotype of markers (Collard *et al.*, 2005)

A detailed view of the genetic architecture of quantitative traits can be obtained through a genetic map saturated with molecular markers. The parameters that quantify the genetic architecture of a quantitative trait include the number and positions of genomic loci, their actions and genetic interactions; and their responses to biotic and abiotic factors. Thus, we can identify quantitative trait loci (QTL) with the availability of polymorphic markers from a single nucleotide and multiple polymorphism markers. The mapping of molecular markers has also proven useful for the identification of genetic characteristics that change the phenotype of an organism over time or in response to other variables in coherence with the environment.

The present study was undertaken at Agricultural Research Station (ARS), Dharwad, with the objective to help enriching the genetic map of the cotton and also identify markers for important yield contributing and fibre quality traits. The mapping population would also serve as good resources for mapping studies in cotton.

Materials and Methods

Phenotypic Analysis. The genetic material for the present investigation comprised of backcross derived inbred lines which were developed at ARS, Dharwad using the two diploid parents belonging to two different species *viz.*, *G. herbaceum* var. Jayadhar and *G. arboreum* var. DLSa17. F1 were backcrossed to *G. herbaceum* var. Jayadhar and inbred lines were developed by continuous selfing BC1F1 till BC1F6. The parents and 274 BILs were grown at Main ARS, Dharwad which is situated in the northern transitional zone (Zone no. 8) of Karnataka state (India). The phenotypic data on productivity and fiber quality traits were recorded from 274 back cross derived inbred lines (BILs) along with the parents.

Genotypic Analysis. The total genomic DNA from young leaves of the parents and BILs plants was isolated using the cetyltrimethyl-ammonium bromide (CTAB) method (Zhang and Stewart, 2000). Two μ l of each sample was

loaded on to 0.8% agarose gel and was electrophoresed at 100 volts. After electrophoresis, gel was stained with ethidium bromide solution (10 μ l/ml) for 15 min. and viewed under trans-illuminator. Quantification was done based on the intensity of the bands. Normalization of DNA was done to bring all DNA concentrations to a relatively equal level (20 ng/ μ l) by appropriate dilutions. Dilutions were done with TE buffer. Forty (40) SSR primers which are polymorphic between two parents were used to generate linkage map using IciQTL map version 3.2. PCR was used for amplification using the following profile: initial denaturing step at 94°C for 5 min followed by initial 35 cycles at 94°C for 40s, 60°C for 40s and 72°C for 40s, with a final extension step at 72°C for 10 min. The PCR amplified products were run on QuiAxeL Capillary Gel electrophoresis. Gel images were saved and presence of a Jayadhar type of band was recorded as '2', DLSa-17 type as '0', hybrid type as '1' and absence of band as '-1' per the typical codominant marker system. Ambiguous data that could not be resolved was discarded.

Linkage Map Construction. The segregation ratio for each marker was tested against the expected Mendelian ratio using Chi-square goodness of fit test. Only markers which are not significantly ($P=0.05$) different from the expected 1:2:1 were utilized for map construction. Linkage map construction was performed using IciQTLmap 3.2 (Wang *et al.*, 2011). The Kosambi map function was used (Kosambi, 1994) to convert recombination frequency to genetic map distance (cM). All the linkage groups were determined at logarithm of odds (LOD) scores ≥ 3.0 . The graphical representation of the LG was obtained using IciQTLmap v.3.2.

Results and Discussion

Linkage map

Sufficient DNA sequence polymorphisms between parents must be present for linkage mapping. Naturally outcrossing species, such as maize, tend to have high levels of DNA polymorphisms and virtually any cross that does not involve related individuals will provide sufficient polymorphism for mapping (Helentjaris, 1987). However, varying levels of DNA sequence variation are generally lower in naturally inbreeding species and finding suitable DNA polymorphisms may be more challenging (Miller and Tanksley, 1990). Sometimes mapping of inbreeding species requires that parents be as distantly related as possible. In the present study, out of 900 SSR markers screened, 152 were found to be polymorphic on PAGE. 40 out of 150 were used for linkage analysis. The per cent of polymorphic markers was 16.88 on PAGE which found to be at par or higher than the similar studies. Muhammed *et al.*, (2011) obtained less than one per cent (0.98)

Table-1 : Number of polymorphic markers, map length, average distance between markers and number of QTLs on each linkage group for mapping population.

Linkage group number	Number of markers	Length (cM)	Average distance (cM)	Number of QTLs
1	6	34.45	5.75	2
2	8	95.53	11.94	3
3	3	7.85	2.61	0
4	9	74.64	8.29	2
5	7	67.13	9.59	1
6	7	63.69	9.08	1
Total	40	343.29	8.58	8

Table-2 : QTLs detected for yield and fibre quality traits in Jayadhar x DLSa-17 BILs based on interval mapping.

Sl. No.	Trait	QTL	Left marker	Right marker	LOD	R ²	Additive Effect
1.	Seed Cotton Yield (kg/ha)	qscy 1.1	NAU2562	MUSB0888	3.1	0.70	11.20
		qscy 1.2	MUCS088	TMB0853	2.4	1.22	-10.90
		qscy 2.1	MUSB0831	MUSS022	2.6	0.58	9.65
		qscy 4.1	BNL2496A	BNL3259	4.2	3.60	12.45
2.	Lint Yield (kg/ha)	qly 2.1	MUSS128	MUSB1112	7.1	5.62	-6.40
		qly 2.2	MUSB0831	MUSS022	2.2	1.67	7.85
3.	Ginning Out Turn (%)	qgot 5.1	NAU997	BNL2632	2.91	5.30	0.54
4.	Uniformity Ratio (%)	qur 4.1	BNL2496A	BNL3259	3.1	0.64	1.14
5.	Fibre Strength (g/tex)	qfs 6.1	MUSS010	MUSS414	4.4	0.72	2.08

polymorphism in the study involving F_2 mapping population derived from intra-hirsutum cross. In one of the studies comprising of intra-hirsutum RIL mapping population, the parental polymorphism survey revealed 2.77 per cent polymorphism (Hong Chen *et al.*, 2009). The molecular mapping study by Rakshit (2010) revealed only four polymorphic markers out of 177 markers used for parental polymorphism survey. Higher polymorphism level in the present study can be attributed to the parents Jayadhar belonging to *G. herbaceum* and DLSa17 belonging to *G. arboreum*. The polymorphic markers surveyed on parents can be further employed for genotyping the mapping population. There are several studies wherein different level of polymorphism was obtained as discussed above. However, little work in the Asiatic cotton genome and QTL mapping has been accomplished due to low rate of polymorphism among A-genome *Gossypium* species (Rong *et al.*, 2004). In this regard, this investigation will be useful in further mapping and marker association studies.

The genotypic data obtained from the polymorphic markers on the mapping population was subjected for linkage map construction. The LOD value fixed was 3.0. The chi-square test was employed to test the Mendelian segregation ratio of expected 1:1 ratio. However, six (6) markers (15%) showed segregation distortion. But, due to a smaller number of polymorphic markers, all the 40 markers were used for linkage map construction. A total of 40 markers were mapped on six linkage groups with the

total span of 343.29cM and an average marker distance was 5.58 cM (Table 1).

QTL mapping for yield and fibre quality traits

In the present study, a total of 8 QTLs were detected for productivity and fibre quality traits using Interval composite mapping by the QTL Ici Mapping 3.2 Version software (Table 2 and Fig 5).

Productivity traits

Four QTLs distributed on three linkage groups (1, 2 and 4) were detected for seed cotton yield. The phenotypic variance ranged from 0.58 to 3.6 per cent. Two QTLs, *qscy1.1* and *qscy4.1* were detected with LOD more than 3. Two QTL *qscy1.1* and *qscy4.1* were detected with LOD of 3.1 and 4.1, respectively. Seed cotton yield is an important trait to be considered for crop improvement. Lot of research work has been focused on improving yield levels of various crops and cotton is not an exception for that. Wang *et al.*, (2007), Quin *et al.*, (2008) and Saeed *et al.*, (2011) also reported QTLs for seed cotton yield in different populations.

There were two QTLs detected for lint yield both located on linkage groups. Among these two QTLs *qly2.1* was detected with 7.1 LOD value. The phenotypic variance explained ranged from 1.67 to 5.62 per cent. Similarly, lint yield is also an important trait to breed for. Wang *et al.* (2007), He *et al.* (2007) and Quin *et al.* (2008) reported four QTLs for lint yield in the interspecific cross between hirsutum and barbadense.

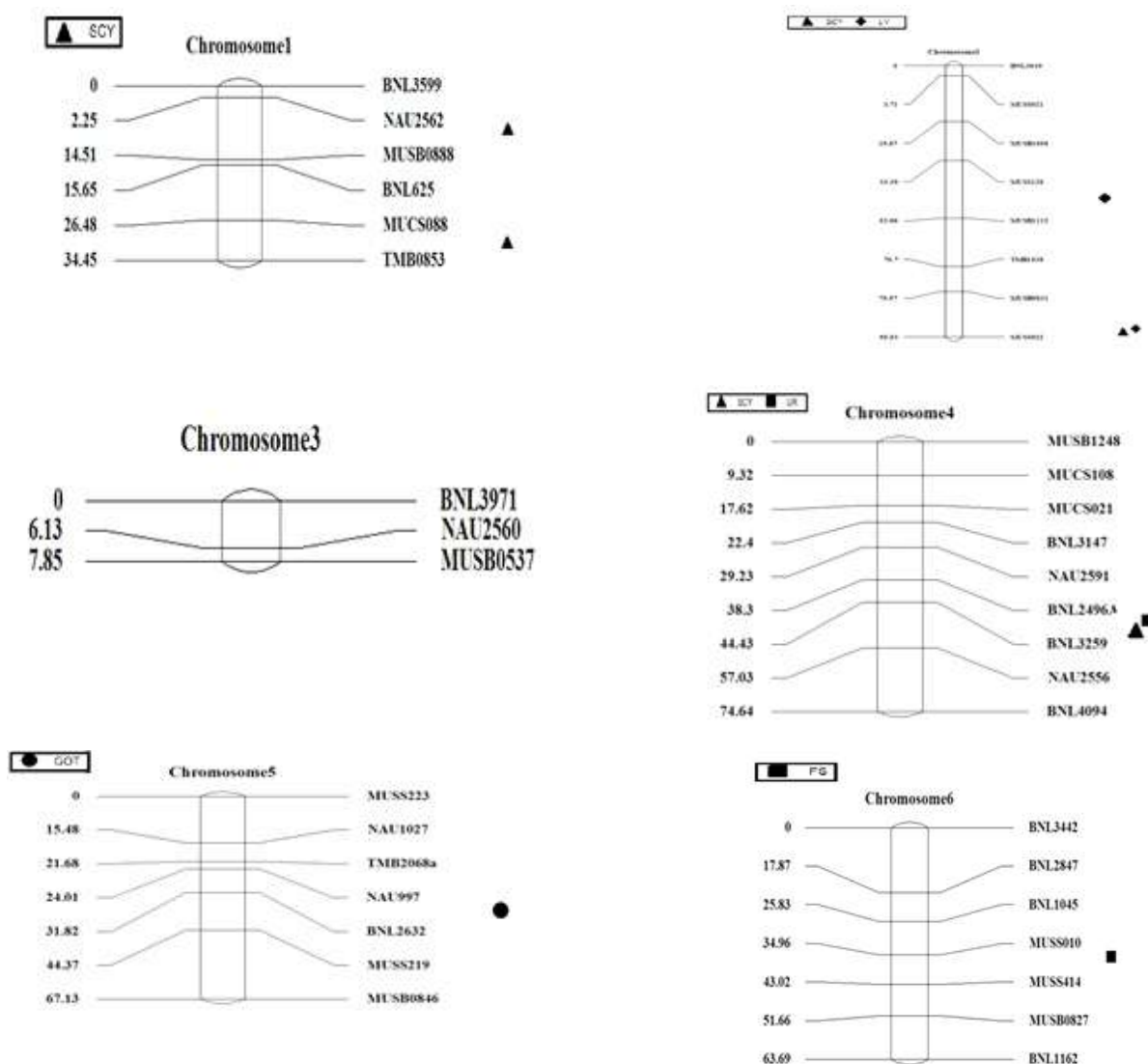


Fig-1 : Linkage maps with QTLs for productivity and fibre quality traits.

One QTLs *qgot5.1* was detected on linkage group 5. The LOD values for this QTL was 2.91. The phenotypic variance explained was 5.30 per cent. This QTLs is between the markers NAU997 And BNL2632. No QTLs were detected for seed index (g) and lint index (g).

Fibre quality traits

One QTL was detected for fibre strength located on linkage group 6. The flanking markers of these QTL were MUSS010 and MUSS414. The QTL was detected with LOD value of 4.4 and it explained the phenotypic variance of 0.72 per cent. Badigannavar (2010) identified two QTLs for fibre strength interspecific diploid cotton F2 population.

One QTL was detected for uniformity ratio which was located on the linkage group 4. The QTL, *qur4.1*, was detected at LOD of 3.55 and it explained 0.64 per cent

phenotypic variance. BNL2496A and BNL3259 flanked this QTL. Similarly, three QTLs for uniformity ratio were reported by Badigannavar (2010) with R^2 values more than 10. Shen *et al.*, (2005), Wang *et al.*, (2006) and Rong *et al.*, (2007) also reported QTLs for fibre uniformity ratio.

Interestingly, the QTLs *qscy2.1* (seed cotton yield), and *qly2.2*(lint yield) were flanked by the same markers, MUSB0831 and MUSS022 on linkage group 2. Similary, two more QTLs *viz.qscy4.1* (seed cotton yield) and *qur4.1* (uniformity ratio) shared a common markers BNL2496A and BNL3259 .Distribution of QTLs on different linkage groups is presented in Table-1.

For the significant QTLs identified, alleles associated with an increase in the trait value originated from both the parents. The potential QTLs having high LOD values, affecting seed cotton yield, lint yield and fiber strength on

linkage group 2, 4 and 6 showed significant additive effects and explained 0.55 to 5.62 per cent of the phenotypic variation. Similarly, Zhang *et al.*, (2005) also observed additivity for fiber strength on linkage group 5 of the upland cotton map, explaining more than 25 per cent of trait variation.

References

- Anonymous (2015). Monthly economic letter, *Cotton Incorporated*, 2015. Pp1-2.
- Badigannavar, A. (2010). Characterization of quantitative traits using association genetics in tetraploid and genetic linkage mapping in diploid cotton (*Gossypium* spp.), *Ph.D. Thesis*, Louisiana State University.
- Bandyopadhyay, T. (2011), Molecular Marker Technology in Genetic Improvement of Tea. *Inter. J. Plant Breed. Genet*, 5: 23-33.
- Fryxell, P. A. (1992), A revised taxonomic interpretation of *Gossypium* L. (Malvaceae). *Rheede*, 2: 108–165.
- He, D.; Lin, Z.; Zhang, X.; Nie, Y.; Guo, X. P.; Zhang, Y. X. and Li, W. (2007) QTL mapping for economic traits based on a dense genetic map of cotton with PCR-based markers using the interspecific cross of *Gossypium hirsutum*. *Gossypium barbadense*. *Euphytica*, 153: 181-197.
- Helentjaris, T. (1987), A genetic linkage map for maize based on RFLPs. *Trends Genet.* 3: 217-221.
- Hong Chen, Neng, Q.; Wangzhen G.; Qingping, S.; Baocheng Li.; Fujun Deng.; Cunguang Dong. and Tianzhen Zhang. (2009). Using three overlapped RILs to dissect genetically clustered QTL for fiber strength on Chro.D8 in Upland cotton. *Theor. Appl. Genet.*, 119: 605-612.
- Katageri, I. S.; Chandrakant, S.; Khadi, B. M.; Vamadevaih, H. M. and Narayan, K. (2004). Transfer of fibre length, strength and fineness from Tetraploid to Diploids in *Gossypium* spp. *International Cotton Genome Initiative ICGI*, October 10-13, Hyderabad, India. pp.1-29.
- Kosambi, D. (1944). The estimation of map distance from recombination values. *Annals of Eugenics*, 12: 172-175.
- Meena, R. A.; Monga, D.; Rajiv Kumar and Veer Singh. (2004). Screening of desi cotton (*Gossypium arboreum*) germplasm for shattering resistance. National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context", August 10-12, ANGRAU, Hyderabad, India. pp.23-28.
- Miller, J. C. and Tanksley, S. D. (1990). RFLP analysis of phylogenetic relationships and genetic variation in the genus *Lycopersicon*. *Theor. Appl. Genet.*, 80:437-448.
- Muhammad, S.; Wangzhen, G.; Ihsan, U.; Nabila, T.; Yusuf, Z.; Mehboob-ur-Rahman and Zhang, T. (2011). QTL mapping for physiology, yield and plant architecture traits in cotton (*Gossypium hirsutum*L.) grown under well-watered versus water-stress conditions. *Electronic Journal of Biotechnology*. 14(3): 1-13.
- Paterson, A. H. (1996a). Making genetic maps, , RG Landes Company, Austin, Tex, USA; Academic Press, San Diego, Calif, USA. *Genome Mapping in Plants*, pp: 23–39
- Paterson, A. H. (1996b). Mapping genes responsible for differences in phenotype, , R G Landes, San Diego, Calif, USA; Academic Press, Austin, Tex, USA, *Genome Mapping in Plants*, pp. 41–54.
- Quin, H.; Guo, W.; Zhang, Y. and Zhang, T. (2008). QTL mapping of yield and fiber traits based on a four-way cross population in *Gossypium hirsutum*L. *Theor Appl Genet.*, 117: 883-894.
- Rakshit, A.; Rakshit, S.; Singh, J.; Chopra, S. K.; Balyan, H. S.; Gupta, P. K. and Bhat, S. R.. (2010). Association of AFLP and SSR markers with agronomic and fibre quality traits in *G. hirsutum* L. *J. Genetics*, 89: 155-162.
- Reinisch, A.J.; Dong, J.; Brubaker, C. L.; Stelly, D. M.; Wendel, J. F. and Paterson, A. H. (1994). A Detailed RFLP Map of Cotton, *Gossypium hirsutum*x *Gossypium barbadense*: Chromosome Organization and Evolution in a Disomic Polyploid Genome. *Genetics*, 138: 829-847.
- Rong, J. K.; Abbey, C.; Bowers, J. E.; Brubaker, C. L.; Chang, C.; Chee, P. W.; Delmonte, T. A.; Ding, x.; Garza, J. J.; Marler, B. S.; Park, C.; Pierce, G. J.; Rainey, K. M.; Rastogi, V. K.; Schulze, S. R.; Tronlinde, N. L.; Wendel, J. F.; Wilkins, T. A.; Wing, R. A.; Wright, R. J.; Zgao, X.; Zhu, L. and Paterson. A. H. (2004). A 3347-locus genetic recombination map of sequence-tagged sites reveals features of genome organization, transmission and evolution of cotton (*Gossypium*). *Genetics*, 166: 389-417.
- Saeed, M.; Guo, W.; Ullah, I.; Tabbasam, N.; Zafar, Y.; Mehboob-ur-Rahman. and Zhang, T.; (2011). QTL mapping for physiology, yield and plant architecture traits in cotton (*Gossypium hirsutum* L.) grown under well-watered versus water stress conditions, *Electronic Journal of Biotechnology*, 14(3): 1-13.
- Shen, X. L.; Guo, W. Z.; Zhu, X.; Yuan, Y.; Yu, J. Z.; Kohel, R. J. and Zhang, T. Z. (2005). Molecular mapping of QTLs for fiber qualities in three diverse lines in upland cotton using SSR markers. *Mol. Breed.*, 15(2): 169-181.
- Wang, J.; Li, H.; Zhang, L.; Li C. and Meng, L. (2011). Users' Manual of QTL IciMapping v3.1, Webpage: <http://www.isbreeding.net>
- Wang, K.; Li, M. and Bucan, M. (2007). Pathway-based approaches for analysis of genome wide association studies. *American J. Hum. Genet.*, 81(6): 1278-1283.
- Zhang, H. B.; Li, Y.; Wang, B. and Chee, P. W. (2008). Recent advances in cotton genomics. *Int. J. Plant Genomics*, 128: 20-42
- Zhang, T. N.; Qian, X. and Zhu. (2013). Variations and transmission of QTL alleles for yield and fiber qualities in upland cotton cultivars developed in China. *PLoS ONE*, 8(2): 116-124.
- Zhang, Z. S.; Xiao, Y. H. and Luo M. (2005). Construction of a genetic linkage map and QTL analysis of fiber-related traits in upland cotton (*Gossypium hirsutum*L.). *Euphytica*, 144 (1): 91–99.



Economic Analysis of Production and Marketing of Milk in Raipur District of Chhattisgarh

Chiranjeet Malakar, B.C. Jain and V.K. Choudhary

Department of Agricultural Economics, Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh, India

Email : malakarchiranjeet@gmail.com

Abstract

The research on "Economic Analysis of Production and Marketing of Milk in Raipur District of Chhattisgarh" were performed For the current study the approach of multistage random sampling was used. The Raipur district of Chhattisgarh was chosen on purpose. The overall average gross returns per unit milch cow was rupees 48349 and net returns was rupees 22760, respectively that increased with herd size and for buffalo was rupees 61193 and net returns was rupees 20876, respectively that increased with herd size. Marketing efficiency according to Acharya's method under different marketing channels i.e. channel I, channel II, channel III were 67.51, 3.68 and 2.62 and 62.33, 3.38 and 2.49 and 61.90, 3.25 and 2.49 respectively in small, medium and large categories respectively.

Keys words : *Milch, marketing efficiency, marketing surplus, gross returns, net returns.*

Introduction

Livestock have an crucial role in economy of India. About 20.5 million people rely upon livestock for their living. Livestock contributed 16% to the income of small farm households and an average of 14% for all rural households. Two-thirds of rural communities rely on livestock for their livelihood. It employs approximately 8.8% of India's population. India's livestock resources are immense, and it accounts for 4.11 percent of GDP and 25.6 percent of overall agriculture GDP. Livestock is the best insurance against natural disasters such as drought, famine, and other natural disasters. India has a significant livestock resource that plays a critical role in improving the socio-economic situations of rural people. Therefore, the knowledge of marketing cost and return structure, different channels of milk marketing, marketing cost and margin of milk was very important to design and implement any dairy development plan. Chhattisgarh is a state rich in agriculture, and has environment useful to milch animal rearing and dairy production. The state has seen emerging in modern milk marketing chains and milk cooperatives but conventional marketing still plays a crucial part in the state's milk supply chain. In Chhattisgarh, the importance of allied sectors is increasing due to its role in supporting livestock. It is a labour-intensive market; employing a large number of people and helping poor households to generate additional income. Animal food has rich protein content so demand is too high in both domestic and foreign markets.

Materials and Methods

Out of the total 4 blocks (Dharsiwa, Tilda , Arang and Abhanpur) of Raipur district. Only two of the total blocks

i.e., Dharsiwa & Arang blocks was selected purposively from which village Dharampura and Mana Basti and Barauda, Korasi was selected respectively on the basis of maximum area under selected milk production for the purpose of the study.

Analytical techniques : To fulfil the specific objectives of the study, the data collected were subjected to statistical analysis. For this purpose the following statistical techniques were adopted.

Tabular analysis : Tabular analysis was adopted to analyse the general economic characteristics of the sample farmers, determine the resource structure, cost structure, returns, profits and opinions of the farmers regarding the problems of production and marketing.

Cost and returns of milk production : To work out the cost and returns of milk production the data were collected on the aspects of number and type of milch animals maintained, production of milk, feeds and fodder fed, maintenance costs and other costs incurred in the maintenance of cow and buffaloes as milch animals.

Consumption and disposal of milk : The data concerning volume of milk produced, consumed at home and disposed off through various marketing agencies were also collected from milk producer households.

Marketing margin and cost : Acharya's Method (MME), (Acharya and Agarwal 2011).

$$FP \div (MC + MM)$$

Where, FP = Net price received by farmer

MC = Total marketing costs

MM = Total net margins of intermediaries

Table-1 : Maintenance cost per milch cow in different categories (Rs/Annum).

Particulars	Categories of farms			
	Small	Medium	Large	Overall average
Variable cost				
Feed and fodder cost	17320.00 (69.66)	17630.50 (69.17)	18110.10 (68.08)	17686.86 (69.11)
Labour cost	3010.00 (12.10)	3075.00 (12.06)	3350.00 (12.59)	3145.00 (12.31)
Veterinary and service charges	175.00 (0.70)	180.00 (0.70)	180.00 (0.67)	178.33 (0.69)
Miscellaneous cost	167.00 (0.67)	172.00 (0.67)	190.00 (0.71)	176.66 (0.69)
Total Variable cost	20672.00 (83.14)	21057.50 (82.62)	21830.10 (82.06)	21186.85 (82.79)
Fixed cost				
Interest on present value of cow	2750.00 (11.06)	2868.50 (11.25)	2957.50 (11.11)	2858.66 (11.17)
Depreciation on present value	275.00 (1.10)	286.85 (1.12)	295.75 (1.11)	285.86 (1.11)
Building interest	687.50 (2.76)	755.00 (2.96)	895.00 (3.36)	779.16 (3.04)
Depreciation	68.75 (0.27)	75.50 (0.29)	89.50 (0.33)	77.91 (0.30)
Repair and maintenance cost	16.40 (0.06)	16.70 (0.06)	19.05 (0.07)	17.38 (0.06)
Machinery and Implements interest	336.10 (1.35)	360.50 (1.41)	435.00 (1.63)	377.20 (1.47)
Depreciation	33.61 (0.13)	36.05 (0.14)	43.50 (0.16)	37.72 (0.14)
Repair charges	22.10 (0.08)	28.60 (0.11)	34.55 (0.12)	28.41 (0.11)
Total fixed cost	4189.46 (16.85)	4427.70 (17.37)	4769.85 (17.93)	4402.33 (17.20)
Grand total of cost (VC+FC)	24861.46 (100)	25485.20 (100)	26599.95 (100)	25589.18 (100)

Note : Figures in parentheses are the percentage to the total maintenance cost.

Table-2 : Maintenance cost per milch buffalo in different categories (Rs/Annum).

Particulars	Categories of farms			
	Small	Medium	Large	Overall average
Variable cost				
Feed and fodder cost	19046.00 (64.64)	19498.00 (63.91)	21098.00 (68.10)	19880.66 (65.57)
Labour cost	4300.00 (14.59)	4620.00 (15.14)	600.00 (131.62)	4173.33 (13.76)
Veterinary and service charges	350.00 (1.18)	396.00 (1.29)	418.00 (1.39)	388.00 (1.27)
Miscellaneous cost	228.00 (0.77)	179.00 (0.58)	167.00 (0.53)	191.33 (0.63)
Total Variable cost	23924.00 (81.20)	24693.00 (80.94)	24283.00 (78.38)	24633.32 (81.25)
Fixed cost				
Interest on present value of buffalo	3640.00 (12.35)	4095.00 (13.42)	3822.00 (12.33)	3852.33 (12.70)
Depreciation on present value	364.00 (1.23)	409.50 (1.34)	382.20 (1.23)	385.23 (1.27)
Building interest	885.00 (3.01)	715.00 (2.34)	775.00 (2.50)	791.66 (2.61)
Depreciation	88.50 (0.30)	71.50 (0.23)	77.50 (0.25)	79.16 (0.26)
Repair and maintenance cost	16.50 (0.05)	9.80 (0.30)	11.10 (0.30)	12.46 (0.04)
Machinery and Implements interest	470.00 (1.59)	430.00 (1.40)	530.00 (1.71)	476.66 (1.57)
Depreciation	47.00 (0.15)	43.00 (0.14)	53.00 (0.17)	47.66 (0.15)
Repair charges	27.50 (0.09)	38.40 (0.12)	47.00 (0.15)	37.63 (0.12)
Total fixed cost	5538.50 (18.79)	5812.20 (19.05)	5697.80 (18.39)	5682.83 (18.74)
Grand total of cost (VC+FC)	29462.50 (100)	30505.20 (100)	30980.80 (100)	30316.16 (100)

Note : Figures in parentheses are the percentage to the total maintenance cost.

Results and Discussion

Maintenance cost of cow : The study imparts that maintenance cost of a cow in a year was Rs. 25589 (Table-1) and of this total maintenance cost and its 80 percent was the variable cost and fixed cost was about 20 percent. Among the different items of variable cost, feed and fodder cost contribute the major item of the cost about 70 percent of the total maintenance cost. The major items of the fixed cost were interest and

depreciation on the value of the milch cows and accounted for about 11 and 2 percent of the total maintenance cost, respectively. The fixed cost of interest and depreciation on buildings and machinery and implements was about 3 percent and 2 percent, respectively of the total cost of maintenance. In various categories, the cost of maintenance of milch cows increased with the size of herd. In small category, cost of maintenance of a cow was about Rs. 24,900. The same cost in large category was found to be more than Rs.

Table-3 : Gross and net returns per milch cow (Rs/Cow).

Particulars	Categories			
	Small	Medium	Large	Overall average
Total maintenance cost of cow	24861.96	25485.20	26599.95	25589.18
Gross returns per cow	45143.00	49120.00	50786.00	48349.66
Net returns per cow	20281.04	23634.80	24186.05	22760.48

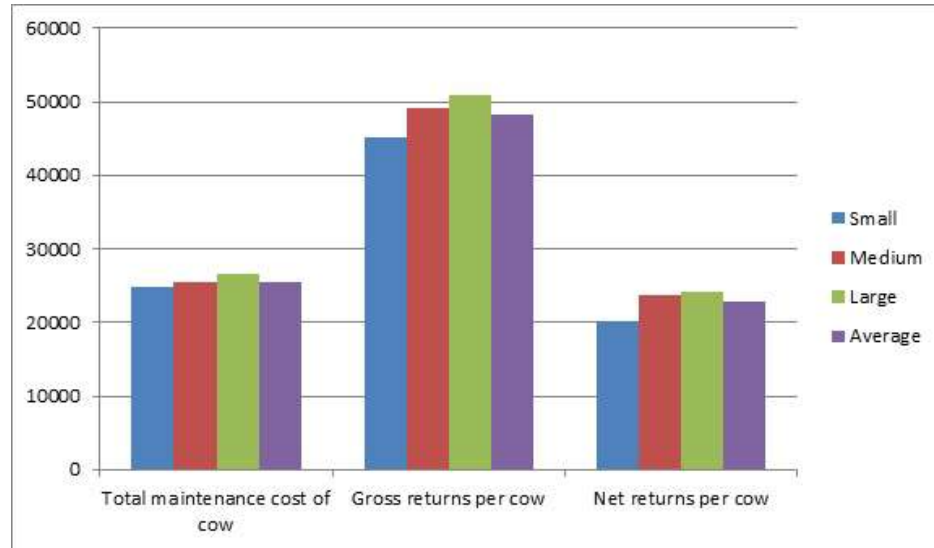


Fig.-1 : Gross and net returns per milch cow.

Table-4 : Gross and net returns per milch buffalo (Rs/Bufferalo).

Particulars	Categories			
	Small	Medium	Large	Overall average
Total maintenance cost of cow	29462.50	30505.20	30980.80	30316.16
Gross returns per cow	59023.00	61560.00	62996.00	61193.00
Net returns per cow	29560.50	31054.80	32015.20	30876.84

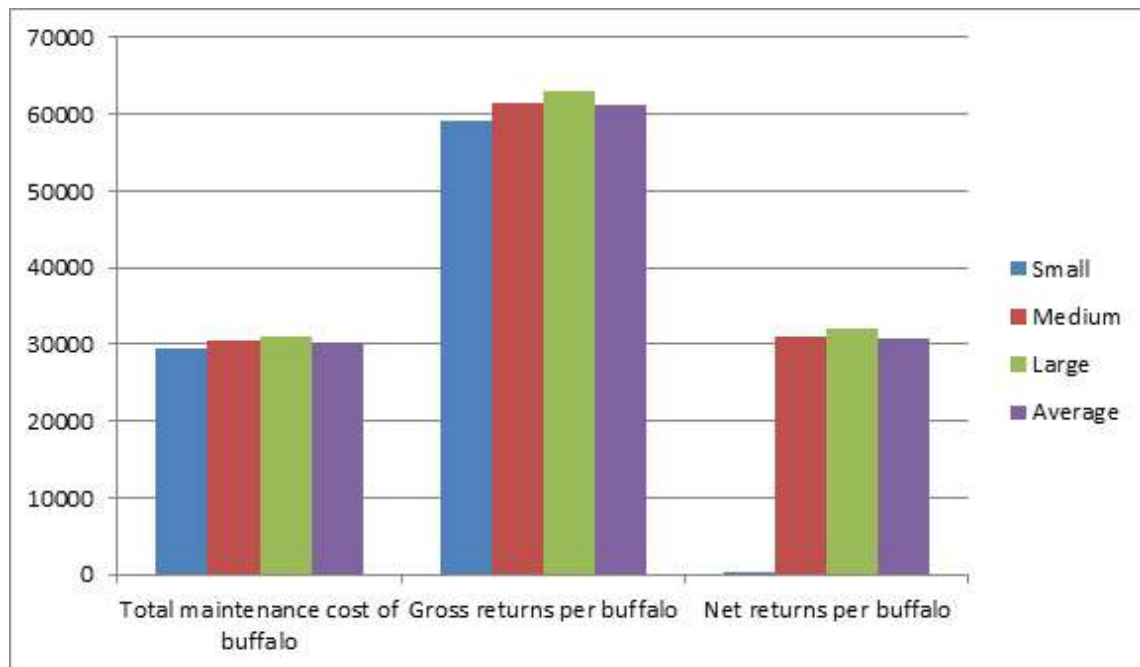


Fig.-2 : Gross and net returns per milch buffalo.

Table-5 : Marketing efficiency of milk in small category under different marketing channels.

S. No.	Particulars	Units	Channel I	Channel II	Channel III
1.	Consumer purchase price (RP)	Rs/lts	39.00	43.00	49.00
2.	Total marketing cost (MC)	Rs/lts	0.62	5.58	9.28
3.	Total net margin of intermediaries (MM)	Rs/lts		3.04	4.34
4.	Net price received by farmers	Rs/lts	38.38	34.38	35.38
5.	Value added (1-4)	Rs/lts	0.62	8.62	13.62
	Index of marketing efficiency				
A.	Acharyas Method (MME) $4 \div (2+3)$	Ratio	61.90	3.98	2.59

Table-6 : Marketing efficiency of milk in medium category under different marketing channels.

S. No.	Particulars	Units	Channel I	Channel II	Channel III
1.	Consumer purchase price(RP)	Rs/lts	40.00	45.00	51.00
2.	Total marketing cost (MC)	Rs/lts	0.64	5.86	9.84
3.	Total net margin of intermediaries (MM)	Rs/lts		3.78	4.80
4.	Net price received by farmers	Rs/lts	39.36	35.36	36.36
5.	Value added (1-4)	Rs/lts	0.64	9.64	14.64
	Index of marketing efficiency				
A.	Acharyas Method (MME) $4 \div (2+3)$	Ratio	61.50	3.66	2.48

Table-7 : Marketing efficiency of milk in large category under different marketing channels.

S. No.	Particulars	Units	Channel I	Channel II	Channel III
1.	Consumer purchase price(RP)	Rs/lts	41.00	47.50	53.00
2.	Total marketing cost (MC)	Rs/lts	0.68	6.00	10.29
3.	Total net margin of intermediaries (MM)	Rs/lts		5.18	5.39
4.	Net price received by farmers	Rs/lts	40.32	36.32	37.32
5.	Value added (1-4)	Rs/lts	0.68	11.18	15.68
0	Index of marketing efficiency				
A.	Acharyas Method (MME) $4 \div (2+3)$	Ratio	59.29	3.24	2.38

26,600. It was due to better feeding and maintenance of cows by large category.

Maintenance cost of buffalo : Table-2 shows that the total maintenance cost of buffalo was Rs. 30316 per year. The variable and fixed costs constituted 80 and 20 percent to the total maintenance cost, respectively. In the variable cost, feed and fodder was observed to be the major items of cost which covered 65 percent of the total maintenance cost, followed by labour cost with an amount of 14 percent. The major items of fixed cost were interest and depreciation on the value of milch animals which constituted 13.9 percent of the total maintenance cost. With respect to various categories, the maintenance cost of a buffalo was found a little lower in small category than large category. This was due to better and higher amount of feeds and fodders fed to the buffaloes by large category than small ones.

Gross and net returns per milch cow : The results shown in Table-3 reveal that the average gross returns per cow were Rs. 48350. However the gross returns per cow increased with the size of milk producing

categories. In small category, the gross returns per cow were about Rs. 45143 and the corresponding figures in medium and large categories were Rs. 49120 and Rs.50786, respectively. The higher returns in large category were mainly because of greater number of cross-breed cows on larger herd sizes than smaller ones. For this reason, the net returns per cow too increased with the size of milk producing categories. The net returns per cow were found to be Rs.20281 in small category, while in large category the net returns per milch cow were as high as Rs. 24186.

Gross and net returns per milch buffalo : It is evident from the Table-4 that the gross and net returns per milch buffalo were Rs. 61193 and Rs. 30876, respectively. The results indicate that the average gross returns per milch buffalo were much higher than in case of cow i.e. Rs. 48350. Similarly, the net returns per milch buffalo were also found higher than the cow. In different categories, the gross as well as net returns are slightly higher in large category. The higher returns per milch buffalo in large category were mainly because of better feeding of feeds and fodders by them.

Marketing efficiency : The Table 5-7 shows that the marketing efficiency of milk in small, medium and large categories under different marketing channels for the year 2020-21. Marketing efficiency according to Acharya's method under different marketing channels i.e. channel I, channel II, channel III were 67.51, 3.68 and 2.62 and 62.33, 3.38 and 2.49 and 61.90, 3.25 and 2.49 respectively in small, medium and large categories respectively. From this efficiency index it was clear that channel I was the most efficient among all marketing channels.

Conclusion

Gross returns per cow on small size units were around Rs. 45143, while gross returns on medium and large size units were around Rs. 49120 and 50786, respectively. Higher profits on larger milk-producing units were expected. The net returns each cow were found to be Rs. 20281 on small size producers, while on large size producers the net returns per milch cow were high as Rs. 24186. The average gross returns per milch buffalo were Rs. 61193,

which are much higher than in case of cow. Similarly, the net returns each milch buffalo were also found higher than cow. Marketing efficiency according to Acharya's method under different marketing channels i.e. channel I, channel II, channel III were 67.51, 3.68 and 2.62 and 62.33, 3.38 and 2.49 and 61.90, 3.25 and 2.49 respectively in small, medium and large categories respectively.

References

1. Ahir N.J. and Singh P.K., 1994. Production and marketing decisions of milk producers in heavy rainfall zone of Gujarat. *Indian Journal of Dairy Science*, 47: 658-658.
2. Jha, J., Singh, D.K. and Singh, R.P., 1982. Cost of buffalo milk production in different seasons, Kathmandu, Nepal. *Indian Dairyman*, 34(2): 59-62.
3. Rao, B. Dayakar, Gourdhani, R.T. and Singh, C.B., 1991. Economics of buffalo milk production on Commercial dairy farms. *Indian Journal of Dairy Science*, 44(1):1-6.
4. Gupta, J.P., 1992. Disposal pattern of milk in Punjab. *Indian Journal of Dairy Science*, 45: 292-293.



In-vitro* Evaluation of Bio Control Agents against *Fusarium oxysporum* f. sp. *Ciceri

D.H. Sarnobat, Y.S. Balgude, R.S. Bhoge and B.T. Shete

Seed Technolog Research Unit, MPKV, Rahuri, Maharashtra

Abstract

Chickpea (*Cicer arietinum* L.) is one of the major rabi pulse crop and is a cheap source of protein. It has also advantages in the management of soil fertility particularly in dry lands and the semiarid tropics. Despite of low productivity of chickpea is attributed to *Fusarium* wilt disease which caused by obligate biotroph *Fusarium oxysporum* f.sp. *ciceri* is consider one of the major limiting factor. Experiment was conducted for find out the *in-vitro* efficacy of bioagents and phytoextracts against *Fusarium oxysporum* f.sp. *ciceri*. Out of different bioagents tested, *T. harzianum* gave maximum inhibition (77.65%) of mycelia growth of test fungus followed by *T. koningii* with 76.55% inhibition and least effective is *G. virens* with 57.72% inhibited fungus growth. In different phytoextracts tested, *A. indica* showed highest inhibition (17.10%, 35.25 % and 53.68%) of test fungus in spite of 2%, 5% and 10% respectively compare to others. This was followed by *L. camera* with 12.80%, 30.51% and 45.81% and lowest inhibition found *J. gossypifolia* with 5.4%, 21.25% and 33.58% in terms of 2%, 5% and 10% respectively. The above findings are very useful for the farmers for making decision over the use of bio based fungicides for management of wilt disease which is safe management practice for environment.

Key words : Chickpea wilt, fusarium, management, bio-agent, phyto-extract.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the major pulse crops, belongs of the family Leguminosae. It is also known Bengal gram. Chickpea is a cheap source of protein compared to animal protein. Chickpea also has advantages in the management of soil fertility, particularly in dry lands and the semiarid tropics (Singh and Saxena, 1996). Low yield of chickpea is attributed to several diseases and insect. Despite of different diseases, *Fusarium* wilt disease is most important disease of chickpea causes severe damage of crop. Vascular wilt caused by an important obligate biotroph *Fusarium oxysporum* f.sp. *ciceri* (Padwick) Matuo & K. Sato, is consider one of the limiting factor for its low productivity. Although the disease is wide spread in the chickpea growing areas of the world, it is most prevalent in the Mediterranean Basin and the Indian subcontinent (Jalil and Chand, 1992).

The fungus is a primarily soil borne pathogen, however, few reports indicated that it can be transmitted through seeds (Haware *et al.*, 1978). The pathogen can infect at all stages of plant growth with more incidences in flowering and pod filling stage. The wilt appeared in field within three to four week after sowing, if the variety is susceptible (Haware, 1990). Early wilting causes more loss than late wilting, but seeds from late-wilted plants are lighter, rough and dull than those from healthy plants (Haware and Nene, 1980). Relatively high temperature with drought may cause up to eighty percent plant mortality (Govil and Rana, 1994).

The pathogen is facultative saprophytic and it can survive as mycelium and chlamydospores in seed, soil and also on infected crops residues, buried in the soil for up to five to six years (Haware *et al.*, 1986). If the disease inoculums establishes in the soil, it is difficult to check the disease or eliminate the pathogen except by following crop rotation for more than six years (Haware and Nene, 1982 and Gupta, 1991). Under favorable condition, the wilt infection can damage the crop completely and cause 100% yield loss (Navas-Cortes *et al.*, 2000; Halila and Strange, 1996). In India annual yield loss due to *Fusarium* wilt were estimated at 10% (Singh and Dahiya, 1973; Trapero-Casas and Jiménez-Díaz, 1985). The better way to manage the pathogen in eco-friendly approach is consider the economic way for management of the disease instead of costly and hazards chemicals.

Biological management is considered to be antagonistic to many soils borne and plant pathogenic fungi (Prasad *et al.*, 2002). Chary *et al.*, 1984 reported that some of the toxic substances obtained from various plant species have been reported to manage a number of fungal diseases of crop plants. A number of plant species have been reported to possess some natural substances which are toxic to many fungi causing plant diseases (Mishra and Dixit, 1977). Therefore the present study was carried out to evaluate the bio-agents and phyto-extract against the growth of *Fusarium oxysporum* f.sp. *ciceri* inciting agent of chickpea wilt, under *in-vitro* condition.

Materials and Methods

Isolation of *Fusarium oxysporum* f.sp. *ciceri* : Wilted

plants of chickpea were collected from different farmers' field of red & lateritic zone of West Bengal and surface sterilized was done by 70% ethyl alcohol. The samples are cut into pieces of disease part along with healthy tissue. These pieces are place aseptically on sterilized Potato Dextrose Agar (PDA) medium in Petri plates. Pure culture was done by transfer of a pinch of mycelium on sterilized Potato Dextrose Agar medium in Petri plates and incubated in BOD. The fungus was identified by colony growth, pigmentation and microscopic characteristics of *Fusarium oxysporum*.

Evaluation of bio-agents : The efficacy of biocontrol agents was evaluated in vitro against *F. oxysporum* f.sp. *ciceri* through dual culture technique (Denis and Webster, 1971; Dhingra and Sinclair, 1985). The bioagents i.e. *Trichoderma viride*, *T. harzianum*, *T. koningii*, *T. hamatum*, *Gliocladium virens* and *Pseudomonas fluorescens* were collected from Vivekananda Institute of Biotechnology, Nimpith and use this experiment. The autoclaved and cooled PDA medium was poured in sterilized 90 mm Petri plate. After solidified Petri plates, 5 mm mycelium disc of bio-agent and test fungus was cut with cork borer from 7 days old culture plates, then placed both opposite end of Petri plates. In case of *Pseudomonas* sticking one end of the Petri plates and opposite end placed test fungus by sterile cork borer. Plate inoculated only with test fungus without bio-agent served as control. All plates were replicated with three times and were incubated at 26±10 C for 7 days. After incubation radial growth measured and % inhibition of growth was calculated using the formula (Vincent, 1947);

$$I = \frac{C - T}{C} \times 100$$

Where,

I = Percent inhibition.

C = Radial growth of test fungus in control plate

T = Radial growth of test fungus in treated plate

Evaluation of phyto-extract : Seven phytoextract were tested in vitro for their antifungal efficacy against growth of *Fusarium oxysporum* f.sp. *ciceri* through poisoned food technique (Nene and Thapliyal, 1993). Fresh leaves, cloves of respective plants use this experiment as details shown in Table-1. Plant parts were first washed with tap water and then with sterilized distilled water and air dried. Weighted plant materials were grind in pestle and mortar using the ratio 1:1 w/v. The materials were homogenized for 5 minutes then filtered through double layered muslin cloth followed by Whatman No. 1 filter paper and filtrates were considered as standard extract (100%) (Kamlesh and Gurjar, 2002; Prasad and Barnwal, 1994). The standard leaf extracts solution were individually

Table-1 : List of different plants and their parts used in experiment.

Sr. No.	Common Name	Botanical Name	Used parts
1.	Neem	<i>Azadirachta indica</i>	Leaf
2.	Tulsi	<i>Ocimum sanctum</i>	Leaf
3.	Lantana	<i>Lantana camera</i>	Leaf
4.	Eucalyptus	<i>Eucalyptus globulus</i>	Leaf
5.	Akanda	<i>Calotropis gigantea</i>	Leaf
6.	Jatropha	<i>Jatropha gossypifolia</i>	Leaf
7.	Garlic	<i>Allium sativum</i>	Cloves

incorporated into Potato Dextrose Agar (PDA) medium in 250 ml conical flasks at required quantities to get 2, 5, and 10% concentration and PDA was autoclaved. These melted PDA were poured in 90 mm sterilized Petri plate and PDA without extracts was maintained as control. All plates were replicated three times and analysis CRD.

Plates were inoculated with 5 mm mycelium disc of seven days old culture test fungus and incubated at 26±10C for seven days. The radial growth of the mycelium was measured after seven days of incubation and % inhibition of growth was calculated using the above cited formula (Vincent, 1947).

Results and Discussion

Effect of bioagents : Six biocontrol agents' viz., *Trichoderma viride*, *T. harzianum*, *T. koningii*, *T. hamatum*, *Gliocladium virens* and *Pseudomonas fluorescens* were evaluated against *F. oxysporum* f.sp. *ciceri* and the results are presented in Table-2.

The results revealed that the antagonists significantly reduced the growth of *F. oxysporum* f.sp. *ciceri* either by exhibiting inhibition zones. Among of them *T. harzianum* was found most effective than all other treatments with 79.63% inhibition. The next best treatment was *T. koningii* with 77.78% inhibition of mycelia growth. This was followed by *T. viride*, *P. fluorescens* and *T. hamatum* with 75.93%, 67.78%, and 58.15% inhibition respectively. *G. virens* was least effective among the six antagonists treated against *F. oxysporum* f. sp. *ciceri* and exhibited 55.93% mycelium growth inhibition. Biological control is an effective, eco-friendly and alternative approach for disease management practice. The result of dual culture technique revealed that all the bioagents significantly reduced the growth of *F. oxysporum* f.sp. *ciceri*.

The present study indicated that *T. harzianum* gave maximum inhibition of mycelial growth, than other bio-agents similar observation were reported by Dar et al., 2013; Rani and Mane (2014) were observed highest growth inhibition by *T. harzianum*; Rehman et al., 2013

Table-2 : In vitro evaluation of bioagents against *F. oxysporum* f. sp. *ciceri*.

Sl. No.	Treatments	Diameter of the mycelium growth after 7 days of inoculation (mm)				% inhibition in mycelium growth of <i>Fusarium oxysporum ciceri</i>	
		Bio-agents		<i>Fusarium oxysporum</i> f. sp. <i>ciceri</i>			
1.	<i>Trichoderma viride</i>	67.70	(55.28)*	22.40	(28.33)*	75.10	(60.05)*
2.	<i>Trichoderma harzianum</i>	69.88	(56.92)	20.12	(26.64)	77.65	(61.76)
3.	<i>Trichoderma hamatum</i>	53.58	(47.03)	36.42	(37.10)	59.54	(50.48)
4.	<i>Trichoderma koningii</i>	68.89	(56.07)	21.11	(27.34)	76.55	(61.01)
5.	<i>Gliocladium virens</i>	51.95	(46.10)	38.05	(38.07)	57.72	(49.43)
6.	<i>Pseudomonas fluorescens</i>	60.55	(51.07)	29.45	(32.85)	67.28	(55.09)
7.	Control	00		90		00	
S. Em.		0.153		0.152		0.159	
C.D.		0.468		0.467		0.487	
C.V.		0.593		0.706		0.571	

*Data parenthesis is Angular Transform value.

Table-3 : In vitro evaluation of phytoextract against *F. oxysporum* f. sp. *ciceri*.

Sr. No.	Common name	Botanical name	% inhibition in mycelium growth					
			Concentration					
			2%	5%	10%	2%	5%	10%
1	Neem	<i>Azadirachta indica</i>	17.10	(24.41)*	35.25	(36.41)*	53.68	(47.09)
2	Tulsi	<i>Ocimum sanctum</i>	11.89	(20.15)	28.72	(32.39)	42.86	(40.88)
3	Lantana	<i>Lantana camera</i>	12.80	(20.95)	30.51	(33.51)	45.81	(42.58)
4	Eucalyptus	<i>Eucalyptus globulus</i>	7.97	(16.39)	24.21	(29.46)	36.84	(37.35)
5	Akanda	<i>Calotropis gigantea</i>	6.72	(15.01)	22.61	(28.38)	34.67	(36.09)
6	Jatropha	<i>Jatropha gossypifolia</i>	5.40	(13.42)	21.25	(27.44)	33.58	(35.40)
7	Garlic	<i>Allium sativum</i>	8.97	(17.42)	26.72	(31.11)	38.74	(38.48)
S.E.			0.276		0.144		0.223	
C.D.			0.845		0.442		0.683	
C.V.			1.619		0.800		0.974	

*Data parenthesis is Angular Transform value.

reported that *T. harzianum* and *T. viride* alone or combination significantly inhibited the mycelia growth of the *F. oxysporum* f.sp. *ciceri*.

Effect of phytoextract : Seven phytoextracts viz. *Azadirachta indica*, *Ocimum sanctum*, *Lantana camera*, *Eucalyptus globules*, *Calotropis gigantea*, *Jatropha gossypifolia*, and *Allium sativum* were evaluated against *F. oxysporum* f.sp. *ciceri* followed poisoned food technique. Phyto-extract was tested at 2, 5 and 10% concentration and the results are presented in Table-3. The results revealed that the phytoextract significantly inhibited the growth of *F. oxysporum* f.sp. *ciceri* at all the tested concentrations. Among of them *A. indica* showed maximum inhibition (16.30%) of mycelia growth at 2% concentration followed by *L. camera*, *O. sanctum*, *A. sativum*, *E. globules*, and *C. gigantea*, with 12.59%, 11.48%, 9.26%, 8.15% and 6.67% respectively. The least effective was *J. gossypifolia* with 4.44% inhibition. In 5% concentration, *A. indica* showed highest inhibition (34.56%) of mycelium growth of fungus followed by *L. camera* 29.83% and least inhibition by *J. gossypifolia* (19.26%).

The result obtained at 10% concentration showed that among the different phytoextracts, *A. indica* inhibited

maximum (52.59%) fungus growth. The next best treatment was *L. camera* with 44.23% inhibition of mycelia growth. This was followed by *O. sanctum*, *A. sativum*, *E. globules*, and *C. gigantea*, with 41.46%, 39.73%, 38.57% and 36.32%. The least effective phytoextract was *J. gossypifolia* with 35.64% inhibition of fungus growth. All the treatments at 10% concentration exhibited maximum mycelial growth inhibition as compared to 2% and 5% concentration against tested pathogen.

The present study indicated that *A. indica* leaf extract restricted the growth of *F. oxysporum* f.sp. *ciceri* at 2, 5 and 10% concentration at seven days after incubation than other treatments. Similar result was reported by Ganie *et al.*, 2013. Singh *et al.*, (1980) reported that growth of four soil borne pathogens including *F. oxysporum* f. sp. *ciceris* was effectively inhibited by aqueous extracts of leaf, trunk bark, fruit pulp and oil of *Azadirachta indica*. Mukhtar (2007) also reported that aqueous leaf extract of *Az. indica* is highly effective in reducing the mycelial growth of *F. oxysporum* f. sp. *ciceris*.

In conclusion, the present study was in vitro testing of bioagents and phytoextract against *F. oxysporum* f.sp. *ciceri*. Among the different bioagents *T. harzianum* was

found to best for inhibiting the growth of test fungus and least effective bioagents was *G. virens*. Among the different phytoextract tested, *A. indica* proved its supremacy in terms of growth inhibition of mycelium of pathogen. Above findings help us to use of bioagents and phytoextracts for management of *Fusarium* wilt disease of chickpea. Use of *T. harzianum* and *A. indica* in field against soil borne diseases can easily be practiced for minimize the menace which is also a safe management practice for environment.

References

1. Carpenter, J.B. 1942. A toximetric study of some eradicator fungicides. *Phytopathol.*, 32: 845.
2. Chary, M.P., Reddy, E.J.A., Reddy, S.M. 1984. Screening of indigenous plants for their antifungal principle. *Pesticide*, 18: 17-18.
3. Dar, W.A., Beig, M.A., Ganie, S.A., Bhat, J.A. Rehman, S.U. and Razvi, S.M. 2013. In vitro study of fungicides and biocontrol agents against *Fusarium oxysporum* f.sp. *pini* causing root rot of Western Himalayan fir (*Abies pindrow*). *Scientific Res. Essays*, 8(30): 1407-1412.
4. Dennis, C. and Webster, J. 1971. Antagonistic properties of specific group of *Trichoderma* II, production of volatile antibiotics. *Transactions of the British Mycol. Society*, 57: 41-48.
5. Dhingra, O.D. and Sinclair, J. B. 1985. *Basic Plant Pathol. Methods*, CRC Press, Florida.
6. Ganie, S.A., Pant, V.R., Ghani, M.Y., Lone, A.H., Anjum, Q., and Razvi, S. M. 2013. In vitro evaluation of plant extracts against *Alternaria brassicae* (Berk.) Sacc. causing leaf spot of mustard and *Fusarium oxysporum* f. sp. *lycopersici* causing wilt of tomato. *Scientific Res. Essays*, 8(37): 1808-1811.
7. Govil, J.N. and Rana, B.S. 1994. Stability of host plant resistance to wilt (*Fusarium oxysporum* f. sp. *ciceri*) in chickpea. *Int. J. Trop. Plant Dis.*, 2: 55-60.
8. Gupta, O. 1991. Symptomless carriers of chickpea vascular wilt pathogen (*Fusarium oxysporum* f.sp. *ciceri*). *Legume Res.*, 14: 193-194.
9. Halila, M.H. and Strange, R.N. 1996. Identification of the causal agent of wilt of chickpea in Tunisia as *Fusarium oxysporum* f.sp. *ciceri* race 0. *Phytopathologia Mediterranea*, 35: 67-74.
10. Haware, M.P., Nene, Y.L. and Rajeswari, R. 1978. Eradication of *Fusarium oxysporum* f. sp. *ciceris* transmitted in chickpea seed. *Phytopathol.*, 68: 1364-1368.
11. Haware, M.P. 1990. *Fusarium* wilt and other important diseases of chickpea in the Mediterranean area. *Options Méditerranéennes Série A: Séminaires*, 9: 63-166.
12. Haware, M.P. and Nene, Y.L. 1980. Influence of wilt at different stages on the yield loss in chickpea. *Tropical Grain Legume Bull.*, 19: 38-40.
13. Haware, M.P. and Nene, Y.L. 1982. Symptomless carriers of the chickpea wilt *Fusarium*. *Plant Dis.*, 66: 809-810.
14. Haware, M.P., Nene, Y.L. and Mathur, S.B. 1986. Seed borne disease of chickpea. Technical Bulletin 1. Danish Government Institute of seed Technology for developing countries. Copenhagen, 1:1-32.
15. Jalil, B.L. and Chand, H. 1992. Chickpea wilt. In: *Plant Disease of International Importance* (Singh, U.S., Mukhopadhyay, A.N., Kumar, J., and Chaube, H.S., ed.) Vol. I. Prentice Hall, Englewood Cliffs, N. J. USA, 429-444.
16. Kamlesh, M. and Gurjar, R.B.S. 2002. Evaluation of different fungal antagonists plant extracts and oil cakes against *Rhizoctonia solani* causing stem rot of chilli. *Annals of Plant Protection Sci.*, 10: 319-322.
17. Misra, S.B. and Dixit, S.N. 1977. Fungicidal Properties of *Clematis gouriana*. *Phytopathol.*, 30: 577-579.
18. Mukhtar, I. 2007. Comparison of phytochemical and chemical control of *Fusarium oxysporum* f. sp. *ciceri*. *Mycopath*, 5(2): 107-110.
19. Navas-Cortes, J.A., Hau, B. and Jimenez-Diaz, R.M. 2000. Yield loss in chickpea in relation to development to *Fusarium* wilt epidemics. *Phytopathol.*, 90: 1269-1278.
20. Nene, Y.L. and Thapliyal, P.N. 1993. Fungicides in plant disease control 3rd editions Oxford and IBH Publishing Co. New Delhi, 531.
21. Prasad, R.D., Rangeshwaran, R., Hedge, S. V. and Anuroop, C.P. 2002. Effect of soil application of *Trichoderma harzianum* on pigeon pea wilt caused by *Fusarium udum* under field conditions. *Crop Protection*, 21: 293-297.
22. Prasad, S.M. and Barnwal, M.K. 1994. Evaluation of plant extracts in management of Stemphylium blight of onion. *Indian Phytopathol.*, 57: 110-111.
23. Rani, S.R. and Mane, S.S. 2014. Efficacy of bioagents against chickpea wilt pathogen. *Int. J. Appl. Biol. Pharmaceutical Technol.*, 5(4): 147-149.
24. Rehman, S.U., Dar, W. A., Ganie, S. A., Bhat, J. A., Mir, G. H., Lawrence, R., Narayan, S. and Singh, P.K. 2013. Comparative efficacy of *Trichoderma viride* and *Trichoderma harzianum* against *Fusarium oxysporum* f.sp. *ciceri* causing wilt of chickpea. *African J. Microbiol. Res.*, 7(50): 5731-5736.
25. Singh, K.B. and Dahiya, B.S. 1973. Breeding for wilt resistance in chickpea. In: *Symposium on Wilt Problem and Breeding for Wilt Resistance in Bengal Gram*. *Indian Agriculture Research Institute*, New Delhi, India, 13-14.
26. Singh, K.B. and Saxena, M.C. 1996. Winter chickpea in Mediterranean type environments. A Technical Bulletin, *International Centre for Agricultural Research in Dry Areas*, Aleppo, Syria,
27. Singh, U.P., Singh, H.B., Singh, R.B. 1980. The fungicidal effect of neem (*Azadirachta indica*) extracts on some soil borne pathogens of gram (*Cicer arietinum*). *Mycologia*, 72(6): 1077-1093.
28. Trapero-Casas, A. and Jimenez-Diaz, R.M. 1985. Fungal wilt and root rot diseases of chickpea in southern Spain. *Phytopathol.*, 75: 1146-1151.
29. Vincent, J.M. 1947. Distortion of fungal hyphae in presence of certain inhibitors. *Nature*, 159:325,850.



Effect of Sowing Windows on Newly Released Varieties for Seed Yield and Economics of Sunnhemp (*Crotalaria juncea* L.)

D.P. Pacharne* P.H. Deshmukh and N.K. Bhute

Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri-413722

*Corresponding author Email : pacharne.dattatray@rediffmail.com

Abstract

A field experiment was conducted during *kharif* 2019 on medium black soils of MPKV, Rahuri (M.S.) to determine the optimum sowing date along with newly released variety for seed yield and economics in sunnhemp (*Crotalaria juncea* L.). The main plot treatments comprises of three sowing dates i.e. D₁- 15th June, D₂-1st July and D₃- 30th July and subplot treatments comprises three varieties i.e. V₁- JRJ 610, V₂- SUIN 037 and V₃- SUIN 053 with 9 combinations of sowing dates and varieties with split plot design during *kharif* season in four replications. The results stated that, the crop sown at 1st July was significantly recorded higher seed yield (18.19 q ha⁻¹) than 15th June (14.54 q/ha) but it was at par with 30th July (16.15 q/ha), respectively. Similarly, it also registered significantly higher gross returns (₹90964), net returns (₹56920) and B:C ratio (2.67) than rest of all treatments during period of experiment. The variety JRJ-610 recorded significantly higher seed yield (17.40 q/ha) than the SUIN 037 (15.42 q/ha) and SUIN 035 (16.05 q/ha). Similarly, the variety JRJ-610 recorded higher economic indices like, gross returns (₹87024), net returns (₹53890) and B:C ratio (2.62) than rest of all treatments. Similar results were recorded in growth and yield attributes. Sowing of sunnhemp (*Crotalaria juncea* L.) crop during *kharif* season in 1st July along with newly released variety of JRJ 610 is beneficial for higher seed production under protective irrigation.

Key words : Growth attributes sowing dates, seed yield, varieties .

Introduction

India is the largest producer of sunnhemp (*Crotalaria juncea* L.) fibre followed by Bangladesh and Brazil. India accounts for about 27 and 23 % world's area and production respectively. Sunnhemp is cultivated almost in all the states of country but leading sunnhemp growing states in India are Uttar Pradesh, Madhya Pradesh, Orissa, Bihar, Maharashtra, Rajasthan, Jharkhand, Punjab, Haryana and West Bengal etc. It is occupying about 65.5 thousand hectares area with a production of about 38.0 thousand tonnes per annum. It has lost its importance in earning foreign exchange because of low production. It is also used for preparation of cordage, fishing nets, ropes, twines, canvas, floor mats and handmade paper etc. (Tripathi et al. 2012). Sunnhemp (*Crotalaria juncea* L.) is a leguminous green manure crop and it has a tremendous potential in harvesting atmospheric nitrogen through biological nitrogen fixation and can supplement fertilizer nitrogen (Chaudhary, Babita 2016). The 60-days-old crop accumulates about 170 kg N, 20 kg P and 130 kg K/ha (Patro, 2002).

Seed is the critical input in any agricultural system and high yield of quality seed can be obtained only with improved agro-techniques. It is significantly affected by temperature along with associated CO₂ and rainfall change is likely to be beneficial for crop yields. As against this, Sowing dates and new released varieties are the major key for climate resilient and useful to sustain the yield of

all crops. Sowing dates is major agro-technique which is helpful for significant interaction with climatic factors of CO₂, rainfall, temperature with the use of crop simulation models. It also affects the crop-pest interaction and crop weed competition (Agrawal, 2008). Availability of newly released quality seed to the farmers at proper time is one of the major constraints faced by sunnhemp farmers. For this purpose research is essential for knowing the optimum sowing date of sunnhemp for better interaction of climatic factors and reduces the cost of cultivation. Keeping these points in view, the present investigation was undertaken to study the performance of sowing windows on newly released varieties for seed yield and economics of sunnhemp (*Crotalaria juncea* L.).

Materials and Methods

The experiment was conducted in farm of Jute and Allied Fibre crops, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra (situated at lies between 19° 48' N and 19° 57' N latitude and 74° 32' E and 74° 19' E longitude. The altitude varies from 495 to 569 meter above mean sea level) during 2013-2015. The soil of the experimental site is clay loam in texture (Clay- 41.40%, Silt-33.20% and Sand- 16.42%) with having pH 8.4 and EC 0.29 dS/m and organic carbon 0.58% in top of 15 cm soil. The soil available nitrogen, phosphorus and potassium were 178.11, 17.02, 423.0 kg/ ha and moderate in Fe, Mn, Zn and Cu were 6.59, 9.51, 0.62 and 3.41 µg/ g of soil. The field capacity, bulk density and permanent wilting point of

Table-1 : Growth and yield attributes of sunnhemp as influenced by different treatments.

Treatment	Plant height (cm)	Number of productive branches/plant	Number of pods/plant	Number of seeds/pod	1000 seed wt. (g)
A. Sowing dates					
D ₁ -15 th June	220.74	7.93	44.69	10.02	39.89
D ₂ -1 st July	215.19	9.77	57.61	10.56	42.57
D ₃ -30 th July	184.62	6.38	46.69	9.94	37.41
SEm+	2.64	0.31	2.03	0.12	0.41
CD at 5%	10.38	1.20	7.95	0.46	1.61
B. Varieties					
V ₁ -JRJ 610	216.32	8.75	57.97	10.81	40.47
V ₂ -SUIN 037	203.83	7.26	41.60	9.43	39.04
V ₃ -SUIN 053	200.41	8.08	49.43	10.28	40.36
SE m +	3.78	0.30	1.19	0.22	0.32
C.D. at 5%	11.64	0.93	3.67	0.69	0.97
D.Interaction : DXV	N.S.	Sig.	N.S.	N.S.	N.S.

Table-2 : Yield and economics of sunnhemp as influenced by different treatments.

Treatment	Seed yield (q/ha)	Gross monetary Returns (₹/ha)	Cost of cultivation (₹/ha)	Net monetary returns (₹/ha)	B : C Ratio
A. Sowing dates					
D ₁ -15 th June	14.54	72704	32243	40461	2.25
D ₂ -1 st July	18.19	90964	34043	56920	2.67
D ₃ -30 th July	16.15	80733	32280	48453	2.50
SEm+	0.67	3335	—	3335	—
CD at 5%	2.02	10305	—	NS	—
B. Varieties					
V ₁ -JRJ 610	17.40	87024	33133	53890	2.62
V ₂ -SUIN 037	15.42	77119	32567	44552	2.36
V ₃ -SUIN 053	16.05	80258	32866	47391	2.44
SE m +	0.43	2159	—	2159	0.07
C.D. at 5%	1.33	6654	—	6654	0.20
D Interaction: DXV	N.S.	N.S.	—	N.S.	—
DXV	N.S.	N.S.	—	N.S.	—

the surface (0-15 cm) soil were 33.23% on volume basis, 1.36 Mg/m³ and 16.71%, respectively. The average annual rainfall at Rahuri is 520 mm. The rainfall received from south-west monsoon from May to November was 618.4, 493.6 and 380.8 mm and rainy days 38, 28 and 33 during 2013, 2014 and 2015, which is beneficial for crop growth and seed development. The average mean annual maximum and minimum temperature ranges from 33° to 43°C and 6° to 18°C, respectively. The average relative humidity during morning and evening hours are 59 and 35 per cent, respectively. The experiment was laid out in split plot design during *kharif* season in four replications. The main plot treatments comprises of three sowing dates i.e. D₁- 15th June, D₂-1st July and D₃- 30th July and subplot treatments comprises three varieties i.e. V₁- JRJ 610, V₂-SUIN 037 and V₃- SUIN 053 with 9 combinations of sowing dates and varieties. The gross plot size was 4.80 x 3.60 m² and net plot sizes were 4.20 x 3.00 m². Application of FYM

5t/ ha along with fertilizer level of 20:60:40 kg, N, P₂O₅ and K₂O was applied at the time of sowing. Crop sown as per treatment wise and harvested to physiological maturity. As regards, for data collection on growth and yield attributing characters of five plants were selected at randomly from each plot. The harvested crop is sundried as per treatment wise, threshed and yield of seeds were obtained from net plot and converted into q/ha. While calculating gross return from prevalent market price for sale of sunnhemp seed was taken as Rs50.0/kg. Net returns was calculated by deducting cost of cultivation from gross income and benefit/cost ratio was calculated by dividing total cost of cultivation (₹/ ha) to gross returns (₹ /ha).

Results and Discussion

Effect of sowing dates on growth and yield : The growth and yield of sunnhemp as influenced by different sowing dates shown as follows in Table 1. Among the

sowing dates, sunnhemp crop sown at 1st July recorded significantly higher growth and yield attributes viz., number of productive branches (9.77), number of pods (57.61) per plant, number of seeds per pod (10.56) and 1000 seed weight (42.57 gm) than sowing date of 15th June and 30th July. The highest growth and yield attributes resulted into significantly higher seed of sunnhemp. The sowing date of 1st July registered significantly higher seed yield (18.19 q/ha) and it was 25.10 % higher than 15th June and 12.63 % higher than 30th July, respectively. Similar results registered by Ulemale *et. al* (2001) and Tripathi *et al* (2013).

Effect of sowing dates on economics : The economics of sunnhemp was influenced by different sowing dates shown as follows in Table 1. The seed production of sunnhemp crop sown in three sowing dates i.e. 15th June, 1st July 30th July. Among three sowing dates, the sowing date 1st July recorded significantly higher seed yield and which are ultimately resulted into higher economic return through the selling price (₹50/kg) of sunnhemp. Similarly, the economic indices viz., gross monetary returns (₹90964), net monetary returns (₹56920) and B:C ratio (2.67) recorded maximum than 30th July and 15th June. Sowing date of 30th July was found second rank in respect of net monetary returns. Similar results reported by Ulemale *et. al* (2001), Yarangoppa *et. al.* (2003) and Chaudhary Babita (2016).

Effect of varieties on growth and yield : The growth and yield of sunnhemp was influenced significantly by different varieties in Table 1 and 2. The growth and yield attributes like plant height (216.32 cm), number of branches (8.75), number of pods per plant (10.81) and 1000 seed weight (40.47 gm) were recorded maximum in the variety JRJ 610 than SUIN 037 and SUIN 053. The variety JRJ-610 recorded significantly higher seed yield (17.40 q/ha) and it was 12.84 % higher than the SUIN 037 and 8.41 % higher SUIN 053.

Effect of varieties on economics : The economic indices of sunnhemp were influenced significantly by different varieties in Table 2. Among the varieties, The JRJ 610 registered maximum seed yield and which is ultimately resulted into higher monetary benefits. Similarly, It was recorded maximum gross monetary returns (₹87024), net monetary returns (₹53890) and B:C ratio (2.62) than the variety SUIN 053 and SUIN 037. This is a legume crop having more nitrate reductase activities in roots which is beneficial for pod seed development

stage. These results are in conformity with the results obtained by Kumar *et al.* (2005) and Tripathi *et al* (2009).

Interaction effect : Interaction effects between the different spacing and fertilizer levels were found to be non significant in growth, yield attributes and seed yield of sunnhemp.

On the basis of three years experiment, it could be concluded that the sowing of sunnhemp (*Crotalaria juncea* L.) crop during *kharif* season in 1st July along with newly released variety JRJ 610 is beneficial for higher seed production under protective irrigation.

References

1. Agrawal, P.K. 2008. Global climate change and Indian agriculture: impacts, adaption and mitigation. *Indian journal of Agricultural Sciences*, 78 (10): 911-919.
2. Chaudhary, Babita. 2016. Traditional cultivation of sunnhemp (*Crotalaria juncea*) in eastern India. *Indian Journal of Agricultural Sciences* 86 (3): 369-372
3. Kumar, C.J., Hiremath, S.M., Chittapur B.M. and Chimmad V.P. 2005. Effect of sowing time and fertilizer levels on seed production of sunnhemp in northern transitional zone of Karnataka. *Karnataka Journal of Agricultural Sciences*, 18 (3): 594-598.
4. Patro, H K. 2002. Integrated nitrogen management in rice-wheat cropping system'. *Ph D thesis submitted to Govind Ballabh Pant University of Agriculture and Technology, Pantnagar*.
5. Tripathi MK, Chaudhary B, Bhandari HR and Harish ER. 2012. Effect of varieties, irrigation and nitrogen management on fibre yield of sunnhemp. *Journal of Crop and Weed* 8 (1): 84-85.
6. Tripathi, M.K. Chaudhary, B., Singh, S.R. and Bhandari, H.R. 2013. Growth and yield of sunnhemp (*Crotalaria juncea* L.) as influenced by spacing and topping practices. *African Journal of Agricultural Research*, 8 (28): 3744-3749
7. Ulemale, R.B., Giri, D.G. and Shivankar, R. S. 2001. Effect of sowing date, row spacing and phosphate level on biomass studies in sunnhemp. *Journal of Maharashtra Agricultural Universities*, 26(3): 323-325.
8. Yarangoppa, S.D., Desai, B.K., Halepyati, A.S. and Pujari, B.T., 2003. Influence of plant densities and phosphorus management on growth and seed yield of *Sesbania aculeata* (Wills.) Poir. *Karnataka Journal of Agricultural Sciences*, 16 (2): 297-299.
9. More, S.R., Pacharne, D.P. and Gaikwad, A.R. 2018. Effect of spacing and fertilizer management on seed production of sunnhemp (*Crotalaria juncea*) *Indian Journal of Agronomy* 63(1): 104-107.



Perception of Rural Agricultural Extension Officers on Climate Change in Balod District of Chhattisgarh State

Damini Ishda, H.K. Awasthi and K.K. Shrivastava

Department of Agricultural Extension, College of Agriculture, IGKV, Raipur- 492012 C.G.

Email : damineeishda@gmail.com

Abstract

Global warming has emerged as one of the most important environment issues ever to confront humanity, this concern arises from the fact that our everyday activities may be leading to change in the earth's atmosphere that have the potential to significantly alter the planet's heat and radiation balance. Keeping in mind the uncertainties of future due to global warming the present investigation was carried out in Balod district of Chhattisgarh state. Three blocks were randomly elected from the Balod district namely, Balod, Gurur, Gunder- dehi, in such way total 80 RAO's were selected from these blocks. In this study most of the respondents belonged to the young age group and majority of respondents were male than female and most of them were graduates with B.Sc. (Ag.). In the psychological characteristics of extension functionaries, most of the RAO's had medium level (71.25%) of professional perception. About 61.25%, most of the extension functionaries had attended less than 7 days training. Most of the RAO's covered medium level of contact with other extension personals with 60 percent. Majority of the extension workers covered medium level (65%) of mass media exposure. Most of the extension functionaries covered medium level (56.25%) of participation in seminar/ conference/ symposium. Most of the extension workers come under medium level (55%) of job satisfaction. Most of the respondents had 10-20 years of service experience. Majority of the extension fumitories come under medium level (70%) of attitude towards global warming and had 60% response towards perception of climate change. Medium level (57.5%) of awareness about global warming had found in most of the respondents.

Key word : Global warming, perception of climate change, rural agricultural extension officer's.

Introduction

Global warming is the greatest environmental threat humanity has ever faced. It is caused by the extensive unsustainable use of natural resource and destruction of carbon sinks that our world has been bestowed with. India has a long history of environment protection and conversion. Since times immemorial the people of Chhattisgarh have been living very close to nature. But in recent years we are facing extreme threats of Climate change, especially due to erratic weather and rainfall. Due to global warming the temperature of earth surface is going up and consequently the rainfall is reducing gradually. During the last 5 decades the average rainfall in Chhattisgarh states has fallen down to 15cm. The change in climate due to global warming has brought the weather scientist into astonishment. The ups and downs of the climate has resulted delay in the monsoon. In Chhattisgarh the arrival of monsoon every year has been second week of June. Whereas monsoon arrived third week of June 2020 (According to H.P. Chandra, meteorologist, Raipur MeT centre). Irregular monsoon, less water, rising sea level, will impact badly on Indian agriculture and it is, major crop yields will be affected by higher temperatures.

Climate changes observed in Earth's climate since the early 20th century are primarily driven by human

activities, particularly fossil fuel burning, which increase heat-trapping greenhouse gas levels in Earth's atmosphere, raising Earth's average surface temperature. These human-produced temperature increases are commonly referred to as global warming. Natural processes can also contribute to climate change, including internal variability (e.g., cyclic ocean patterns like El nino, La Nina and the Pacific Decadal Oscillation) and external forcing e.g., volcanic output, variations in earth's orbit.

Human interaction with climate occur at all levels but so far research has focused on government employees that are Rural Agricultural Extension Officer's from district level that influence decisions and behaviour at the individual level they drives societal change via adoption of technologies and support for policies, to successfully communicate about risk, change behaviours that contribute to climate change and facilitate capabilities, cognitive processes, biases, values, beliefs, norms, identities and social relationships and to integrate this understanding into broader understanding of human interactions with a climate change.

Materials and Methods

The present study awareness of rural agricultural extension officers about global warming was conducted purposively in Balod district of Chhattisgarh state during

Table-1 : Distribution of respondents according to Perception of climate change.

Sr. No.	Category	Frequency	Percentage
1.	Low (below 15 score)	13	16.25
2.	Medium (15 to 18 score)	48	60.00
3.	High (above 18 score)	19	23.75
	Total	80	100

From the table-1, the result concluded that majority of the rural agricultural extension officer's had medium level (60.0%) of perception towards climate change followed by high (23.75%) and low level (16.25%) of perception of climate change. Table 1.1 shows the extent of response of rural agricultural extension officer's for the each statement towards perception of climate change that, majority of the responses are likewise, 85.0% had responded for rainfall is unpredictable day by day, 83.75%

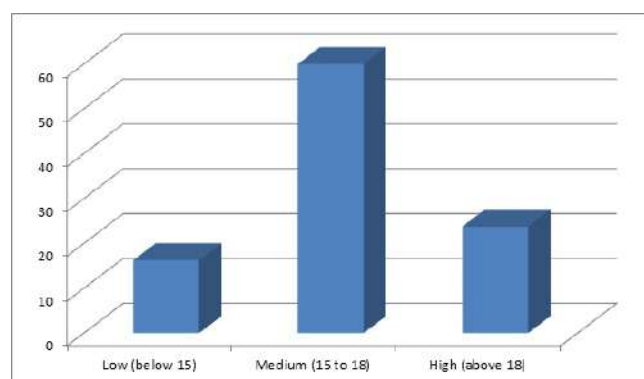
Table-2 : Distribution of respondents according to their extent of response towards perception of climate change.

Sr. No.	Statements	Response		
		Agree	Undecided	Disagree
1	Change in intensity and pattern of rainfall	61 (76.25%)	7 (8.75%)	12 (15.00%)
2	Rainfall is being unpredictable day by day	68 (85.00%)	4 (5.00%)	6(20.00%)
3	Sudden heavy rainfall and storms/cyclone increased	60 (75.00%)	8 (10.00%)	12(15.00%)
4	Late onset of monsoon	57 (71.25%)	5 (6.25%)	18(22.5%)
5	Early withdrawal of monsoon	58 (72.5%)	3 (3.75%)	19 (23.75%)
6	Uneven distribution of rainfall	67 (83.75%)	7 (8.75%)	6 (20.00%)
7	Duration of cloudy days decreased	51 (63.75%)	16 (20.00%)	13 (16.25%)
8	Duration of rainy days decreased	63 (78.75%)	4 (5.00%)	13 (16.25%)
9	Winds are getting warmer	65 (81.25%)	6 (7.50%)	9 (11.25%)
10	Incidents of drought and floods is increasing	61 (76.25%)	8 (10.00%)	11 (13.75%)

2019-2020. Three blocks were randomly selected namely Balod, Gurur and Gunderdehi and from all the three blocks total 80 number of rural agricultural extension officer's were selected for the study. The data were collected by personal interview schedule with the help of well prepared, structured and pretested interview schedule. The data collected were tabulated and analyzed using appropriate statistical tools and methods.

Results and Discussion

Perception of climate change refers to the opinion of rural agricultural extension officer's towards climate change and its impact on agriculture. The findings regarding rural agricultural extension officer's perception of climate change are given in the Table-1 and 2 and Fig-1.

**Fig.-1 : Distribution of respondents according to Perception of climate change.**

responded for uneven distribution of rainfall, 81.25% for winds are getting warmer, 78.75% for duration of rainy days decreased, 76.25% for incidents of drought and floods is increasing, and change in intensity and pattern of rainfall, 75.00% for sudden heavy rainfall and storms/cyclone increased, 72.5% for early withdrawal of monsoon, 71.25% for late onset of monsoon and very least for duration of cloudy days decreased 63.75%.

So the study show that majority of the respondents had knowledge and awareness about climate change and they had medium level of perception towards climate change.

Conclusion

Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. These changes have a broad range of observed effects that are synonymous with the term. The study shows that majority of the rural agricultural extension officer's had knowledge and awareness about global climate change and their perception towards climate changes. Most (85.00%) of the rural agricultural extension officer's were Agree for "Rainfall is being unpredictable day by day" statement, most (20.00%) of the rural agricultural extension officer's were responded Undecided for "Duration of cloudy days decreased" statement, and most (23.75%) of the rural agricultural extension officer's were Disagree for "Early withdrawal of monsoon" statement.

The rural agricultural extension officer's had given some suggestion to overcome from global warming and climate change are, more plantation, limited use of natural resources, use 3R formula i.e., Recycle, Reuse and Reduce, less use of chemical insecticides and fertilizer and more use of organic manure and FYM, adapt sustainable agriculture and crop rotation etc.

References

1. Anonymous 2010. Impact of global climate change on agriculture. *Agril Today* 13: 56-57.
2. D. Estelita, (2015). Awareness, Knowledge and Attitude on climate change of students; input for the development of ICM on climate change. *International journal of Current Research*, 05 vol 07, pp 15857.
3. Dey, Tanushri. (2015), Perception on effect of climate change on forest and adaptation strategies of forest dependent communities in a humid tropical foothill forest of Indian Eastern Himalayas. *M.Sc.(Forestry) Thesis. Uttar Banga Krishi Vishwavidyalaya, West Bengal.*
4. Hansen, James, Sato Makiko and Retro Ruedy. 2012. Perception of climate change, *Proceedings of the National Academy of Sciences* 109 (37), E2415- E2423.
5. Jan, C. Semenza 2008, Public perception of climate Change, voluntary mitigation and barriers to behaviour change. *Behavioural and public Communication issue*, Vol 35, issue 5, P479-487
6. Odjugo, A.O.P., and Ikhuoria Isi, A(2003), The impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. *Global Journal of Environmental Science*, 2(2), 118-126
7. Ramani, Pallavi. 2020, to study the impact of Agricultural technology management agency (ATMA) on socio-economic status of women self help group members associated with vegetable production in Durg district of Chhattisgarh. *M.Sc.(Ag.)Thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)*
8. Rankoana, Sejabaedi A. 2018, Human perception of climate change, *Royal Meteorological Sociey* Vol. 73, Issue 11, p. 367-370. <https://doi.org/10.1002/wea.3204>
9. Shankara, H.M., 2010. Farmer's perception of climate change and their adaptations. *M .Sc. (Ag.) Thesis, University of Agricultural Sciences GKVK, Bengaluru.*
10. X. Yang, 2018. Impact of climate change on TN load and its control in a River Basin with complex pollution sources, *Science of the Total Environment*, vol. 615, pp. 1155-1163, 2018.



The Study About Socio-Economical Profile of the Respondents of Direct Seeded Rice Cultivation Practices of Paddy of Chhattisgarh State

Deeksha Baghel, P.K. Pandey, M.A. Khan and M.L. Sharma

Department of Agricultural Extension, College of Agriculture, IGKV, Raipur-492012, C.G.

Email: deekshabaghel95@gmail.com

Abstract

The purpose of this study was to study about socio-economical profile of the respondents of Direct Seeded Rice cultivation practices of Paddy of Chhattisgarh state. To serve this purpose, sample sizes of 80 respondents were selected from Patan blocks of Durg district during the year 2019-20. The result of study shows that majority of the respondents (farmers using Seed Drill method of rice sowing) were educated up to high school with medium family size (6-10 members) and having membership in one organization. Most of the respondents were doing agriculture as main occupation with 11 to 20 years of farming experience, however many of them were engaged in subsidiary occupation to support their livelihood. Most of them were having land holding more than 10 acres. The average family income was found between ₹ 500000 to 1000000 per annum.

Key word : Socio-economical profile, direct seeded rice, cultivation practices of paddy.

Introduction

Rice (*Oryza sativa* L.) is cultivated all over the world, with the exception of the Antarctica. It has a strong impact on human nutrition and food security in the world as a global crop. This is the staple food for more than half of the population worldwide. More than 2 billion people in Asia alone get 60-70 per cent of their caloric intake from rice and its derivatives. Each human being in the world, on average consumes about 57.50kg of rice annually. Rice is the most rapidly growing food source in Africa. In Asia, Africa and America, nearly a billion household depend on rice systems for their key source of jobs and livelihood. Hence, rice is at front-line in the fight against hunger and poverty in the world. Rice is also a symbol of both culture identity and global unity.

Rice is mainly produced and consumed in Asia. Worldwide acreage is 158.8 million hectares and annual rice production is approximately 740.9 million tonnes (2015) (www.Statista.com). India has the largest rice area, accounting for 28.50 per cent of the world's rice area. China, the world's largest producer, accounts for 30.70% of total world production followed by India with 21.60 %. Rice occupied 45.50 million hectares in India, with 104.32 million tons of annual production (2015) (www.Indiastat.com). Rice occupies one-quarter of the total cultivated area within the country, contributions about 40% of total food grain production, and continues to play a vital role in the national food and livelihood security system.

The Green Revolution technologies (combining higher-yielding cultivars, use of agrochemicals, including fertilizers and irrigation) led to a rapid increase in rice

yield, production and area resulting in lower rice price, thus benefiting poor consumers in rural and urban areas of Asia. The word "rice is life" is most fitting for India as this crop plays a vital role in the food security of the country, and is the backbone of living for millions of rural households. By 2010 rice production had reached 151Mt, second only after China in the world (FAO, 2010). The rise has been about four times since 1950.

Regardless of the fact that rice output has increased in tandem with Asia's population rise, rice productivity growth has declined since 1985 and has dropped below the population growth rate in more recent years. If continued, this rice productivity growth would cause major imbalances between supply and demand over the longer term. The productivity and long-term viability are affected by (1) inefficient input utilization (fertilizer, water, labour); and (2) rising scarcity of resources, particularly water and manpower (3) climate change, (4) The looming energy crisis and soaring gasoline prices; (5) rising cultivation costs and (6) emerging socioeconomic changes such as urbanization, labour migration, non-agricultural work preferences, and concerns about farm-related pollution (Ladha *et al.*, 2009).

In Asia, rice is commonly cultivated by transplanting seedlings into puddle soil (land preparation with wet tillage). Puddling benefits rice by reducing water percolation losses, controlling weeds, promoting fast seeding and creating anaerobic conditions to increase the availability of nutrients (Sanchez, 1973). Repeated puddling, on the other hand, has a negative impact on soil physical qualities by eroding soil aggregates, limiting permeability in subsurface layered, and generating hardpans at shallow depths (Aggarwal *et al.*, 1995;

Table-1 : Distribution of respondents according their socio-personal characteristics.

S.No.	Categories	Frequency	Percentage
Education			
1.	Illiterate	03	3.75%
2.	Functionally literate	14	17.50%
3.	Primary school	13	16.25%
4.	Middle school	14	11.66%
5.	High school	18	22.50%
6.	Higher secondary school	16	20.00%
7.	Graduation	04	5.00%
Family size			
1.	Small family (< 5 members)	31	38.75%
2.	Medium family (5-8 members)	32	40.00%
3.	Large family (> 8 members)	17	21.25%
Farming experience			
1.	1 to 10 years	31	38.75%
2.	11 to 20 years	32	40.00%
3.	21 to 30 years	14	17.50%
4.	Above 30 years	03	3.75%
Social Participation			
1.	No members of any organization	04	5.00%
2.	Member of one organization	59	73.75%
3.	Member in more than one organization	12	15.00%
4.	Holding position in organization	05	6.25%

Sharma and De Datta, 1985; Sharma *et al.*, 2003), all of which can have a negative impact on the non-rice upland crop in the rotation (Hobbs and Gupta, 2000; Tripathi *et al.*, 2005). Moreover, rice production is becoming less viable due to the massive amounts of water and manpower required for puddling and transplanting, both of which are becoming increasingly rare and costly. Furthermore, the hard nature of transplanting-a labour that is predominantly performed by women-is a major source of concern. All these factors demand a major shift from puddle-transplanted rice production (CT-TPR) to direct seeded of rice (DSR) in irrigated areas. Low salaries and adequate water availability support transplanting, while high wages and little water prefer DSR, according to Pandey and Velasco (2005). Farmers either adjust their rice establishment method (from transplanting to direct sowing in puddle soil [wet-DSR]) or both tillage and rice establishment methods, depending

on water and manpower scarcity (puddle transplanting to dry seeding in unpuddled soil [Dry-DSR]).

In India, the highest area under rice cultivation is in Uttar Pradesh 5.81million hectares, followed by West Bengal 5.12 Million hectares and Chhattisgarh 3.76 million hectares. West Bengal is the largest producer of rice with 14.97 million tons production followed by Punjab 13.38million tons and Andhra Pradesh 13.27million tons (Directorate of economics and statistics 2018). The area, production and productivity of rice in Chhattisgarh state from 2013-17 was given in figure-1. In Durg district, rice occupied 125.99 hectares in 2016-17, with a production of 173.19 million tons (Directorate Agriculture, Chhattisgarh Raipur).

The Durg district of Chhattisgarh is one of the most important paddy growing district and the increase area under paddy crops in Durg district has brought a change in the social as well as economic condition of the farmers.

Research Methodology

The present study was carried out during 2019-2020 at the Durg district of Chhattisgarh due to its maximum area coverage and productivity under Direct Seeded Rice cultivation practices. The Durg district is divided in 3 blocks i.e. Durg, Dhamdha and Patan. Out of these three blocks, the study is conducted in 1 block i.e. Patan due to having maximum area under rice cultivation through direct seeding crop establishing method. 10 villages will be selected purposively from selected Block, where the DSR practice of rice establishment are adopted by the farmers in this way, these villages will be considered for study purpose from the block. 8 respondents were purposively from 10 villages each which were nearer to KVK. Total 80 farmers were considered as respondents ($1 \times 8 \times 10 = 80$) for the proposed study sample. The data was collected by personal interviewed with the help of well structured and pretested interview schedule with purpose to obtain the primary information from the respondents. The data collected were tabulated and analyzed using appropriate statistical tools and methods.

Results and Discussion

The data in Table-1 reveal that the most of the respondents (22.50%) had high school of education. However, 20.00 per cent of the respondents had higher secondary level of education, followed by 17.50 per cent were functionally literate, 16.25 per cent primary level of education, 15.00 per cent had middle school, 5.00 per cent had graduation and only 3.75 per cent respondents were illiterate. The majority of the respondents in the research are had completed high school, according to the findings (Table-1). In their studies Chandra (2001), Mao *et*

Table-2 : Distribution according to occupation held by the respondents.

Categories	Percentage*
Agriculture	100.00
Agriculture + Animal husbandry	5.00
Agriculture + Labour	6.25
Agriculture + Business	2.50

*Data is based on multiple responses

Table-3 : Distribution of the respondents according to their annual income.

S.No.	Category	Frequency	Percentage
1.	₹ 100001 to 500000	25	31.25%
2.	₹ 500001 to 1000000	32	40.00%
3.	₹ 1000001 to 1500000	16	20.00%
4.	Above ₹ 1500000	07	8.75%

Table-4 : Distribution of respondents according to their land holdings.

S.No.	Categories	Frequency	Percentage
1.	Small (2.5-5 acres)	5	6.25%
2.	Medium (5.1-10 acres)	13	16.25%
3.	large (>10 acres)	62	77.50%

al. (2008), and Sathish (2010) found similar accuracy. It has been seen that majority (40.00%) of respondents were having medium size of family (5-8 members), followed by, 38.75 per cent of the respondents had small family size (less than 5 members) and about 21.25 per cent of the respondents were having large size of family (Above 8 members). This conclude that majority of the respondents belonged to medium size of family. Kavitha and Reddy (2007) and Lad *et al.* (2012) also found similar findings. The farmers practicing DSR had experience in farming from 5 to 40 years. The data regarding the farming experience reveals that about majority (40.00%) of the farmers had 11 to 20 years of farming experience, while 38.75 per cent of the respondents had 1 to 10 years of farming experience, followed by 17.50 percent of respondents had 21 to 30 years of farming experience and only 3.75 per cent of the farmers had above 30 years of farming experience. On the basis of above, it may be concluded that majority of the respondents belonged to 11 to 20 years farming experience. Sowjanya cheruku (2016) also reported similar findings in his study.

The respondents were asked about their participation in different local organization as a member and holding of positions. According to their responses, they were classified into four groups viz.; (i) no membership, (ii) membership in one organization (iii) membership in more than one organization and (iv) holding position in organization. The data regarding this clearly indicate that the majority of the respondents (73.75%) had membership of one organization, followed

by 15.00 per cent of the respondents had member of more than one organization, 6.25 per cent of respondents were holding position in organization and only 5.00 per cent of the respondents had no membership of any organization. Yadav (2006) and Dubey (2008) also noticed almost similar findings in their study.

The data given in Table-2 regarding occupation of the respondents reveals that about 100.00 per cent of the respondents involved in agriculture followed by Agriculture + Labour work (6.25%), Agriculture + Animal husbandry (5.00%) and Agriculture + Business (2.50%). Whereas no respondents falls under Agriculture + Service and other categories. All the respondents are practiced agriculture as the primary occupations out of them about 86.25 per cent of the respondents were total depended on agriculture and had not practiced any other enterprise as secondary occupation.

It was extremely difficult to determine the average annual income of each individual as they do not keep such record. The annual income of the respondents was attempted to gather through conversation and interpretation from various perspectives. Regarding annual income, the data are presented in Table 3. The findings indicated that 40.00 per cent of the respondents had earn annual income in the range of ₹ 500001 to 1000000, followed by 31.25 per cent of the respondents had annual income in the range of ₹ 100001 to 500000. Similarly, it was observed that 20.00 and 8.75 percent of the respondents obtained the annual income in the range of ₹ 1000001 to 1500000 and above ₹ 15 lakhs respectively. It also shows that 0.00 percent respondents come below ₹ 100000 ranges.

The respondents were categorized into three groups on basis of their operational land holding. Data presented in the Table-4. Showed that about 77.50 per cent of the respondents had large land holding category followed by medium (16.25%), small (6.25%) and no respondents belong to marginal land holding category. So it was observed that most farmers fell in the category of large land holding (above 10 acres).Whereas, marginal land holding was not reported by the selected respondents.

Conclusion

The majority of the respondents in the study area had their education up to high school. They had medium size of family and majority, farming experience between 11 to 20 years and had membership in one organization. Only 13.75 per cent of the respondents had other subsidiary occupation along with agriculture. Majority (40.00%) of the respondents get their annual income between Rs.5,00,000 to 10,00,000. Majority (77.50%) of the respondents had larger (>10 acre) land holdings.

References

1. Flinn J.C. and Mandac A.M. (1986) *Wet Seeding of Rice in Less Favored Rainfed Environments Working Paper. Agricultural Economics Department, International Rice Research Institute*, Los Ban, Philippines.
2. Kumar V. and Ladha J.K. (2011) Direct Seeded Rice: Recent Developments and Future Research Needs. *Adv Agron* 111: 297-13.
3. Narioka H., Ogura C. and Sukuchan S. (2011) Introduction of Direct Seeding and Selection of Farmland in Rainfed Rice Fields in Small Water Sheds in Northeast Thailand. *JARQ* 45: 337-47.
4. Pandey D.K., Sharma S.K., Gangwar K.S. and Tomar O.K. (2005). Effect of crop establishment Methods on performance of rice (*Oryza sativa*) cultivars and their effect on Succeeding wheat (*Triticum aestivum*). *Indian J Agron* 50: 253-55.
5. Param, P.P. (2006). A study on knowledge and extent of adoption of recommended paddy production technology by the paddy growers in Khambhat Taluka of Anand District. *M.Sc. (Agri.) Thesis, GAU, Anand*.
6. Rao A.N., Johnson D.E., Sivaprasad B., Ladha J.K. and Mortimer A.M. (2007) Weed Management in Direct-Seeded Rice. *Adv Agron* 93: 153-55.
7. Salunkhe, S.R (2012). Correlation between the personnel, Social-economic, Psycological and Situational Characteristics and factors affecting to the Agro Services Provider and Beneficiaries. *Agric. Updat.*, 7(3&4): 203-205.
8. Tyagi, A.S.; Sharma, A. and Tyagi, B.D. (2003). Socio-economic variables and technological gap in rice. *Agri. Extn. Review*, 15 (3): 16-19.



Seasonal Incidence of Sweet Potato Weevil, *Cylas formicarius* (Fab.) (Brentidae, Coleoptera) and its Correlation with Weather Parameters

A. Deepthy, C.P. Viji, N. Emmanuel and V. Sudha Vani

College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem-534101, A.P.

Abstract

Studies on seasonal incidence of sweet potato weevil (*Cylas formicarius*) in relation to major abiotic factors was carried out at College of Horticulture, Venkataramannagudem. Seasonal incidence of the weevil was recorded on the basis of the population of adult weevils caught in pheromone traps and stem injury caused by the grub in sweet potato. Population of sweet potato weevil and stem damage was recorded from first week after planting that increased till the harvest of the crop. The highest number of weevils (367.27/trap/week) and highest stem injury percent (36.14 percent/ plant) was observed during 11th SMW (5th Mar.–11th Mar.). The adult sweet potato weevil population was significantly positively correlated with maximum temperature and stem injury percentage was significantly positively correlated with the maximum temperature and maximum humidity.

Key words : Sweet potato weevil, seasonal incidence, abiotic factors.

Introduction

Sweet potato, *Ipomoea batatas* (L.) is the second most important root crop in the world. Globally sweet potato is cultivated in 117 countries in an area of 8.62 million ha producing 105.19 million tons with a yield of 12.20 t ha⁻¹. In India, the area under sweet potato cultivation is 0.13 million ha with a production of 1.47 million tonnes (FAO, 2016). It is largely grown in states of Odisha, Bihar, Chattisgarh, Jharkhand, West Bengal, Uttar Pradesh, Andhra Pradesh, Tamilnadu, and Karnataka (Prakash *et al.*, 2018). Beyene (2015) reported that sweet potato weevil (*Cylas* sp.) is a cosmopolitan insect and most serious insect pest of sweet potato in Central America, Africa and Asia, production losses often reach 60-100 %. Sweet potato weevil was first recorded during 1972 from Tanquibar near Pondicherry in India. Seasonal population dynamics of the pest provides knowledge on the impact of weather factors on insect pest population and their occurrence which cautions the farmer to take up management program.

Materials and Methods

The study was carried out at College of Horticulture, Venkataramannagudem, Andhra Pradesh from 25th November, 2020 to 15th March, 2021. Incidence of sweet potato weevil was noted in variety Pusa Safed by observing the number of adult weevils collected in the pheromone trap and stem injury caused by the sweet potato weevil. Sweet potato weevil pheromone traps was purchased from Alpha scents, Canada. Adult weevil population count was made in each pheromone trap at standard week interval. Stem injury was recorded by counting total and damaged vines in 15 plants per standard meteorological week (SMW).

Weather parameters viz. maximum temperature, minimum temperature, relative humidity (RH I – RH at 8.00AM, RH II – RH at 2.00 PM) and rainfall were recorded at each standard meteorological weeks from meteorological observatory, College of Horticulture, Venkataramannagudem. The population of adult weevil and percent stem injury was correlated with abiotic factors and regression equation was worked out.

Results and Discussion

Observations during the course of present investigation at College of Horticulture, Venkataramannagudem showed that sweet potato weevil (*Cylas formicarius*) is a major pest of sweet potato in this area. Meteorological parameters are presented in table 1. Data on adult weevil population and percent stem injury collected in weekly intervals in different SMW starting from the date of planting to date of harvesting is presented in table 2 and fig. 1. Data on correlation and regression coefficients were presented in table-3.

Observations showed that the population of sweet potato weevil was recorded from first week after planting till the harvest of the crop. The population of adult weevils/trap/week increased from 48th SMW to 11th SMW. The population of weevils recorded were 35.26, 74.84, 95.47, 108.39, 119.45, 128.25, 151.22, 172.63, 194.59, 216.43, 231.17, 244.83, 276.92, 298.67, 360.74 and 367.27 at 48th, 49th, 50th, 51st, 52nd, 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th and 11th SMW, respectively. Maximum population of sweet potato weevil was recorded at 11th SMW which coincided with the tuber maturity. The adult sweet potato weevil population was significantly positively correlated with maximum temperature and stem injury

Table-1 : Weekly meteorological data during 2020-21 at College of Horticulture, Venkataramannagudem.

SMW	Date	Temperature (°C)		Relative humidity (%)		Rain fall
		Max.	Min.	RH I	RH II	
48	26 th Nov – 02 nd Dec, 2020	29.07	22.56	81.16	53.15	16.93
49	03 rd Dec – 09 th Dec, 2020	32.29	21.10	84.10	40.46	0.00
50	10 th Dec – 16 th Dec, 2020	33.08	20.73	83.77	40.30	0.00
51	17 th Dec – 23 rd Dec, 2020	31.04	20.02	88.63	45.87	0.00
52	24 th Dec – 31 st Dec, 2020	30.62	19.83	86.72	45.57	0.00
1	01 st Jan – 07 th Jan, 2021	29.90	21.08	86.32	54.28	0.00
2	08 th Jan – 14 th Jan, 2021	32.36	21.27	88.11	49.74	0.00
3	15 th Jan – 21 st Jan, 2021	32.85	21.94	90.29	52.39	0.00
4	22 nd Jan – 28 th Jan, 2021	32.45	22.56	90.40	59.89	0.00
5	29 th Jan – 04 th Feb, 2021	32.58	21.54	91.84	58.22	0.00
6	05 th Feb – 11 th Feb, 2021	32.17	19.93	92.62	54.75	0.00
7	12 th Feb – 18 th Feb, 2021	32.84	19.46	90.46	58.12	0.00
8	19 th Feb – 25 th Feb, 2021	33.12	22.41	90.43	60.16	0.00
9	26 th Feb – 04 th Mar, 2021	32.68	21.34	84.67	42.48	0.00
10	05 th Mar – 11 th Mar, 2021	33.05	22.84	86.47	44.94	0.00
11	12 th Mar-18 th Mar, 2021	32.48	21.56	88.15	46.24	0.00

SMW – Standard Meteorological Week

Table-2 : Seasonal incidence of sweet potato weevil, *Cylas formicarius* during 2020-21.

SMW	Period of observation	Week after transplantation	No. of adult weevils/ trap/week*	Stem injury (%) **
48	26 th Nov – 02 nd Dec, 2020	0	35.26	2.54
49	03 rd Dec – 09 th Dec, 2020	1	74.84	5.34
50	10 th Dec – 16 th Dec, 2020	2	95.47	6.67
51	17 th Dec – 23 rd Dec, 2020	3	108.39	8.89
52	24 th Dec – 31 st Dec, 2020	4	119.45	13.34
1	01 st Jan – 07 th Jan, 2021	5	128.25	15.56
2	08 th Jan – 14 th Jan, 2021	6	151.22	17.78
3	15 th Jan – 21 st Jan, 2021	7	172.63	21.14
4	22 nd Jan – 28 th Jan, 2021	8	194.59	24.46
5	29 th Jan – 04 th Feb, 2021	9	216.43	28.00
6	05 th Feb – 11 th Feb, 2021	10	231.17	30.20
7	12 th Feb – 18 th Feb, 2021	11	244.83	31.06
8	19 th Feb – 25 th Feb, 2021	12	276.92	31.73
9	26 th Feb – 04 th Mar, 2021	13	298.67	32.46
10	05 th Mar – 11 th Mar, 2021	14	360.74	33.40
11	12 th Mar – 18 th Mar, 2021	15	367.27	36.14
	Average		192.26	21.17

SMW = Standard Meteorological Week, *Data based on average of 3 pheromone trap collections, **Data based on average of 15 observations

percentage was significantly positively correlated with the maximum temperature and maximum humidity.

The adult weevil population exhibited significant positive correlation with maximum temperature ($r = 0.609$). Whereas the maximum humidity ($r = 0.433$), minimum temperature ($r = 0.229$) and minimum humidity ($r = 0.133$) are positively correlated but not significant with adult population. Rainfall ($r = -0.424$) was negatively correlated with adult population, but not significant. The multiple correlation coefficient (R) based on adult population with

abiotic factors was significant ($R^2 = 0.4683$). The regression equation developed for population fluctuation of adult weevil is :

$$Y = -2354.34 + 28.51X_1 + 29.78 X_2 + 12.88 X_3 + (-2.575) X_4 + (-1.163) X_5$$

Where, Y - Insect population, X_1 – Maximum Temperature, X_2 – Minimum Temperature, X_3 – Relative humidity I, X_4 – Relative humidity II, X_5 – Rainfall

Mondal *et al.* (2006) found higher seasonal catches

Table-3 : Correlation coefficients of incidence of sweet potato weevil with meteorological parameters.

Weather parameters	Pheromone trap catches		Stem injury	
	Correlation coefficients	Regression coefficient	Correlation coefficients	Regression coefficient
Maximum temperature	0.609*	49.25	0.593*	5.51
Minimum temperature	0.229NS	21.28	0.149NS	1.59
Maximum humidity	0.433NS	13.19	0.610*	2.14
Minimum humidity	0.133NS	1.91	0.354NS	0.582
Rainfall	-0.424NS	-9.852	-0.440NS	-1.174
R ²		0.4683		0.541
R		0.6843		0.736
Constant (A value)		-2354.34		-260.45

*Significant at 0.05 level

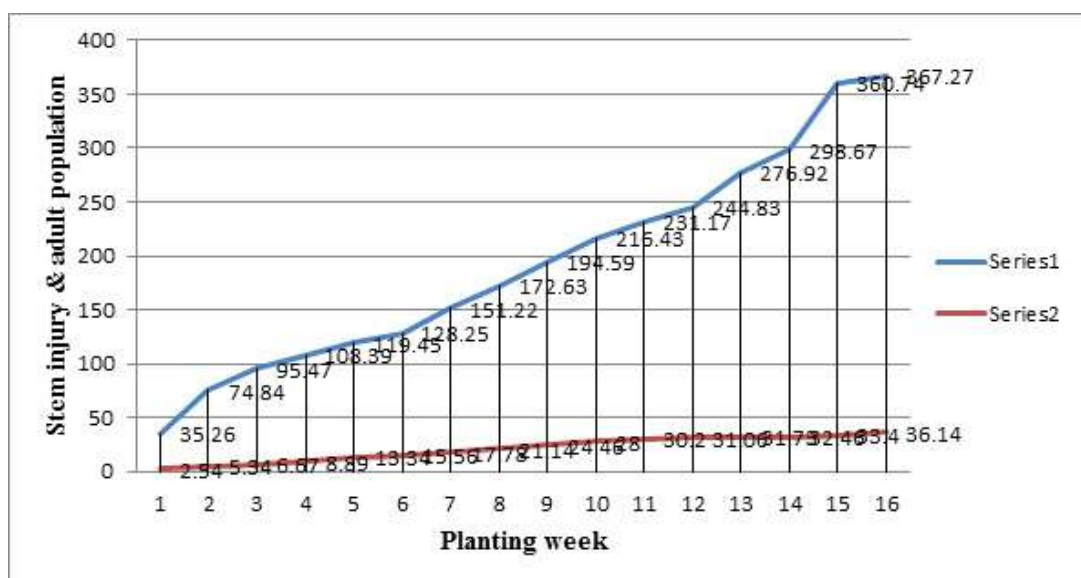


Fig-1 : Adult weevil population and stem injury observed in different weeks after planting.

of male sweet potato weevil during February - March. They further reported that late season activity typically started in late February and was followed by high peak in late March. Mahida et al. (2011) studied the population fluctuation of adult weevil population using pheromone trap in relation to weather factors and found the population was significantly correlated with abiotic factors.

Percent stem damage was recorded from first week after planting that increased till the harvest of the crop. The percentage of stem injury increased from the date of planting till the time of harvesting. The percent stem injury recorded was 2.54, 5.34, 6.67, 8.89, 13.34, 15.56, 17.78, 21.14, 24.46, 28.00, 30.20, 31.06, 31.73, 32.46, 33.40 and 36.14 at 48th, 49th, 50th, 51st, 52nd, 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th and 11th SMW, respectively. The highest percent stem injury (36.14) was recorded during 11th SMW (12th Mar. - 18th Mar.) that coincide with the harvest of the crop at the time of tuber maturity and there were maximum number of vines.

The correlation studies showed that maximum

temperature (0.593) and relative humidity I (0.610) are significantly positively correlated with stem injury where as minimum temperature (0.149) and relative humidity II (0.354) was positively correlated but not significant. Rainfall (-0.440) was negatively correlated with stem injury but was not significant. The regression coefficient (R) based on per cent stem injury with abiotic factors was significant ($R^2 = 0.541$). The regression equation developed for percent stem injury is:

Regression equation for stem injury

$$Y = -260.45 + 3.329X_1 + 2.069X_2 + 1.424X_3 + 0.122X_4 + (-0.150) X_5$$

Rajamma and Pillai (1984) in Trivandrum reported that sweet potato planted from June to February was heavily attacked by *C. formicarius*, wherein the population increased to 50 and 72 per cent.

The basic step for formulation of IPM strategy in any cropping system is the documentation and quantification of insect population fluctuation in relation to

environmental factors (Bokan *et al.*, 2015). Study of population dynamics helps in forewarning the pest situation to farming community through media which in turn would be highly economical to take up plant protection measures in right time to avoid yield losses.

References

1. Beyene, K. 2015. Destitution, Biology, Yield Loss and Management of Sweet Potato Weevils in Ethiopia. *Journal of Biology, Agriculture and Healthcare*. Vol.5, No.22.
2. Bokan, S.C, Jadhav, K.M, Zamwar, P.R, and Bhosle, B.B.(2015) Studies on population dynamics of major pests of chilli and its correlation with weather parameter. *J. Ent. Res.* 39(1): 61-64.
3. FAO, 2016. FAO Statistics, Food and Agricultural Organization, Rome, Italy.
4. Mondal, S, Tarafdar, J. and Sen, H. 2006. Use of sex pheromone trap for monitoring and management of sweet potato weevil (*Cylas formicarius*, Fabricus). *Journal of Environment and Ecology*, 24 (Special 3): 525-28.
5. Mahida, D.R. 2011. Seasonal incidence, varietal screening and assessment of crop loss by sweet potato weevil, *Cylas formicarius* (Fab.), *M.Sc (Agri.) Thesis, Navasari Agricultural University, Gujarat*.
6. Prakash, P, Prabhat, K, Jaganathan, D, Sheela, I. and Sivakumar, P.S. 2018. Status, performance and impact of sweet potato cultivation on farming communities of Odisha, India. *30th International Conference of Agricultural Economists*.
7. Rajamma, P. and Pillai, K.S. 1984. Studies on sweet potato weevil. *In Annual Progress Report 1983*, pp.71-72. *Central Tuber Crops Research Institute, Trivandrum, India*.



Influence of Cluster Frontline Demonstration of Blackgram Var. WBU-109 in Giridih District of Jharkhand

Devkant Prasad^{1*} and Srikant Singh²

¹Krishi Vigyan Kendra, Giridih (Birsa Agricultural University) Jharkhand, India

²Krishi Vigyan Kendra, Pakur (Birsa Agricultural University) Jharkhand, India

*Corresponding author Email : drprasaddevkant@gmail.com

Abstract

The demonstration carried under Cluster Front Line Demonstration (CFLD) programme under NFSM during 2016-17 to 2020-21 by Krishi Vigyan Kendra, Giridih to minimize the yield gap, technology gap, extension gap and maximize the economic return through improved package of practices. The outcome of the study revealed that yield of the black gram under Cluster Front Line Demonstration varied from 11.5 q/ha to 12.0 q/ha during five years which was 46.04% higher than the yield under farmers practice. The average technology gap and extension gap was 1.12 q/ha and 3.74 q/ha respectively. The technology index over the five years varied from 6.1% to 11.5%, net return of demonstrated plot was between Rs. 35,200/ha to Rs. 38,200/ha during different years. The Benefit Cost ratio of demonstrated plot varied from 2.20 to 2.32 whereas it varied from 1.66 to 1.81 for farmers practice plot.

Key words : Technology gap, Extension gap, Technology index, CFLD, Yield and Economics.

Introduction

The land of Jharkhand is predominantly upland and medium land suitable for pulse production and black gram is one of the important *kharif* pulse crops in Jharkhand in general and in Giridih District in particular. Due to lack of awareness and knowledge about the recent varieties and improved technologies farmers are still using old varieties and traditional cultivation practices resulting in poor productivity (430 kg/ha) of black gram. This is far below the average national productivity (750 kg/ha) and state average of 588 kg/ha. It is, therefore, necessary to find out the technology gap in black gram production and also to know the problems and constraints in adopting modern black gram production technologies, Islam *et al*, (2011). The Krishi Vigyan Kendra makes an effort to reduce the time lag between generations of technology at the research institution and its transfer to the farmers for increasing productivity and income from the agriculture and allied sectors on sustained basis. Krishi Vigyan Kendra is grass root level organisation meant for application of technology through assessment, refinement and demonstration of proven technologies under different micro farming situations in a district (Das, 2007). Krishi Vigyan Kendra, Giridih took this opportunity of CFLD programme under NFSM to analyse the constraints and gaps in technology transfer and to overcome it through farmers deep involvement by means of training, goathi, group discussion and field days. Frequent farmer scientist interaction and scientists visit to farmers field right from sowing to harvesting could generate enthusiasm in farmers for successful conduction of demonstration. Considering

the above discussed issue a project implementation was under taken by the KVK, Giridih with the main objective of studying the effect of Cluster Frontline Demonstration on Blackgram var. WBU-109 in Giridih District of Jharkhand to boost the production and productivity of pulses through CFLDs with latest and specific technologies.

Materials and Methods

The study was carried out during kharif season from 2016-17 to 2020-21 (5 consecutive years) by KVK, Giridih, Jharkhand. The demonstrations were conducted in farmer's field of 10 different villages of Giridih District in agro climatic zone-IV of Jharkhand. During these five years of study a total numbers of 50,48,27,31 beneficiaries were selected in 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21 respectively for the project. Farmers were trained to follow the package and practices for black gram cultivation as recommended by the Birsa Agricultural University and need based inputs were provided to the beneficiaries (Table 2). The farmers followed the full package of practices like soil testing seed treatment with bio-fertilizer, fertilizer application, weed management, Integrated pest management (IPM) practices etc shown in Table-1. In case of local check, the traditional practices were followed by using existing varieties. An area of 70 hectare was covered under cluster front line demonstration with active participation of 187 farmers. Before conducting CFLDs, a list of farmer was prepared from group meeting specific skill training was imparted to the selected farmers.

In general, the soil of the Demonstration plot sites

were sandy loams in texture, acidic in reaction (pH 5.0 – 5.4), low to medium in organic carbon (0.4 – 0.6%) and low in available nitrogen (186.6 – 210.8 kg N/ha), low in available phosphorus (7.7 – 9.8 kg P₂O₅/ha) and low in available potassium (86.4 – 110 kg K₂O/ha) shown in Table-1.

In demonstration plots, use of quality seeds of improved varieties (WBU-109), line sowing and timely weeding, need based pesticide as well as balanced fertilizer were emphasized and comparison has been made with the existing practices. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale. The beneficiaries under the programme were facilitated by KVK Scientists in performing field operations like sowing, spraying, weeding, harvesting etc during the course of training and visits. The traditional practices were maintained in case of local checks. The data were collected from both CFLD plot as well as control plots by random crop cutting method and analysed by using simple statistical tools. The technology gap and technological index (Yadav *et al.*, 2004) along with the benefit cost ratio (Samui *et al.*, 2000) were calculated by using following formula as given below.

Technology Gap = Potential yield – Demonstration yield

Extension Gap = Demonstration yield – Farmer's Practice yield

Technology Index = $\frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$

Additional Return = Demonstration Return - Farmer's Practice Return

Percentage increase in yield

= $\frac{\text{Demonstration yield} - \text{Farmers Practice yield}}{\text{Farmer's Potential yield}} \times 100$

Table-1 : Soil nutrient status of the demonstration plot.

Soil test report	Demonstration plot
PH	5.0 – 5.4
Ec (dS m ⁻¹)	1.10 – 1.19
Available N (Kg ha ⁻¹)	186.6 – 210.8
Available P ₂ O ₅ (Kg ha ⁻¹)	7.7 – 9.8
Available K ₂ O (Kg ha ⁻¹)	86.4 - 110
Organic Carbon (%)	0.4 – 0.6

Results and Discussion

Cluster Front Line Demonstration (CFLD) conducted during 2016-17 to 2020-21 in different locations of Giridih district indicated that the components of package and practices like improved variety, spacing, balance dose of fertiliser and weed/pest management had significant effect on different yield and economic parameters of black gram. The data in respect of yield performance of demonstrated plot of black gram was much higher than

the local check/farmer's practices. The average per cent increase in yield comparing to local variety/farmers practice was highest in 2020-21 (50.6%) and lowest in 2019-20 (40.2 %). The average demonstrated yield during five years was 11.88 q/ha as compared to farmers yield of 8.14 q/ha. On an average, the yield of demonstrated plot of black gram was 46.04 % superior to the farmers plot during five years. The difference in yield or yield gap between demonstrated crop and farmers practice plot was clearly due to adoption of improved variety of black gram (WBU 109) as well as due to improved package of practices including sowing methods, seed rate, seed treatment, balance fertilizer application and proper plant protection measures. The non-uniform yield pattern in different years as shown in the Table 3. The yield superiority of demonstrated plot is in conformity with Saikia *et al.*, (2018). Similar result was also observed by Dubey *et al.*, (2010) and Hiremath and Nagaraju. (2009).

Technology Gap : The observed technology gap has been presented in Table-3. The data of demonstrated yield and potential yield shows that technology gap during the different years varies from 0.8 q/ha to 1.5 q/ha. On an average the technology gap for the demonstrated lack gram was 1.12 q/ha which may be due to less difference between potential yield and demonstrated yield. Variation in climatic conditions over the different years resulted in variation in yield attributing characters and impacting the yield and economic parameters of demonstrated plot as well as of farmers practice plot. This reflected in variation in technology gap over the years marginally. Similar findings were also recorded by Katare *et al.* (2011) and Sharma and Sharma (2004).

Extension Gap (Q/ha) : The data in respect of extension gap during different years as given in Table No.3. During the demonstration period of 2016-17 to 2020-21 the extension gap varied from 3.5 q/ha to 4.0 q/ha between demonstrated and farmers practice plots. The low value of extension gap clearly indicates farmer support and involvement in carrying out these demonstrations. The support and involvement of farmers in demonstration of black gram was due to training and frequent visit of scientist to farmers field along with field day organised by Krishi Vigyan Kendra. The result is in conformity with Bairwa *et al.*, (2013).

Technology Index : The calculated data of technology index is clearly on lower side and varied from 6.1 % to 11.5 % during the demonstration period of five years (2016-17 to 2020-21) has been depicted in Table 3. This indicates the increased feasibility of technology on location specific farming situation. Since technology index is influenced by technology gap and potential yield so lower value of technology gap resulted in lower value of index indicating

Table-2 : Difference between technological intervention and farmer's practices under CFLD on Blackgram.

Particulars	Technological Intervention in CFLD	Farmers Practices	Gap
Variety	WBU – 109	Local/own seed	Full gap
Seed rate	20 kg/ha	40 kg/ha	High Seed rate
Sowing method/spacing	Line sowing , Row to row- 30 cm Plant to plant – 15 cm	Broadcasting uneven plant population	Partial gap
Time of sowing	20-30 june	10 20 july	Partial gap
Seed treatment	Seed treatment was done with 2.0 gm of Carbendazim per kg seed, and with Rhizobium culture + PSB @ 2 packet each for 10 kg seed. 5ml imidachlorpid per kg seed for sucking pests.	No seed treatment	Full gap
Fertilizer	Balanced fertilizer application as per soil test values, 112 kg DAP, 12 kg Urea and 40 kg/ha MOP.	Imbalanced use of fertilizer 50 kg urea as top dressing and 50 kg of DAP as basal dose /ha	Full gap
Weed management	Application of Fluchloralin 1.25 lit. ha-1 as pre – emergence + 1 hand weeding at 30 DAS	Manual weeding at 35 – 40 DAS	Full gap
Plant Protection	Dichlorovas 1.0 lt/ha spray of insecticide to control pod borer at 75 % flowering and pod filling stage	Injudicious use of insecticides and fungicides based on advice of input dealers	Partial gap with high cost

Table-3 : Grain Yield and Gap analysis of cluster frontline demonstration on Blackgram.

Year	Sample Area (ha)	Sample No. of Farmers	Average Yield (q/ha)			% increase over FP	Technology Gap (q/ha)	Extension gap (q/ha)	Technology Index (%) CFLD
			Potential	CFLD	FP				
2016-17	20.0	50	13.0	12.0	8.1	48.1	1.0	3.9	7.6
2017-18	20.0	48	13.0	11.8	8.2	43.9	1.2	3.6	9.2
2018-19	10.0	27	13.0	11.5	7.8	47.4	1.5	3.7	11.5
2019-20	10.0	31	13.0	12.2	8.7	40.2	0.8	3.5	6.1
2020-21	10.0	31	13.0	11.9	7.9	50.6	1.1	4.0	8.4
Average	70.0 (total)	187 (total)	13.0	11.88	8.14	46.04	1.12	3.74	

Table-4 : Economic analysis of the cluster frontline demonstration on Blackgram.

Year	Total return (Rs per ha)		Input Cost (Rs. Per ha)		Net Return (Rs per ha)		Additional return (Rs per ha) CFLD	B : C ratio	
	Recomm ended Practice (RP)	Farmer's Practice (FP)	Recomm ended Practice (RP)	Farmer's Practice (FP)	Recomm ended Practice (RP)	Farmer's Practice (FP)		Recomm ended Practice (RP)	Farmer's Practice (FP)
2016-17	66,000	44,550	28,500	25,800	37,500	18,750	21,450	2.31	1.72
2017-18	64,900	45,100	27,900	26,100	37,000	19,000	19,800	2.32	1.72
2018-19	64,400	43,680	29,200	25,700	35,200	17,980	20,720	2.20	1.69
2019-20	68,320	48,720	30,100	26,800	38,220	21,920	19,600	2.26	1.81
2020-21	67,830	45,030	30,200	27,100	37,630	17,930	22,800	2.24	1.66
Average	66,290	45,416	29,180	26,300	37,110	19,116	20,874	2.26	1.72

Note : Price of Black gram @ Rs.5500/qt in 2016-17 & 2017-18, Rs.5600/q in 2018-19 and 2029-20 and Rs.5700/qt in 2020-21.

more feasibility of provided technology on farmers field. Similar results is also found by Dhaka *et al.*, (2015) and Tomar *et al.*, (2003)

Economics of CFLD : Based on local inputs and labour cost, significantly higher additional return of demonstrated plot over farmers practice was achieved which varied from Rs. 19,600/ha to Rs. 22,800/ha. On an average the total return and net return was Rs. 66,290/ha and Rs.

37,110/ha respectively, during five years which was much higher than farmers practice of Rs. 45,416 and Rs.19,116 respectively, for same period. On an average benefit cost ratio for demonstrated plot and farmers practice plot was 2.26 and 1.72 respectively. The gross return of black gram was calculated on local market rate of black gram lifted by merchants from farmers field, which varied from Rs. 55/kg to Rs. 57/kg over the different years. which has

been shown in table 4. Here the quality of black gram grains under CFLD has been assumed at par with farmers practice produce plots. The result is similar to Chakrawarty *et al.*, (2017), Meena *et al.*, (2012), Prasad *et al.*, (2017) and Jha *et al.*, (2020).

Conclusion

The above finding of CFLD on black gram may be concluded in the way that technology gap can be minimised to a considerable extent by adopting improved variety and scientific package of practices along with proper training of farmers. The productivity and profitability can be enhanced by bringing down extension gap through full involvement of farmers in the demonstration process in form of training, group discussion etc. It may be concluded that cluster demonstration in a scientific way plays a vital role in convincing farmers to adopt the improved technology. The demonstration enhances the knowledge of farmers in regard to improved variety, improved package of practices and timely agricultural operations in the crop. All the indicators like yield of black gram, technology gap, extension gap and technology index evaluated in this demonstration clearly indicates the enhanced productivity and profitability of black gram in the district and contributing to great extent in overall pulse production of the district.

References

1. Bairwa R.K.; Verma S.R.; Chayal K.; and Meena N.L. (2013). Popularization of improved blackgram production technology through front line demonstration in humid southern plain of Rajasthan. *Indian Journal of Extension Education and RD*. 21 : 97-101.
2. Das Mamoni.; Puzari N. N.; and Ray B.K. (2010). Impact of training of skill and knowledge development of rural women. *Agricultural Extension Review*. 1 (1) : 29-30.
3. Dhaka B.L.; Poonia M.K.; Meena B.S.; and Bairwa R.K. (2015). Yield and economic viability of coriander under front line demonstration in Bundi district of Rajasthan. *J. Hortl. Sci*. 10 (2): 226-228.
4. Dubey S.; Tripathi S.; Singh P.; and Sharma R.K. (2010). Yield gap analysis of blackgram production through frontline demonstration. *J. Prog. Agric*. 1 (1): 42-44.
5. Hiremath S.M.; and Nagaraju M.V. (2010). Evaluation of on front line demonstrations on the yield of chilli. *Karnataka J. Agric. Sci*. 23 (2):341-342.
6. Islam M.; Mohanty A.K.; and Kumar S. (2011). Corelation growth yield and adoption of urdbean technologies . *Indian Research Journal of Extension Education*. 11(2) : 20-24.
7. Jha Amrit Kumar.; Chatterjee Kaushik.; Mehta Birendra Kumar. and Kumari Maya. (2020). Assessment of technological interventions on productivity and profitability of chickpea through cluster front line demonstration in Sahibganj district of Jharkhand. *International Journal of Advanced Biological Research*. 10 (4) : 213-217
8. Katore S.; Pandey S.K.; and Mustaafta M. (2011). Yield gap analysis of rapeseed - mustard through front line demonstrations. *Agric. Update*. 6: 5-7.
9. Mitnala Jayalakshmi.; Babu G. Prasad.; Chowdhary K. Ragavendra.; Vijayabhinandana B.; and Subba Rao M. (2018). Impact of cluster front line demonstrations (CFLD) on pulse production productivity, profitability and transfer of technologies in Kurnool District of Andhra Pradesh, India. *Int. J. Curr. Microbial. App. Sci*. 7(12): 937-947.
10. Poonia T.C.; and Pithia M.S. (2011). Impact of frontline demonstrations of chickpea in Gujrat. *Legume Research*. 34(4) : 304-307.
11. Prasad Devkant.; Singh Srikant.; Kumar Sunil. and Kumar Madhukar (2017). Assessment of package demonstration under chickpea in Garhwa district of Jharkhand. *Progressive Research—An International journal*. 12 (special-1) : 1311-1313.
12. Sahu Premal.; Chandravanshi S.S.; Paikara Panduram.; Sinha Amit.; and Verma Shakti. (2021). Influence of cluster front line demonstrations (CFLD) on blackgram productivity, profitability and transfer of technologies in Dhamtari district of Chhattisgarh, India. *The Pharma Innovation Journal*. Sp-10(5): 713-715.
13. Saikia Nabadeep.; Nath Kapildeb.; and Chowdhuri Pulakabha. (2018). Impact of cluster front line demonstration on popularization of blackgram var. PU 31 in Cachar district of Barak valley region of Assam. *Journal of Pharmacognosy and Phytochemistry*. 7 (4) : 940 – 942.
14. Samui S.K.; Maitra S.; Roy D.K.; Mandal A.K.; and Saha D. (2000). Evaluation of front line demonstration on groundnut. *J.Indian Soc. Coastal Agri. Res*.18 (2): 180-183.
15. Sharma R.N.; and Sharma K.C. (2004). Evaluation of frontline demonstration trials on oilseeds in Baran district of Rajasthan. *Madhya J. Exten. Edu*. 7: 72-75.
16. Singh Narendra.; and Singh Aditya Kumar. (2020). Yield gap and economics of cluster frontline demonstrations (CFLD) on pulses under rain-fed condition of Bundelkhand in Uttar Pradesh. *International Journal of Advanced Research in Biological Sciences*. 7(8): 1-7.
17. Tomer L.S.; Sharma B.P.; and Joshi K. (2003). Impact of front line demonstration of soyabean in transfer of improved technology. *J. Ext. Edu*. 22(1) : 390-420.
18. Yadav D.B.; Kamboj B.K.; and Garg R.B. (2004). Increasing the productivity and profitability of sunflower through front line demonstrations in irrigated agro ecosystem of eastern. *Haryana J. Agron*. 20 : 33-35.



Performance Evaluation of Cluster Frontline Demonstration on Sesame (*Sesamum Indicum* L.) in Giridih District of Jharkhand

Devkant Prasad^{1*} and Srikant Singh²

¹Krishi Vigyan Kendra, Giridih (Birsa Agricultural University) Jharkhand, India

²Krishi Vigyan Kendra, Pakur (Birsa Agricultural University) Jharkhand, India

*Corresponding author Email : drprasaddevkant@gmail.com

Abstract

The Cluster Front Line Demonstration (CFLD) on sesame was carried out by 207 farmers on an area of 80 ha over the period of five years (2016-17 to 2020-21). The individual plots selected were of the size of 0.5 to 1.5 acre per farmer. The technology demonstrated was variety 'subhra' with full package of practice including recommended dose of fertiliser (40:30:20 NPK, Kg/ha) with plant protection as per requirement. The average yield during five years was 5.06 q/ha which was 47.5 % more than farmers check yield. The average value of technology gap, extension gap and technology index were 2.4 q/ha, 1.6 q/ha and 32.5 % respectively. Average net return and benefit cost ratio were Rs.21,480/ha and 2.54 respectively over the period of five years which were far better than farmers practice net return of Rs.11,560/ha and benefit cost ratio of 1.9. This could be due to good management of demonstration plots with introduction of new variety and adopting improved package of practices.

Key words : Yield, technology gap, extension gap, technology index, CFLD and economics.

Introduction

Sesame (*Sesamum indicum* L.,) popularly known as til in many parts of India and apart from high oil content it is widely used in sweet dishes known as Tilkut, rewadi etc. in many parts of India in general and Jharkhand in particular. India ranks first in the world with 19.50 lakh ha sown area and 8.50 lakh tonnes production. It is a versatile crop and the average yield of sesame (436 kg/ha) in India is low as compared with other country in the world (535 kg /ha) (Anonymous, 2015). It is having the highest oil content (46-64 %) and rich in beneficial properties due to their high content of proteins, minerals and vitamins.

Sesame is important oilseed crop in Jharkhand mostly grown in Kharif season and in some parts in summer season too. Farmers of this region grow sesame mainly for its use in festivals and special occasions like marriages etc. and are emotionally attached to it.

Sesame adds beneficials residue within the whole soil profile, resulting in improved tillage and in a crop rotation reduces nematodes in the soil. As a drought and heat tolerant crop, it has the ability to retain a relatively high level of hydration under conditions of soil/atmospheric water stress. Under the changing climate scenario with low monsoon precipitation it becomes necessary to develop mechanism for reaching out and demonstrating the improved technology under the farming conditions of Giridih district, the Govt. of India has devised a programme to promote the oilseed cultivation in cluster mode under National Food Security Mission through KVKs. The main objective of CFLD is to demonstrate

production technology and its management practices on farmers field under different farming situations. These demonstrations are carried out under supervision of agricultural scientists and feedbacks from the different farmers have to be generated for the demonstrated technology, keeping the importance of Cluster Front Line Demonstration (CFLD) the KVK , Giridih conducted demonstrations on sesame at farmer's field. The present study has been undertaken to increase the per capita availability of oilseed and popularization of new production technology amongst the farming community for sesame crop.

Materials and Methods

The study was carried out during kharif season from 2016-17 to 2020-21 (five years) by KVK Giridih of Jharkhand. The demonstration were conducted in farmer's field of 10 different villages of Giridih District in agroclimatic zone -IV of Jharkhand. During these five years of study a total numbers of 50, 51, 25, 26 and 55 beneficiaries were selected in 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21 respectively for this project. Farmers were trained to follow the package and practices for sesame cultivation as recommended by the Birsa Agricultural University and need based inputs were provided to the beneficiaries (Table-1). The farmers followed the full package of practices like soil testing, seed treatment with fungicide and bio-fertilizer, recommended fertilizer application, weed management, Integrated pest management (IPM) practices etc. In case of local check, the traditional practices were followed by using existing varieties. An area of 80 hectare was covered under cluster

front line demonstration with active participation of 207 farmers. Before conducting CFLDs, a list of farmer was prepared from group meeting and specific skill training was imparted to the selected farmers.

In general, the soil of the Demonstration plot sites were sandy loams in texture, acidic in reaction (pH 5.0 – 5.3), low to medium in organic carbon (0.4 – 0.6 %) and low in available nitrogen (185.4 – 211.5 kg N/ha), low in available phosphorus (7.6 – 9.6 kg P₂O₅/ha) and low in available potassium (85.7 – 111 kg K₂O/ha) shown in Table-1.

In demonstration plots, use of quality seeds of improved varieties (Subhra), line sowing and timely weeding, need based pesticide as well as balanced fertilizer were emphasized and comparison has been made with the existing practices shown in Table-2. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale. The beneficiaries under the programme were facilitated by KVK Scientists in performing field operations like sowing, spraying, weeding, harvesting etc. during the course of training and visits. The traditional practices were maintained in case of local checks. The data were collected from both CFLD plot as well as control plots by random crop cutting method and analysed by using simple statistical tools. The technology gap and technological index (Yadav *et al.*, 2004) along with the benefit cost ratio (Samui *et al.*, 2000) were calculated by using following formula as given below.

Technology Gap = Potential yield – Demonstration yield

Extension Gap = Demonstration yield – Farmer's Practice yield

Technology Index = $\frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$

Additional Return = Demonstration Return - Farmer's Practice Return

Percentage increase in yield

= $\frac{\text{Demonstration yield} - \text{Farmers Practice yield}}{\text{Farmer's Potential yield}} \times 100$

Table-1 : Soil nutrient status of the demonstration plot.

Soil test report	Demonstration plot
PH	5.0 – 5.3
Ec (dS m ⁻¹)	1.10 – 1.17
Available N (Kg ha ⁻¹)	185.4 – 211.5
Available P ₂ O ₅ (Kg ha ⁻¹)	7.8 – 9.6
Available K ₂ O (Kg ha ⁻¹)	85.7 – 111
Organic Carbon (%)	0.4 – 0.6

Results and Discussion

The yield data of five years under cluster frontline demonstration on sesame over the area of 80 ha (in 5 years) shows significant yield increase over farmers

practice to the tune of 47.5%. The average productivity of sesame was 5.06 q/ha during the period of 2016-17 to 2020-21. This yield increase over farmers practice was clearly due to improved variety and improved package of practices given on farmer's field. The non-uniform yield pattern in different years as shown in the Table-3. may be due to climatic variations particularly rainfall and average temperature during the crop period. Highest yield was obtained during 2018-19 (5.6 q/hq) and lowest yield was found during 2019-20 (4.5 q/ha). Similar result was obtained by Tripathi and Rajput (2007) and Khan *et al* (2009).

Technology Gap (Q/ha) : The observed technology gap has been presented in Table-3. The low value of technology gap in some of the years is due to constraints delay in sowing time and moisture stress. To overcome the technology gap location specific agricultural activities are highly required apart from technology provided in the demonstration. Technology gap for the sesame under Cluster Front Line Demonstration (CFLD) varied from 1.9 q/ha to 3.0 q/ha. The lower value of technology gap shows that demonstrated yield was not much below the potential yield due to technology provided in the form of improved variety and package of practices. The variation of technology gap during different years may be due to varied microclimatic conditions. The result is in conformity with the finding of Jain 2016, Kumar *et al* (2018) and Meena *et al* (2018).

Extension Gap : The data in respect of extension gap during different years as given in Table No.3. Extension gap varied from 1.1 q/ha to 2.0 q/ha over the period of five years. The low value of extension gap indicates that both farmers and scientist have co-operated each other nicely in successful conduction of the demonstration in farmers field. On an average the extension gap was 1.6 q/ha during the period of 2016-17 to 2020-21. This value of extension gap is average of 207 farmers over an area of 80 ha. The higher extension gap in the year 2018-18 (2.0 q/ha) may be due to delay in sowing time and weather variations in respect of rainfall and average temperature during the crop period. The result is similar to that of Sandhu and Dhaliwal (2016), Samui *et al* (2000) and Singh *et al* (2019).

Technology Index : The technology index for the year 2016-17 to 2020-21 has been depicted in Table 3. Technology index is the technology gap expressed per unit of potential yield obtained by efficient utilisation of technology provided to the farmer's field. It depends upon various factors which may be biotic or abiotic. Sesame is a water sensitive crop due to which single day heavy rainfall (stagnation of water in the field) may have adverse effect on productivity of crop by influencing the technology

Table-2 : Difference between technological intervention and farmer's practices under CFLD on Sesame.

Particulars	Technological Intervention in CFLD	Farmers Practices	Gap
Variety	Subhra	Local/own seed	Full gap
Seed rate	5 kg/ha	8-10 kg/ha	High Seed rate
Sowing method/spacing	Line sowing : Spacing Row to Row – 30 cm Plant to Plant – 15 cm	Broadcasting uneven plant population	Partial gap
Time of sowing	12-18 July	25-30 July	Partial gap
Seed treatment	Seed treatment was done with 2.5 gm of Carbendazim.	No seed treatment	Full gap
Fertilizer	Balanced fertilizer application as per soil test values, 52 kg/ha urea 88 kg/ha DAP and 35 kg/ha MOP.	Imbalanced use of fertilizer 50 kg urea as top dressing and 50 kg of DAP as basal dose /ha	Full gap
Weed management	Application of oxadiazon @ 1.25 lit. ha ⁻¹ as pre – emergence + 1 HW	Manual weeding at 35 – 40 DAS	Full gap
Plant Protection	Spray of insecticide as per nature of insects at 75 % flowering and pod filling stage	Injudicious use of insecticides and fungicides based on advice of input dealers	Partial gap with high cost

Table-3 : Grain yield and gap analysis of cluster frontline demonstration on sesame.

Year	Sample Area (ha)	Sample No. of Farmers	Average Yield (q/ha)			% increase over FP	Technology Gap (q/ha)	Extension gap (q/ha)	Technology Index (%) CFLD
			Potential	CFLD	FP				
2016-17	20.0	50	7.5	4.8	3.0	60.0	2.7	1.8	36.0
2017-18	20.0	51	7.5	5.5	3.7	48.6	2.0	1.8	26.6
2018-19	10.0	25	7.5	5.6	3.6	55.5	1.9	2.0	25.3
2019-20	10.0	26	7.5	4.5	3.4	41.17	3.0	1.1	40.0
2020-21	20.0	55	7.5	4.9	3.4	32.3	2.6	1.5	34.6
Average	80.0	207	7.5	5.06	3.42	47.5	2.4	1.6	32.5

Table-4 : Economic analysis of the cluster frontline demonstration on Blackgram.

Year	Total return (Rs. per ha)		Input Cost (Rs. Per ha)		Net Return (Rs. per ha)		Additional return (Rs per ha) CFLD	B : C ratio	
	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)		Recommended Practice (RP)	Farmer's Practice (FP)
2016-17	33600	21000	13000	11200	20600	9800	14600	2.58	1.87
2017-18	38500	25900	13700	12800	24800	13100	8600	2.81	2.02
2018-19	39200	25200	14000	12500	25200	12300	14000	2.80	1.95
2019-20	31500	23800	14000	12500	17500	11300	7700	2.25	1.90
2020-21	34300	23800	15000	12500	19300	11300	10500	2.28	1.90
Average	35420	23940	13940	12380	21480	11560	11080	2.54	1.92

Note : Price of sesame seed@ Rs.70/kg

index. It varied from 25.3 % to 40 % with an average of 32.5 % over the period of five years. Lower values of technology index indicates the feasibility of technology provided on the farmers field and demands immediate attention of extension workers and scientist to fill the technology gap as well as extension gap with concentrated efforts. Timely agricultural operations with full package of demonstrated technology may work well in increasing the productivity of sesamum. Similar findings were reported by Prasad *et al* (2017), Tomar *et al* (2003) and Kumar *et al* (2013).

Economics : Total return obtained from sesamum crop varied from Rs. 31,500/ha to Rs. 39,200/ha return average of Rs 35,420/ha. which has been shown in table-4. This is significant higher value than that of farmers practice (Rs. 23,940 /ha). This is due to higher yield of sesamum in recommended practice than the yield of farmer practice. The data from the Table 4 clearly shows much higher average net return (Rs. 21,480/ha) in recommended practice than the net return (Rs.11,560 /ha) of farmers practice. The variation in net return during different years in both recommended practice and farmers

practice is due to variation in yield as shown in Table 3. Similar result has been found by Kumar *et al* (2020), Meena *et al* (2018) and Sagar *et al* (2004). The absolute additional return under Cluster Front Line Demonstration (CFLD) varied from Rs. 7,700/ha to Rs. 14,600 /ha with on an average of Rs. 11,080/ha over the period of five years (2016-17 to 2020-21). The benefit cost ratio of Cluster Front Line Demonstration (CFLD) varied from 2.25 to 2.81 during five years as shown in the given Table 2. The benefit cost ratio of the farmers practice varied from 1.87 to 2.02 with an average of 1.92 over the five years. This is clearly a significant value of B:C ratio over farmers practice during different years. The higher value of total return, net return, additional return and benefit cost ratio shows the successful outcome of the Cluster Front Line Demonstration (CFLD). Similar economic output has been reported by Singh *et al* (2019), Khan *et al* (2009) and Khaleque and Begum (1991).

Conclusion

From the above findings it can be concluded that if Cluster Front Line Demonstration (CFLD) is conducted with proper norms and guidelines taking suitable technology the desirable outcome in the form of higher productivity and profitability can easily be achieved. The present study was an eye opener for all the stakeholders in the district. Technology gap and extension gap were minimised and farmers could see the result of demonstration in respect to higher yield and higher return. Such demonstration may contribute the significant oilseed production in the district as well as horizontal spread of oilseed area in the district.

References

1. Kumar, Shailesh., Tiwari, R.K., Kumar, Sanjay., Kumar, Ranjan., Ghosh, Sanchita., Upadhaya, Bharti., Rani, Nisha., and Choudhary, Vidyapati. (2020). Performance evaluation of Cluster Front Lin Demonstration programme on sesame in Samastipur district, Bihar, India. *International Journal of Current Microbiology and Applied Sciences* . 9(5): 316-320.
2. Jain, L.K. (2016). Impact assessment of front line demonstrations on green gram in Barmer district of western Rajasthan. *Journal of Food Legumes*. 29(3&4): 249-252.
3. Kumar, S., Tiwari, R.K., Asthana, R.K., and Kumar, Shailesh. (2018). Evaluation of different cultivars of lentil under Cluster Front Lin Demonstration programme in Samastipur district, Bihar. *Journal of Community Mobilization and Sustainable Development*. 13(2): 271 – 274.
4. Meena, Ram. Kishan., Singh, Bacchu., Meena, K.C., Meena, R.K., Singh, B., and Gurjar, Prakash. (2018). Performance of front line demonstration on sesame in Karauli, District of Rajasthan, India. *International Journal of Current Microbiology and Applied Sciences*. 7(3) : 1507-1511.
5. Sagar, R.L. and Chandra, G. (2004). Front line demonstration on sesame in West Bengal. *Agricultural Extension Review*. Pp 7-10 .
6. Samui, S.K., Maitra, S., Roy, D.K., Mondal, A.K., and Saha, D. (2000). Evaluation of front line demonstration programme on groundnut (*Arachis hypogea* L.). *Journal of Indian Society of Coastal Agriculture Research*. 18 (2): 180-183.
7. Sandhu, B.S. and Dhaliwal, N.S. (2016). Evaluation of front line demonstration programme on summer moong in South Western Punjab. *Journal of Food Legumes*. 29(3&4): 245-248.
8. Singh, K.M., Singh, L.B., and Gautam, U.S. (2019). Cluster Front Line Demonstration an effective tool for spreading the advance technology of sesame among the farmers. *The Journal of Rural and Agricultural Research*. 19(1): 10-14.
9. Khaleque, M.A and Begum, D. (1991). Area and production of oilseed crops 1988-90. In fifteen years of oilseed research and development in Bangladesh. AST/CIDA 28:190
10. Khan, M.A.H., Sultana, N.A ., Islam M.N. and Hasanuzzaman, M (2009). Yield and yield contributing of sesame as affected by different management practices. *American – Eurasian Journal of Scientific Research*. 4(3) : 195-197.
11. Tripathi, M.L and Rajput, R.L. (2007). Response of sesame (*Sesamum Indicum*) genotypes to levels of fertilizers. *Advances in Plant Sciences* 20: 521-522.
12. Tomer, L. S., Sharma, B. P. and Joshi, K. 2003. Impact of front line demonstration of soybean in transfer of improved technology. *J. Ext. Edu*. 22: 130.
13. Kumar, Pramod, Kumar, Rakesh and Sewainya, Kumar Sanat 2013. On-Farm Evaluation of Front Line Demonstrations on the yield of mustard in West Singhbhum district of Jharkhand. *Indian Journal of Social Research* 54(5): 417-422.
14. Prasad, Devkant., Singh, Srikant. and Kumar, Madhukar (2017). Evaluation of Front Line Demonstration on Mustard (*Brassica Juncea* L.) in Garhwa District of Jharkhand. *Progressive Research – An International Journal*. 12 (special-1) : 1314-1316.



Changes in Physico-Chemical and Biological Properties of Soil under Conservation Agriculture Based Pearl Millet-Wheat Cropping System

Dhinu Yadav*, Rohit Rana¹, Leela Wati and Prashun Sachan²

Department of Microbiology, CCS Haryana Agricultural University, Hisar

¹Department of Entomology, R.K. (PG) College, Shamli, UP

²Department of Agronomy, CSA University of Agriculture and Technology, Kanpur-208002

*Corresponding author Email : drdhinu@gmail.com

Abstract

Conservation agriculture (CA)-based crop management practices may increase crop productivity and yield while conserving and sustaining natural resources. In the present study, the effect of long-term zero-tillage practices on selected physico-chemical properties and microbiological properties was determined in pearl millet-wheat system at 0-15 and 15-30 cm soil depth in Rewari district of Haryana (latitude- 28.10°N and longitude- 76.50°E) during the year 2014. The texture of soil samples collected from conventional and zero-tillage cultivated farms was sandy. After harvesting of wheat in 2017, triplicate soil samples from undisturbed and disturbed soil were obtained for determination of pH, electrical conductivity (EC), available N, P, K and S content and enzymatic activities and results showed that EC and pH were not significantly affected by tillage systems. The long-term zero-tillage practices resulted that relatively higher soil available nitrogen, phosphorous, potassium and sulphur contents, dehydrogenase, alkaline phosphatase, cellulase and urease activities at the 0-15 cm depth than conventional tillage. These results indicated that the zero-tillage system under pearl millet-wheat crop-rotation and soil depth were two important factors affecting soil microbial activity. The zero-tillage practices improved physico-chemical as well as microbiological properties of soil that may lead to enhanced crop yield.

Key words : Crop-rotation, microbiological properties, soil health and zero-tillage.

Introduction

Pearl millet (*Pennisetum glaucum* L.) is the fifth largest cereal crop and the largest millet, accounting for over 55 per cent of global millet production. It is grown in more than 40 countries, primarily in Africa and Asia, as a staple diet for the vast majority of poor farmers and is also an important feed crop for livestock in arid and semi-arid regions of the globe (Vetriventhan *et al.*, 2008). It is nutritionally better than many bowls of cereal from a quality standpoint, as it is a good source of iron, protein and fat (Jukanti *et al.*, 2016). Although some crops have the potential to contribute to food security, nutrition, dietary and culinary diversification, health and income generation (Sandeep *et al.*, 2020). Because of its remarkable ability to withstand and grow in the harsh environment, this crop is mostly confined to low fertile water deficit soils obtaining fair and almost assured harvests. Consequently, due to increased evidence of irregular seasonal rainfall, terminal heat and regular incidence of extreme weather events combined with limited water supplies, greater attention is paid to (Singh *et al.*, 2010).

Soil tillage is one of the main factors which affect soil properties and crop yield. Tillage contributes up to 20 per cent of the factors of crop production (Khurshid *et al.*, 2006) and affects the sustainable use of soil resources by

affecting soil properties (Lal and Stewart, 2013). The judicious use of tillage practices overcomes edaphic constraints, while inopportune tillage can lead to a number of unwanted effects, such as destruction of soil structures, accelerated erosion, loss of organic matter and fertility and disruption of water, organic carbon and plant nutrient cycles (Lal, 1993). Reducing tillage positively affects many aspects of the soil while excessive and unnecessary tillage operations result in opposite phenomena harmful to the soil. Therefore currently, there is a significant interest and focus on the change from intense tillage to conservation and zero-tillage methods for the purpose of controlling the erosion process (Iqbal *et al.*, 2005). Traditional tillage methods, such as organic tillage, induce soil structure changes by altering soil bulk density and soil moisture. Therefore, repeated disruption from traditional tillage gives birth to a finer and loose-setting soil structure while conservation and zero-tillage methods leave the soil intact (Rashidi and Keshavarzpour, 2007), which can lead to improved soil health, soil composition, crop productivity, and yield.

Materials and Methods

Study site and soil sampling : The study site was located at CCSHAU, Regional Research Station, Bawal, District-Rewari (Haryana) and zero-tilled and conventionally tilled plots were established in 2014. The

soil samples collected during 2017 after wheat harvest from surface and subsurface soil profile from five random spots/tillage plots were sieved through 2 mm sieve and stored at 4 ± 1 C. For determination of microbial activities, the soil was moistened to 60 % water holding capacity (WHC) and incubated at 30° C for 10 days to permit uniform rewetting and allow the microbial activity to equilibrate after the initial disturbances. Sub-samples were air-dried and ground for chemical analysis.

Characterization of Soil Physical and Chemical Properties

Electrical conductivity, soil pH : To measure the EC and pH of different soil samples, five-gram soil was mixed with 12.5 ml of distilled water. It was shaken for 30 minutes and EC was measured with Naina electrical conductivity meter and pH of soil suspension was measured at room temperature with Systronics 331 pH meter.

Available N, P, K and S : Available N, P, K and S in soil were determined by micro-kjeldahl method (Subbiah and Asija, 1956), Olsen *et al.* (1954), Jackson, 1967 and Chesin and Yien (1951).

Soil enzyme activities : Soil enzymatic activities viz. dehydrogenase, alkaline phosphatase, cellulase and urease activities were determined by the method of Casida *et al.* (1964), Tabatabai and Bremner (1969), Deng and Tabatabai (1995) and Tabatabai and Bremner (1972).

Statistical analysis : The significance of treatment effects was analyzed by using two factorial RBD analysis and OP Stat software, at CCS HAU, Hisar.

Results and Discussion

EC and pH : All the soil samples were non-saline as the EC of soils at different spots/depths was lower than the critical limit of 0.8 dS m^{-1} . EC of soils under conventional-tillage was 0.14 dS m^{-1} at 0-15 cm depth and 0.12 dS m^{-1} at 15-30 cm depth whereas under zero-tillage, respective values were 0.15 and 0.13 dS m^{-1} at 0-15 and 15-30 cm depth. On comparing tillage system, it was observed that EC of soil under pearl millet-wheat rotation was comparatively lower under CTW-CTPM than ZTW-ZTPM (Fig.-1).

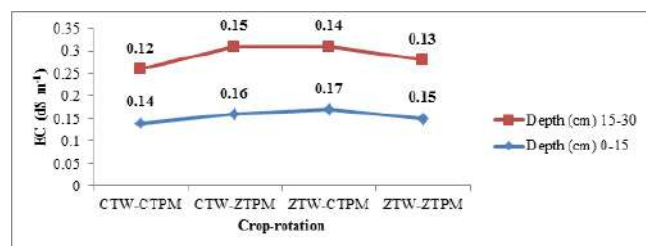
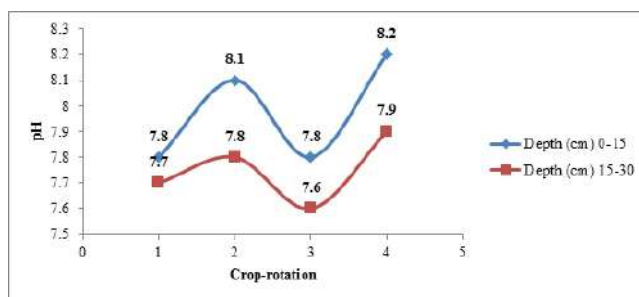


Fig.-1 : Effect of conventional and zero tillage on soil EC.

Various chemical properties of soil under pearl millet-wheat cropping systems were studied to find the impact of conservation tillage. In the present study, the effect of tillage on EC was non-significant under pearl millet-wheat cropping system at different depths. Kumar *et al.* (2018) found decreased soil EC under CT that might be due to opening and aeration of the topsoil layers which allowed increased leaching to occur at surface soil.

The pH of soil samples varied between 7.8 to 8.2 under pearl millet-wheat cropping system with the values ranging between 7.8-8.2 at 0-15 cm depth and 7.6-7.9 at 15-30 cm depth under two tillage systems. Effect of tillage systems on pH and EC was however non-significant. In the present study, not many differences were found in pH of soil under CT and ZT at 0-15 and 15-30 cm depth (Fig.-2). Similar results have been reported by other researchers. Asenso *et al.* (2018) reported no significant difference on soil pH at 0–40 cm depth under zero-tillage that might be due to the fact that no liming material was App. as part of treatment. In contrast, Kumar *et al.* (2018) reported that significant effect of tillage on soil pH and higher pH was recorded in zero tillage at surface layer compared to conventional tillage system, this might be due to the fact that the experiment was compared for several years as a part of long term on dryland agriculture. Tillage may not directly affect soil pH but its effects on pH will depend on the prevailing climatic condition, soil type and management factors. The sandy texture, as well as climatic conditions under present study, authenticates our results.



1= CTW-CTPM, 2= CTW-ZTPM, 3= ZTW-CTPM, 4= ZTW-ZTPM
Fig.-2 : Effect of conventional and zero tillage on soil pH.

Available N, P, K and S : The results of this investigation regarding primary (N, P, K and S) nutrients affected by different type of tillage practices are presented in Fig. 3. Zero tillage was found to be beneficial for producing the highest available nitrogen, phosphorus, potassium and sulphur in the soil. In general, across the tillage management practices, all these primary nutrients in the 0-15 cm depth were higher than the 15-30 cm depth. This indicated a stratification of crop residues and organic matter in the surface depth under ZT. The data on

available N, P, K and S presented in Fig. 3 revealed that the values were comparatively higher in the surface layer as compared to the subsurface layer under CT as well as ZT. The available N, P, K and S contents were relatively higher under ZTW-ZTPM at surface layer with values 127, 8.1, 132 and 3.4 kg ha⁻¹ and 118, 7.5, 122 and 3.1 kg ha⁻¹ at subsurface layer, while the lower respective values on the adoption of CTW-CTPM practice were 121, 7.6, 123 and 3.1 kg ha⁻¹ at surface layer and 111, 6.7, 112 and 2.5 kg ha⁻¹ at subsurface layer. Individually, the effect of tillage and depth on available N, P, K and S content was varied under pearl millet-wheat system but the interaction of tillage and depth was non-significant.

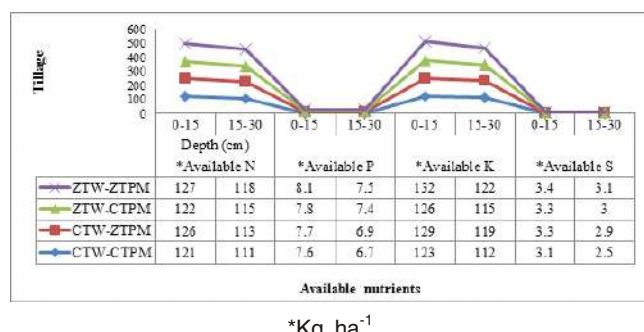


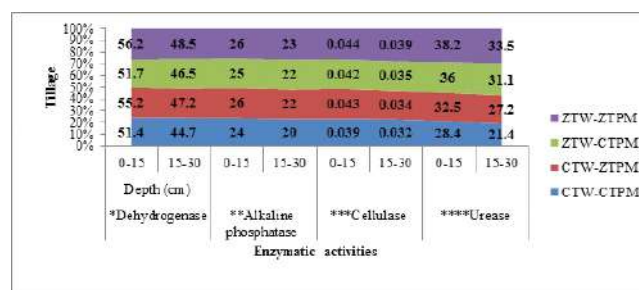
Fig.-3 : Effect of conventional and zero tillage on available N, P, K and S content of soil.

During the present investigation, available N, P, K and S contents were found relatively higher under ZT in sandy textured soil at 0-15 cm depth and similar observations have been reported by different researchers under different systems. ZT reported to accumulate higher nutrients closer to the surface as zero tilled 16 years old wheat experimental plots hoarded greater NO₃-N, SO₄-S, and PO₄-P in upper 2.5 cm than tilled plots (Tracy *et al.*, 1990). ZT recorded significantly higher values of soil phosphorus and potash than that of the ZT (Gangwar *et al.*, 2004; Singh, 2006). According to Gangwar *et al.* (2004) during the initial phase of the tillage experiments, soil available phosphorus and potash were not affected after each crop sequence (Bhatt and Kukal, 2015a). Increasing levels of phosphorus enhanced the growth parameters, yield attributes and yield of crop (Tyagi and Shukla 2020). Higher organic carbon status was reported under zero tilled plots compared to that of the conventionally tilled plots. Thus, under ZT, nutrient availability increased near the soil surface which might be available to the seeds weather it is of economical crop or of the weeds (Bhatt, 2015).

Microbiological properties : Soil management practices and other perturbations of soil system affect the soil microbial processes that are agriculturally and environmentally important. Various microbiological properties of soil under conventional and zero-tillage

systems under pearl millet-wheat crop rotation at RRS, Bawal (Rewari) were determined.

Enzyme activity : Enzymes in the soil are biologically significant as they influence the availability of plant nutrients and all microbial activities are directly related to the different enzymatic activities, which are released extracellularly by various microorganisms or plant roots. In soil, microorganisms, active roots and dead cells are the principal sources of enzymes. Soil enzymatic activity is a sensitive marker of the effect of ecological factors on microbial functions. In the present study, the effect of soil management practices under various crop-rotations at different locations on different enzymatic activities viz. dehydrogenase, alkaline phosphatase, cellulase and urease was studied and activities of various enzymes were also observed higher in 0-15 cm layer as compared to 15-30 cm layer (Fig.-4).



*µg TPF/g soil 24 h⁻¹, **µg PNP/g soil 24 h⁻¹ ***µg glucose/g soil 24 h⁻¹, ****µg NH₄⁺-N /g soil 24 h⁻¹

Fig.-4 : Effect of conventional and zero tillage on soil

Dehydrogenase activity (DHA) reflects the total range of oxidative activity of soil microflora. In the present study, DHA was affected with different tillage practices under pearl millet-wheat cropping system and decreased with depth. DHA activity of sandy textured soil was relatively higher under ZTW-ZTPM system and it has 56.2 and 48.5 µg TPF g⁻¹ soil 24 h⁻¹ at surface and subsurface layer, respectively, while under the conventional tillage system corresponding values were 51.4 and 44.7 µg TPF g⁻¹ soil 24 h⁻¹. Individually, the effect of tillage and depth was significant but the interaction of tillage and depth on DHA was non-significant under pearl millet-wheat system.

Long term impact of conservational tillage affected the alkaline phosphatase activity in the soil. Under conventional tillage system (CTW-CTPM), the value of alkaline phosphatase activity was 24 and 20 µg PNP g⁻¹ soil 24h⁻¹ at the surfaces and subsurface layer, respectively, and increased in a range of 26 and 23 µg PNP g⁻¹ soil 24h⁻¹ at surface and subsurface soil, respectively, by the adoption of zero tillage practices (ZTW-ZTPM). Individually, the effect of tillage and depth and the interaction of tillage and depth on alkaline phosphatase activity were significant.

Cellulase activity was relatively higher in ZTW-ZTPM system which was in a range of 0.044 and 0.039 μg glucose g^{-1} soil 24 h^{-1} , at 0-15 and 15-30 cm depth, respectively, by the adoption of the zero-tillage system and corresponding values were 0.039 to 0.032 μg glucose g^{-1} soil 24 h^{-1} in the conventional-tillage system (CTW-CTPM). Individually, the effect of tillage and depth was significant but the interaction of tillage with depth on cellulase activity was non-significant.

The activity of urease enzyme on the adoption of conventional tillage (CTW-CTPM) was comparatively lower which was in a range of 28.4 and 21.4 μg $\text{NH}_4^+\text{-N}$ released g^{-1} soil 24 h^{-1} at surface and subsurface layer of soil, respectively, which further increased in a range of 38.2 and 33.5 μg $\text{NH}_4^+\text{-N}$ released g^{-1} soil 24 h^{-1} at surface and subsurface soil, respectively, by the adoption of the zero-tillage system (ZTW-ZTPM). Individually, the effect of tillage and depth on urease activity was significant but the interaction of tillage and depth was non-significant (Fig. 4). The effect of tillage and depth on enzymatic activity was significant individually but the interaction of tillage with depth varied (Fig.-4).

Our results are similar with the findings of Janušauskaite et al. (2013) that dehydrogenase activity was highest at 0-10 cm depth under no-tillage might be due to high microbial biomass and nutrient in NT than CT. Similarly, Majchrzak et al. (2016) and Bhaduri et al. (2017) reported a significant impact of tillage systems on DHA that was significantly higher under NT due to accumulation of organic matter and nutrients at the surface soil layer under no-tillage. The reason for higher alkaline phosphatase activity in the surface layer could be due to the high amount of inorganic phosphate released from organic matter under zero-tillage, resulting in higher alkaline phosphatase activity at the surface layer. The results are supported by the findings of that of Acosta-Martinez et al. (2003); Mathew et al. (2012) and Gajda et al. (2013).

The findings of the present study on relatively higher cellulase activity under ZT system are contrary to the observation of Mina et al. (2008) and Bini et al. (2014) that cellulase activity under no-tillage was lower as compared with conventional tillage because of greater inputs of organic matter into the soil due to ploughing and harrowing in CT, which made the organic C pools more prone to microbial and soil enzyme attacks. The results of the present study on urease activity under different systems are similar with the observations of Raiesi and Kabiri (2016) that higher urease activity reported under reduced tillage practices compared with CT practices might be due to high accumulation of soil organic carbon under no-tillage. In contrast, Asenso et al. (2018) found

highest enzyme activities under sub-soiling (SS) treatment compared to ZT treatments because SS treatment loosened the soil and resulted into higher organic C added into the soil, which increased the abundance of soil microorganisms resulting enhanced soil enzyme activities as a result of an increased substrate and oxygen availability.

Conclusion

After five years, different tillage practices showed that they influenced soil chemical and microbiological properties under the pearl millet (*Pennisetum glaucum* L.)-wheat cropping system. ZT with pearl millet biomass and residue incorporation conserved moisture in the soil profile and improved other soil properties. After five years, the chemical properties were also improved due to ZT practices, and the highest available N, P, K, and S content and enzymatic activity were found in zero tillage. Therefore, zero tillage (minimum soil disturbance) with 30% residue retention was found to be suitable to improve soil conditions and to achieve optimum yield under pearl millet (*Pennisetum glaucum* L.) -wheat cropping system in Rewari soil (Haryana).

References

1. Acosta-Martínez V., Zobeck T.M., Gill T.E. and Kennedy A.C. (2003). Enzyme activities and microbial community structure in semiarid agricultural soils. *Biol. Fertil. Soils*, 38(4): 216-227.
2. Asenso E., Li J., Hu L., Issaka F., Tian K., Zhang L., Zang L. and Chen H. (2018). Tillage effects on soil biochemical properties and maize grown in latosolic red soil of southern China. *Hindawi. App. Env. Soil Sci.*, 1-10.
3. Bhatt R., Kukal S.S. (2015a). Soil physical environment as affected by double ZT in rice wheat cropping system of North-West India. *Asian J. Soil Sci.*, 10(1):166-172.
4. Bhatt R. (2015). Soil water dynamics and water productivity of rice-wheat system under different establishment methods. *Dissertation submitted to the Punjab Agricultural University, Ludhiana*.
5. Bhaduri D., Purakayastha T.J., Patra A.K., Singh M., Wilson B.R. (2017). Biological indicators of soil quality in a long-term rice-wheat system on the Indo-Gangetic plain: combined effect of tillage-water-nutrient management. *Env. Earth Sci.*, 76(5):1-14.
6. Bini D., Dos Santos C.A., Bernal L.P.T., Andrade G., Nogueira M.A. (2014). Identifying indicators of C and N cycling in a clayey Ultisol under different tillage and uses in winter. *App. Soil Eco.*, 76: 95-101.
7. Casida L.E., Klein D.A., Santoro R. (1964). Soil dehydrogenase activity. *Soil Sci.*, 98: 371-376.
8. Chesin L., Yien C.H. (1951). Turbidimetric determination of sulfate. *Soil Sci. Society Am. Proc.*, 15: 149-151.
9. Deng S.P. and Tabatabai M.A. (1995). Cellulase activity of soils: Effect of trace elements. *Soil Biol. Biochem.*, 27: 977-979.

10. Gangwar K.S., Singh K.K. and Sharma S.K. (2004). Effects of tillage on growth, yield and nutrient uptake in wheat after rice in Indo-Gangetic Plains of India. *J. Agri. Sci.* 142: 453-459.
11. Gajda A.M., Przew³oka B. and Gawryjo³ek K. (2013). Changes in soil quality associated with tillage system. *App. Inter. Agrophys.* 27(2): 133-141.
12. Iqbal M., Hassan A.U., Ali A. and Rizwanullah M. (2005). Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). *Inter.J. Agri. Biol.* 1: 54-57.
13. Jackson M.L. (1967). Soil chemical analysis: Prentice Hall Inc. Englewood clip, N.J. 129p.
14. Janušauskaite D., Kadpienė G. and Auðkalnienė O. (2013). The Effect of tillage system on soil microbiota in relation to soil structure. *Polish J. Env. Stud.*, 22(5): 1387-1391.
15. Jukanti A.K., Gowda C.L.L., Rai K.N., Manga V.K., Bhatt R.K. (2016). Crops that feed the world Pearl Millet (*Pennisetum glaucum* L.): an important source of food security, nutrition and health in the arid and semi-arid tropics. *Food Secur.*, 8: 307-329.
16. Khurshid, K., Iqbal, M., Arif, M.S. and Nawaz, A. (2006). Effect of tillage and mulch on soil physical properties and growth of maize. *Inter. J. Agri. Biol.*, 8: 593-596.
17. Kumar A., Panda A., Mishra V.N. and Srivastav L.K. (2018). Short-term effect of conservation tillage on carbon pools under rainfed cropping systems of central India. *Int. J. Curr. Micro. App. Sci.*, 7(1): 2040-2053.
18. Lal R. (1993). Tillage effects on soil degradation, soil resilience, soil quality, and sustainability. *Soil Tillage Res.*, 27(1-4): 1-8.
19. Lal R., Stewart B.A., 2013. Eds., Principles of Sustainable Soil Management in Agroecosystems. CRC Press., 20.
20. Majchrzak L, Sawinska Z, Natywa M, Skrzypczak G, G³owicka-Wo³oszyn R. 2016. Impact of different tillage systems on soil dehydrogenase activity and spring wheat infection. *J. Agri. Sci. Tech.*, 18(20): 1871-1881.
21. Mathew R.P., Feng Y., Githinji L., Ankumah R. and Balkcom K.S. (2012). Impact of no-tillage and conventional tillage systems on soil microbial communities. *App. Env. Soil Sci.*, 1-10.
22. Mina B.L., Saha S., Kumar N., Srivastva A.K. and Gupta H.S. (2008). Changes in soil nutrient content and enzymatic activity under conventional and zero-tillage practices in an Indian sandy clay loam soil. *Nutr. Cyc. Agroecosyst.* 82(3): 273-281.
23. Olsen S.R., Cole C.V., Watanbe F.S. and Dean L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U.S. Department of Agricultural Circular. Washington, D.C. 939 p.
24. Tabatabai M.A. and Bremner J.M. (1969). Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biol. Biochem.* 1: 301-307.
25. Tabatabai M.A. and Bremner J.M. (1972). Assay of urease activity in soils. *Soil Biol. Biochem.* 4: 479-487.
26. Tracy P.W., Westfall D.G., Elliott E.T., Peterson G.A. and Cole C.V. (1990). Carbon, nitrogen, phosphorus, and sulfur mineralization in plow and no-till cultivation. *Soil Sci. Society Am. J.* 54: 457-461.
27. Raiesi F. and Kabiri V. (2016). Identification of soil quality indicators for assessing the effect of different tillage practices through a soil quality index in a semi-arid environment. *Eco. Indi.* 71:198-207.
28. Rashidi M. and Keshavarzpour F. (2007). Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). *Inter. J. Rural Dev.* 2: 274-277.
29. Sandeep Kumar Bangarwa, P.B. Singh, Manmohan Singh, Vijaypal Singh and S.P. Singh 2020. Conservation, utilization and constrains of underutilized crop species. *Frontiers in Crop Improvement*, 8(2): 77-82.
30. Singh A.K. (2006). Effect of tillage, water and nutrient management on soil quality parameters under rice wheat and maize-wheat cropping zone. 18th world congress of soil Science, Pannsylvania. USA. 1-2 p.
31. Singh Y., Singh T., Singh U.N. and Rajput P.K. (2010). Effect of nutrient management on yield, quality and economics of irrigated Indian mustard (*Brassica juncea*). *Indian J. Agri. Sci.*, 80: 691-694.
32. Subbiah B. and Asija G.L. (1956). Alkaline permanganate method of available nitrogen determination. *Curr. Sci.*, 25: 259.
33. Tyagi P.K. and Shukla K.C. 2020. Effect of phosphorus and bio-organics on growth, yield attributes and yield of summer green gram. *Frontiers in Crop Improvement*, 8(2): 141-144.
34. Vetriventhan M., Nirmala kumar A. and Ganapathy S. (2008). Heterosis for grain yield components in pearl millet (*Pennisetum glaucum* L.) R. Br. *World J. Agri. Sci.* 4: 657-660.



Characterization of Soil Available Nutrients using Multivariate Statistics in North Eastern Karnataka, India

J.B. Kambale¹ and Shashidhar K.K.²

¹Department of Agricultural Engineering, College of Agriculture, Bheemarayanagudi, UAS, Raichur, Karnataka

²Department of Agricultural Extension, College of Agriculture, Bheemarayanagudi, UAS, Raichur, Karnataka

Email : jbkambale@uasraichur.edu.in

Abstract

This study undertaken to describe the soil quality in the Yadgiri district of Karnataka, India based on randomly selected 26 sampling points. Statistical techniques such as multivariate statistics are applied to characterize soil quality, which is a most important factor for controlling the yield of food grain production from the agriculture. The analysed soil samples observed the pH values ranged from 6.831 and 9.171 with a mean value of 8.396, indicating acidic to alkaline in nature. The standard error, standard deviation, variance, skewness and kurtosis of pH observed 0.07, 0.37, 0.14, -2.64 and 12.51 respectively. Principle component analysis (PCA) of all soil particles carried out. The findings of cluster analysis (CA) are also consistent with the PCA results. It is expected that study will provide insights for decision makers taking proper measures for soil quality management in Northeastern Karnataka, India.

Key words : Statistical techniques, principle component analysis, cluster analysis.

Introduction

The assessment of soil available nutrients in the world is done by numerous models and statistical methods. For example, multivariate statistical techniques help to identify of possible factors/sources that influence nutrients availability and offers a robust tool for trustworthy site specific nutrients management (1). Therefore, Soil quality parameters that result in large data sets necessitate to understand complex figures matrices, better understand the soil fertility status and interrelationships between parameters and sampling sites. Therefore, statistical tools including principal components analysis (PCA) and cluster analysis (CA) coupled with Pearson correlation matrix analysis (CM) are used to resolve this complex data sets interpretation (2,3,4,5). However, the objective of this paper is to develop a reliable multi statistical method to characterize soil available nutrients quality of soil samples in Yadgir district of the Northern Karnataka, Which will be useful for decision makers to take proper initiative/s for site specific nutrient management.

Materials and Methods

Study Area : Yadgiri District is situated in North-Eastern part of Karnataka in India and geographically it lies between 16°36'39"-16°45'34" N latitude and 76°45'34"-76°54'16" E longitude. The average daily maximum temperature of 40°C and average daily minimum temperature of 24°C, average relative humidity is 67% and normal rainfall is 753 mm with 80% of rainfall occurring in monsoon season in the study area. The

geology of the study area is dominated by grey/pink granites. The area is characterized mixed soil, black and red soil.

Sample collection and analytical procedure : Total 26 Soil samples were collected from study area of the Yadgiri district of North-East part of Karnataka in India (Fig.-1).

The geographical position of each sampling point was recorded by handheld global positioning system (GPS) (Trimble-Juno Series). However, the sampling locations (S1 to S26) are shown in Fig.-1. The randomly collected soil samples from various points approximate depth of 15 cm from the surface. Collected soil samples from the field shifted to laboratory for the further analysis. All the sampled later analyzed in the laboratory by standard procedure to determine its P^H, EC, OC, N, P, K, S, Ca, Mg, Zn, Fe, Mn Cu and B.

Analytical data analysis : To evaluate the analytical data for variability of soil availability nutrients, micro nutrients and properties, multivariate statistical techniques, e.g., correlation analysis, principal component analysis (PCA) and cluster analysis (CA) are commonly used in environmental studies (2,3,4,5). In this study, multivariate analysis was performed by using SPSS 23 for Windows. PCA is widely used to reduce data and to extract a small number of latent factors for analyzing relationships among the observed variables (4). PCA was performed to extract principal components (PC) from soil sampling data and from all the sampling point, to evaluate spatial variations. On the other hand, cluster analysis (CA) was performed to

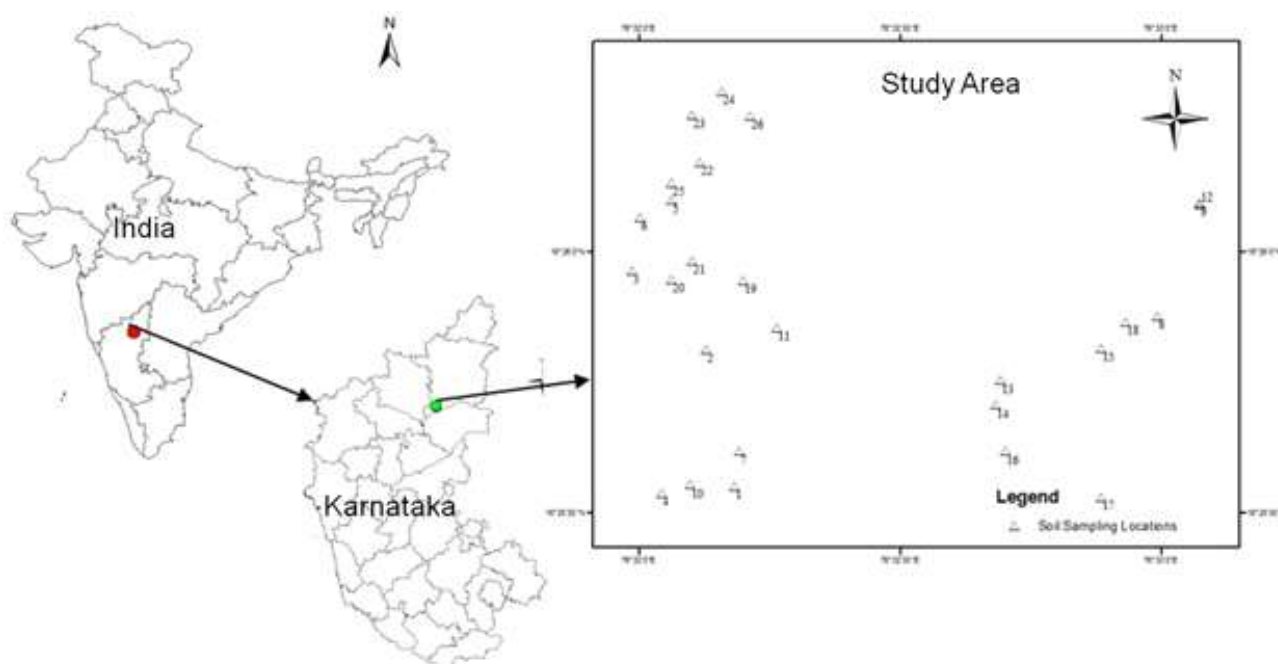


Fig.-1 : Study area and soil sampling points.

Table-1 : Descriptive statistics of physiochemical parameters in the study area.

Parameters, Units	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance	Skewness	Kurtosis
PH	2.34	6.83	9.17	8.39	0.07	0.37	0.14	-2.64	12.51
EC	0.35	0.12	0.47	0.22	0.01	0.08	0.01	1.20	1.83
OC	0.92	0.28	1.21	0.62	0.03	0.18	0.03	0.82	3.23
N	73.13	102.39	175.52	130.32	4.01	20.47	419.39	0.35	-0.66
P	60.75	9.90	70.65	39.25	2.70	13.79	190.41	-0.09	0.34
K	778.40	44.40	822.80	270.04	40.14	204.67	41892.88	1.39	1.82
S	227.29	49.76	277.05	195.31	10.97	55.97	3133.17	-0.55	0.28
Ca	40.80	9.40	50.20	27.93	1.85	9.45	89.45	0.47	0.64
Mg	6.00	0.80	6.80	4.07	0.26	1.37	1.88	-0.44	0.42
Zn	0.38	0.29	0.67	0.43	0.02	0.10	0.01	1.01	0.34
Fe	4.56	0.11	4.67	0.77	0.19	0.98	0.96	3.00	10.10
Mn	5.42	0.04	5.46	0.68	0.27	1.39	1.93	3.12	8.92
Cu	2.48	0.12	2.60	0.86	0.11	0.61	0.37	1.18	1.16
B	1.06	0.18	1.24	0.51	0.05	0.29	0.08	0.89	-0.02

further classify elements of different sources on the basis of the similarities of their properties (4). Hierarchical agglomerative clustering is the most common approach, which provides intuitive similarity relationships between any one sample and the entire data set, and is typically illustrated by a dendrogram (7). The dendrogram provides a visual summary of the clustering processes, presenting a picture of the groups and their proximity, with a dramatic reduction in dimensionality of the original data. Cluster analysis was applied on experimental data standardized through z-scale transformation in order to avoid miss classification due to wide differences in data dimensionality. The correlation coefficient matrix

measures how well the variance of each constituent can be explained by relationships with each other (6)

Results and Discussion

General characteristics of Soil samples : General characteristics of all collected soil samples physicochemical properties for the study area presented in Table-1 with Range, minimum, maximum, mean, standard error, standard deviation, variance, Skewness and Kurtosis values. All the samples (n=26) showed the pH values ranged from 6.831 and 9.171 with a mean value of 8.396, indicating acidic to alkaline in nature. The standard error, standard deviation, variance, skewness and kurtosis of pH observed 0.07,

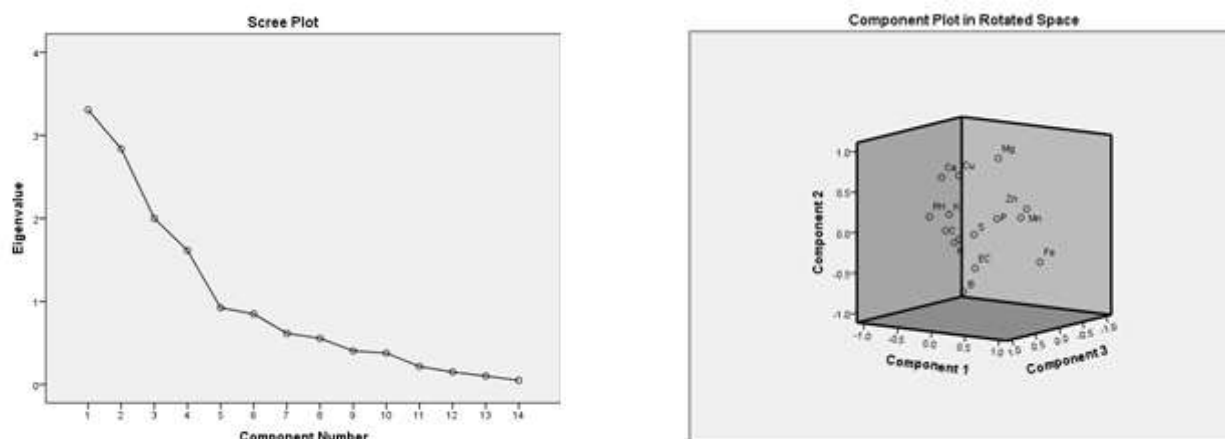


Fig-2 : Principal component analysis by (a) scree plot of the characteristic roots (eigenvalues), and (b) component

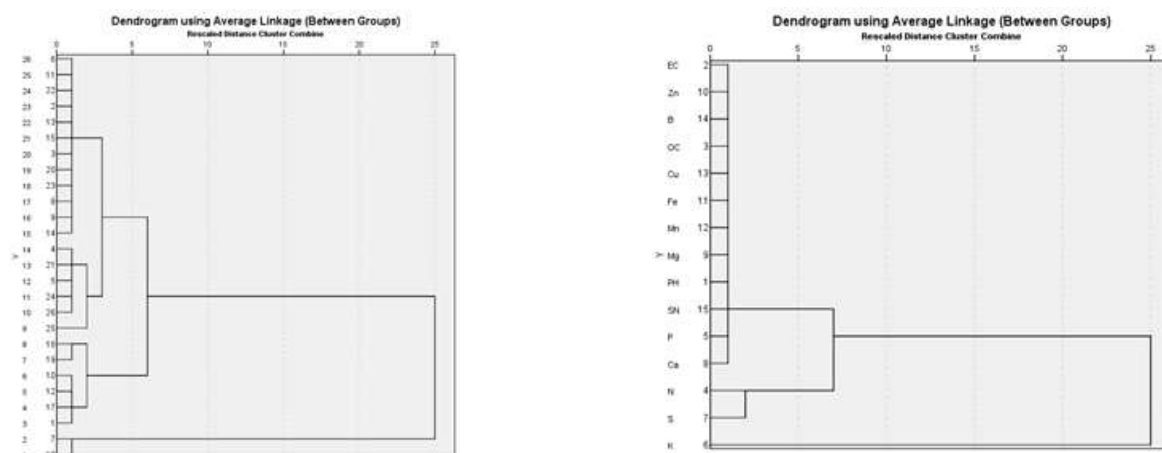


Fig-3(a) : Dendrogram showing the hierarchical clusters of analyzed parameters. (b) Dendrogram (Seaton *et al.*, 2020) showing the hierarchical clusters of analyzed samples site.

0.37, 0.14, -2.64 and 12.51 respectively. The findings of (1) are consistent with this study, which assessed the soil quality in the northeastern part of Karnataka and found to be acidic to little alkaline soil. The EC and OC in the study area varied from 0.12 to 0.47 and 0.28 to 1.21 with a mean value of 0.22 and 0.62 respectively. Among the all the major nutrients observed in studied samples, the concentrations of N, P, and K, ranged from 102.39 to 175.52 mg/kg, 9.90 to 70.65 mg/kg, 44.40 to 822.80 mg/kg, with the mean values of 130.32 mg/kg, 39.25 mg/kg, and 270.04 mg/kg respectively. The concentration of S, Ca, Mg, Zn, Fe, Mn, Cu, and B varied from 49.76 to 277.05 mg/kg, 9.40 to 50.20 mg/kg, 0.8 to 6.80 mg/kg, 0.29 to 0.67 mg/kg, 0.11 to 4.67 mg/kg, 0.04 to 5.46 mg/kg, 0.12 to 2.60 mg/kg and 0.18 to 1.24 mg/kg with the mean concentrations of 195 mg/kg, 24.93 mg/kg, 4.07 mg/kg, 0.43 mg/kg, 0.77 mg/kg, 0.68 mg/kg, 0.86 mg/kg and 0.51 mg/kg, respectively. It is found that most of the soil samples showed the high concentrations of K and S values in the study area.

Source and factor controlling of Soil quality : Principal component analysis (PCA) was performed on the soil quality data using Varimax rotation with Kaiser Normalization, which was used to elucidate the observed relationship of cluster variables in simple ways, expressed in the patterns of variance and covariance between the variable and similarities between observations. This technique exhibits a complex soil chemistry in the area along with interplay of ions exchange, leaching of material, agricultural fertilizer, domestic sewage and weathering of minerals. Kaiser proposed the use of only factors with eigenvalues exceeding one (5). 4 factors were extracted for soil quality data sets based on eigenvalues more than 1, which represented 15.38 % of total variance in the study area (Fig.- 2(a) and (b)). On the other hand, the scree plot (Fig.-2(a)) was used to identify the number of PCs to be retained to understand the underlying parameters structure.

Spatial similarity and sampling sites grouping : The R-mode cluster analysis (CA) retained three main clusters for data sets of analyzed parameters. R-mode cluster analysis (3) was applied to predict physicochemical groupings in the soil samples, and the results are shown in Fig. 3(a). Parameters belonging to the same cluster were likely to be found from a same source. Cluster 1 included EC, Zn, B, OC, Cu, Fe, Mn, Mg, PH, P and Ca, which might be explained by combining mix sources of fertilizers in the soil horizon. Cluster 2 consists of P, Ca, N and it reflected the influence of domestic and agricultural pollution (Firdous et al., 2016). Cluster 3 included As, N and S by the under basic condition. Cluster 4 included as, N, P, K, Ca and S by the under major fertilizer condition. The CA results mostly good agreed with that of PCA (4). Particular group/class shows similar characteristics with respect to the analyzed parameters in a samples cluster.

Conclusions

The assessment results of the all soil samples shown soil quality in the north eastern Karnataka to be acidic to little alkaline in nature. It was also found that most of the soil samples showed the high concentrations of K and S values in the study area. The scree plot used to identify the number of PCs to be retained to understand the underlying parameters in the study area. The CA results mostly good agreed with that of PCA. Particular group/class shows similar characteristics with respect to the analyzed parameters in a samples cluster.

References

1. Kambale J.B, and Rudramurthy H. V. (2017) Application of Geographical Information System to Understand Spatial Variability of Soil Available Nutrients in Northern Karnataka, India. *Curr. World Environ.*, 12(1). DOI:<http://dx.doi.org/10.12944/CWE.12.1.20>
2. Sharma, K.L.; Mandala, U. K.; Srinivasa, K.; Vittala, K.P.R.; Biswapati, M.; Kusuma, G. J.; Ramesha. V. (2005) Long-term soil management effects on crop yields and soil quality in a dryland Alfisol. *Soil and Tillage Res.*, 83: 246–259
3. Zhang, M.; He, P.F. and Chen, W.Q. (2010) Spatio-temporal variability analysis of soil nutrients based on GIS and geostatistic. *J. of Northeast Agril. Uni.* 41(3): 53–58
4. Seaton, F. M.; Barrett, G.; Burden, A.; Creer, S.; Fitos, E.; Garbutt, A.; Griffiths, R.I.; Henrys, P.; Jones, D.L.; Keenan, P.; Keith, A.; Lebron, I.; Maskell, L.; Pereira, M.G.; Reinsch, S.; Smart, S.M.; Williams, B.; Emmett, B. A. and Robinson, D.A. (2020). Soil health cluster analysis based on national monitoring of soil indicators. *Euro. J. of Soil Sci.* <https://doi.org/10.1111/ejss.12958>
5. Abdel-Fattah, M.K.; Mohamed, E.S.; Wagdi, E.M.; Shahin, S.A.; Aldosari, A.A.; Lasaponara, R.; Alnaimy, M.A. (2021) Quantitative Evaluation of Soil Quality Using Principal Component Analysis: The Case Study of El-Fayoum Depression Egypt. *Sustainability*, 13, 1824. <https://doi.org/10.3390/su13041824>
6. Firdous, S.; Begum, S and Yasmin, A. (2016) Assessment of soil quality parameters using multivariate analysis in the Rawal Lake watershed. *Environ. Monitor. and Assess.* 188. 533. 10.1007/s10661-016-5527-5.
7. Kumar, D.A. and Kannathasan, N. (2013). A study and characterization of chemical properties of soil surface data using K-means algorithm, 2013 International Conference on Pattern Recognition, Informatics and Mobile Engineering, pp. 264-270, doi: 10.1109/ICPRIME.2013.6496484.



Impact of Front Line Demonstration on Productivity of Brinjal cv. Kashi Uttam through Drip and Fertigation in Tribal Belt of Korea District (C.G.)

K.C. Rajhansa, Ranjeet Singh Rajpoot, Harishankar, Vijay Kumar, Kamlesh Singh, P.R. Bobdae, Doman Singh Tekam and P.C. Kanwar

Krishi Vigyan Kendra, Korea, Indira Gandhi Krishi Vishwavidyalaya (C.G.)

Abstract

A front line demonstration was conducted at five farmers field comprising of 0.20 ha each in Korea district of Chhattisgarh during *Kharif* 2017-18 to 2019-20 to demonstrate the improved package of practice of Brinjal. There were two treatments in which one was local check and cultivation of brinjal with full package of practice with drip and fertigation which was second one. Field diagnostic visits, regular surveys, farmer meetings and training programmes ensured application of balanced and optimum doses of nutrients through fertigation and timely plant protection measures. The result revealed that local check gave a yield of 7.78 t/ha. While brinjal cultivation with full package of practices along with drip and fertigation gave a yield of 29.98 t/ha. which showed that by adopting package of practices there were 299.39 % increase in brinjal yield. Similarly, net return was also calculated which showed that local check gave a net income of Rs. 55505 / ha with a B:C ratio of 1.68 against a net income of Rs. 295470/ha with B:C ratio of 3.90 in demonstration field. With frontline demonstration (FLD) of proven technology revealed that yield potential and net income from brinjal cultivation could be enhanced to a great extent resulting in higher income to the farming community. By conducting front line demonstration (FLDs) of proven technologies, yield potential of brinjal can be increased up to greater extent. The extension gap and technology gap ranged between 19.22 to 25.277 t/ha and 27.71 to 41.24 t/ha, respectively, with the technology index of 33.63 per cent during the demonstration years. Besides this, the demonstrated plots gave higher gross return, net return with higher benefit cost ratio when compared to farmer's practice.

Key words : *Brinjal, front line demonstration, farmers practice, drip irrigation, fertigation, yield.*

Introduction

Brinjal (*Solanum melongena* L.) is cultivated as one of the leading vegetable crops grown in India. It is called brinjal in India and aubergine in Europe. The name "brinjal" derives from the shape of the fruit of some varieties, which are white and shaped similarly to chicken eggs. Brinjal belongs to the family "Solanaceae" and it is a vegetable commonly grown by the farmers throughout the world. (Kishore and Daniel, 2018). It is highly productive and usually finds a place as "poor man's crop". It is highly nutritive and possesses excellent medicinal properties. It is a good source of minerals like phosphorus, iron and vitamins especially the B complex. It can be grown in almost all states of India except in higher altitudes. Major states growing brinjal are West Bengal, Orissa, Bihar and Gujarat. Now a days demand for brinjal as a fruit vegetable is increasing rapidly among the vegetables consumers in view of its better fruit colour, size and taste.

Brinjal is a long duration crop with high yield which removes large quantities of nutrients from the soil. Availability of irrigation water is limited and therefore, it should be utilized most efficiently by adopting latest irrigation technologies (Patel *et al.*, 2000). Information on water requirement by brinjal and fertigation is lacking for Korea region among the various factors contributing towards the attainment of potential yield and quality of

brinjal. Reduced agricultural productivity and water use efficiency are mainly due to conventional method of irrigation (flooding) and poor adoption of scientific water management practices. With an objective to combat the causes of poor yield and low economic returns, dissemination of recommended technology through frontline demonstration was attempted in the Korea district of Chhattisgarh. The main objective of Front line Demonstration (FLD) is to introduce suitable agriculture practices like high yielding varieties, seed treatment, spacing, timely sowing, drip irrigation and fertigation, pest and disease management etc. among the farmers accompanied with organizing extension programmes (field day) for horizontal dissemination of the technologies.

Materials and Methods

Krishi Vigyan Kendra, Korea carried the technology to the farmers field through frontline demonstrations in the villages viz Pusla, Umjher and Dudhaniya between 2017-18 and 2019-20. The average area under each demonstration was 0.20 ha with 5 beneficiaries in each demonstration. The genuine seed of brinjal cv Kashi Uttam was procured and distributed to selected farmers. All the participating farmers were trained on various aspects of brinjal production technologies. The field was prepared by deep ploughing and harrowing. The seeds

were sown in well prepared raised bed during first week of July. All the recommended practices i.e. seed treatment by carbandazim @ 2g/kg seed, transplanting of one month old seedlings, maintaining row spacing of 60cm and 60 cm spacing with in rows. The data related to cost of cultivation, production, productivity, total return and net return were collected in both treatments as per schedule from all selected farmers. An average of cost of cultivation, yield, net returns of different farmers was analyzed by the formula. The drip irrigation system was installed and operated daily except on rainy days to provide the sufficient moisture to the plants. The lateral lines were laid parallel to the crop rows and each lateral served two rows of crop. The laterals were provided with on line emitters of 4 lt hr⁻¹ discharge capacity. Emitters were fixed 0.3m apart to serve the irrigation water requirement of four plants. Inline drippers with a discharge rate of 4 lt hr⁻¹ was followed for all the plants spaced at 60x 60 cm. Fertigation is done as per the recommended dose with 100:50:50 NPK kg of NPK/ha and is applied throughout the cropping period once in three days. Water soluble fertilizers like 19:19:19, 0:0:50 and urea are used. The scheduling interval of fertigation was followed at weekly intervals for 13 weeks starting from 5th to 17th week after planting in the field. Weed management, need based plant protection chemicals were used to manage the problem. All other steps like site and farmer selection, layout of demonstration, farmers' participation etc were followed as suggested by Choudhary (1999). In case of local check (control plots) no change was made in the existing practices of imbalanced use of organic and inorganic fertilizers and little or no use of fungicides and pesticides. Well before the demonstrations training was imparted to the farmers and their exposure visits to the KVK instructional-cum demonstration farms were conducted. Visits of the farmers and the extension functionaries were also organized to demonstration plots to disseminate the message at large. Yield data were collected from the control and demonstration plots and cost of cultivation, net income and benefit/cost ratio were computed. The data related to cost of cultivation, production, productivity, total return and net return were collected in both treatments as per schedule from all selected farmers. An average of cost of cultivation, yield, net returns of different farmers was analyzed by the formula. Through field diagnostic visits, surveys, farmer meetings etc the factors contributing to low productivity like varietal issues, faulty management practices, lack of irrigation, poor nutrient management, negligent plant protection measures were identified. In case of local check (control plots) no change was made in the existing practices of imbalanced use of organic and inorganic fertilizers and little or no use of fungicides and pesticides. Well before the demonstrations training was

imparted to the farmers and their exposure visits to the KVK instructional-cum demonstration farms were conducted. Visits of the farmers and the extension functionaries were also organized to demonstration plots to disseminate the message at large. Yield data were collected from the control and demonstration plots and cost of cultivation, net income and benefit/cost ratio were computed.

Results and Discussion

Performance of Brinjal var. Kashi Uttam under drip and fertigation was found to be substantially higher under the demonstration plots than under control during all the demonstration years (Table-1). The fruit yield under demonstrations was 28.32, 30.32, 31.32t/ha during 2017-18, 2018-19 and 2019-20 respectively. The findings are confirmed with the findings of Vijayakumar, *et al.*, 2010, Kumar *et al.*, 2016, Rajasekar, *et al.*, 2017 Adawadkar *et al.*, 2019 and Kale *et al* 2020, in brinjal. The yield enhancement due to technological intervention was to the tune of 211.20, 269.30 and 417.68 per cent respectively over control. The cumulative effect of technological intervention over three years revealed an average yield of 29.98 t/ha i.e 299.39 per cent higher over local check. The year-to-year fluctuations in yield and cost of cultivation can be explained based on variations in microclimatic conditions and marketability price. Mukherjee (2003) also reported that depending on identification and use of farming situation specific interventions may have greater implications in enhancing systems productivity. Similar variations in results have been documented by Kumar *et al.*, 2012, Misra *et al.*, 2013, Shalini *et al.*, 2016, Desai *et al.*, 2016, and Harisha *et al.*, 2017 in different crops. The data clearly reveal that the net returns from the demonstration plots were substantially higher than control plots during all the years. An average net return was observed to be Rs 295470 in comparison to control plot i.e Rs 55505. Thus, on an average additional income of Rs 239965 is attributed to the technological intervention provided in demonstration plots. Economic analysis revealed that benefit/cost ratio in demonstration plots was comparatively higher than control plots. The highest benefit cost ratio (3.98) was observed in the year 2019-20 followed by 3.94 in the year 2018-19 under demonstration plot. The variation in B:C ratio could be due to price variation during the study years. The average B:C ratio of demonstration and control plots was 3.90 and 2.18 respectively during the study period. Hence, favourable B:C ratio proved the economic viability of the intervention made under demonstration and convinced the farmers on the utility of intervention. Similar findings were reported by Vijayakumar, *et al.*, 2010, Kumar *et al.*, 2016, Rajasekar, *et al.*, 2017 Adawadkar *et al.*, 2019 and Kale *et al* 2020 in brinjal.

Table-1 : Yield performance and technology gap, technology index and extension gap in brinjal var. Kashi Uttam production under FLD.

Year	No. of FLDs	Fruit yield (t/ha)			% increase over FP	Technology gap (t/ha.)	Extension gap (t/ha)	Technology index (%)
		PY	RP	FP				
2017-18	5	40	28.32	9.1	211.20	11.68	19.22	41.24
2018-19	5	40	30.32	8.21	269.30	9.68	22.11	31.93
2019-20	5	40	31.32	6.05	417.68	8.68	25.27	27.71
Average	5	40	29.98	7.78	299.39	10.01	22.2	33.63

PY= Potential yield, RP= Recommended practice, FP= Farmers practice, B:C ratio= Benefit/cost ratio

Table-2 : Comparative economics of brinjal var. Kashi Uttam production under FLD and farmers practice.

Year	Gross expenditure (Rs)/ha		Gross return (Rs)/ha		Net return (Rs)/ha		B:C ratio	
	RP	FP	RP	FP	RP	FP	RP	FP
2017-18	112123	52760	424800	136500	318277	49240	3.79	2.59
2018-19	115543	53776	454800	123150	299857	50424	3.94	2.29
2019-20	118123	54148	469800	90750	268277	66852	3.98	1.68
Average	115263	53561.3	449800	116799.9	295470	55505.3	3.90	2.18

Technology gap, Extension gap and Technology index : Extension gap of 19.22, 22.11 and 25.27t/ha were observed during 2017-18, 2018-19 and 2019-20 respectively. On an average extension gap under three year FLD programme was 22.20 t/ha. This emphasized the need to educate the farmers through various techniques for the adoption of improved agricultural production technologies to reverse this trend of wide extension gap. More and more use of latest production technologies with high yielding variety will subsequently change this alarming trend of galloping extension gap. The technology gap, the differences between potential yield and yield of demonstration plots was 11.68, 9.68 and 8.68 t /ha during 2017-18, 2018-19 and 2019-20 respectively. On an average technology gap under three year FLD programme was 10.01 t/ha. This may be due to the fertility, managerial skills of individual farmer's and climatic condition of the area. Hence, location specific recommendations are necessary to bridge these gap. The technology index showed the feasibility of the demonstrated technology at the farmer's field. The technology index varied from 27.71 to 41.24 (Table 1). On an average technology index of 33.63 per cent was observed during the three years of FLD programme, which showed the effectiveness of technical interventions. This accelerate the adoption of demonstrated technical interventions to increase the yield performance of brinjal.

Conclusion

The results of front line demonstration convincingly proved that the fruit yield of brinjal could be increased by 299.39 per cent with the better technological intervention with drip and fertigation. Favourable benefit/cost ratio is self-explanatory of economic viability of the

demonstration. The technology is suitable for enhancing the productivity of brinjal crop and appropriate time for area expansion under brinjal production in Korea dist. The suitable climate for its growth can transform lives of many rural growers if more interventions are conducted and technical knowledge is given to the growers with bottom up policy.

References

1. Adawadkar, M.P., Deshmukh, M.M., Wadatkar, S.B. 2019. Effect of drip fertigation with different fertilizer levels and traditional method of fertilizer application on growth and yield of brinjal. *Int. J. Curr. Microbial. App. Sci.* 8(9): 2793-2800.
2. Adawadkar, M.P., Deshmukh, M.M., Wadatkar, S.B. 2019. Effect of Drip Fertigation with Different Fertilizer Levels and Traditional Method of Fertilizer Application on Growth and Yield of Brinjal. *Int. J. Curr. Microbial. App. Sci.* 8(9): 2793-2800.
3. Choudhary BN 1999. Krishi Vigyan Kendra - A guide for KVK managers. Publication Division of Agricultural Extension, ICAR, pp 73-78.
4. Desai, N, Mamatha B, and Prashant J.M.. 2016. Impact of frontline demonstration in adoption of production technology and economics of tomato at farmers field of Tumakuru district 11(2): 349-354.
5. Harisha, CB, Asangi, H and Singh R, 2017. Impact of Drip Irrigation and Fertigation on Residual Soil Nutrient Status, Nutrient Uptake and Nutrient Use Efficiency of Fenugreek under Semi Arid Conditions *Int. J. Pure App. Biosci.* 5 (2): 661-667.
6. Kale K.D., Nagalkar D.D. Pawarand A. V. 2020. Effect of fertigation on yield of brinjal (*Solanum melogena*). *Bioinfolet - A Quarterly Journal of Life Sciences.* 17(3): 445-448.
7. Kishore P. and Daniel S. 2018. Effect of mulching on varietal influence of brinjal (*Solanum melongena*) in

- agroforestry system. *Journal of Pharmacognosy and Phytochemistry*, 7(4): 2466-2468.
8. Kumar R, Himanshu Trivedi, Rahul Yadav, Bhagwan Das & Ankur Singh Bist 2016 Effect of drip irrigation on yield and water use efficiency on Brinjal (*Solanum melongena*) cv. Pant samrat. *Int. J. Engg. Sci. Res. Technol.* 5: 7–17.
 9. Kumar, A., Avasthe, R.K., Lepcha, B., Mohanty, A.K., and Shukla, G. 2012. Impact of frontline demonstration on yield enhancement of ginger (var Majauley) in tribal reserve biosphere of Sikkim Himalaya. *Journal of Agricultural Sciences* 3(2): 121-123.
 10. Meena M, Sagarka B.K., Man, M.K., 2017. Influence of drip irrigation along with nitrogen levels on yield attributes, yield and quality parameters of rabi drill fennel (*Foeniculum vulgare* Mill). *International Journal of Current Microbiology and Applied Sciences*; 6(5): 2115-2121.
 11. Misra, P.K., Singh, P.N., Singh, S.N., Kumar P. 2013. Impact of Frontline demonstration on yield and economy of tomato in Varanasi district of Uttar Pradesh *European Journal of Biotechnology and Bioscience*; 1(3): 84-87.
 12. Mukherjee, N. 2003. Participatory learning and action. *Concept Publishing Company*, New Delhi, India, pp 63-65.
 13. Patel, B.S., Patel, K.P., Patel, I.D. and Patel, M.I. 2000. Response of fennel (*Foeniculum vulgare* Mill) to irrigation, nitrogen and phosphorus. *Indian Journal of Agronomy*, 45: 429-432.
 14. Rajasekar, M., Nandhini, D.U., Swaminathan V. and Balakrishnan. K. 2017. Impact of mulching and fertigation on growth and yield of grafted brinjal (*Solanum melongena* L.) under drip irrigation system. *International Journal of Chemical Studies*; 5(3): 163-166.
 15. Shalini, M., Devaraja and Manjunath Gowda, M. 2016. Impact of Front line demonstrations on yield and economics of Tomato in Chikkaballapur district of Karnataka *International Journal of Applied and Pure Science and Agriculture* 2(7): 4-8.
 16. Vijayakumar, G., Tamilmani, D. and Selvaraj, P. K. 2010. Irrigation and fertigation scheduling under drip irrigation in brinjal (*Solanum melongena* L.) crop. *International Journal of Bio-resource and Stress Management*, 1(2): 72-76.



Role and Application of Nanotechnology in the Modern Agriculture Practice

Mamta Rathore, Pooja Singh and H.G. Prakash

C.S. Azad University of Agriculture and Technology, Kanpur-208002, U.P.

Abstract

Nanotechnology is considered the most important technological advancement in recent years, and it is utilized in all industries due to its potential applications. Almost all of the industries (food, agriculture, medicine, automotive, information and communication technologies, energy, textile, construction, etc.) reorganize their future in the light of nanotechnological developments. As the most important source of income of countries, the agriculture industry increases the use of nanotechnology products gradually as a solution to the problems encountered. Reducing the use of agricultural inputs (pesticides, herbicides, fertilizers, etc.) by increasing their efficiency utilizing nano-carriers, detecting the environmental conditions and development of the crops in the field simultaneously by making use of nanosensors, reducing the sample volume and the amount of analyte used thanks to nanoarrays, effective treatment of water resources through nano-filters, accelerating the development of crops by using nanoparticles are the prominent nanotechnological applications in the agriculture industry. This review presents information on the benefits of the recent developments in nanotechnology applications in the agriculture industry. To meet the food requirement of a huge population the food grain production need to be enhanced accordingly. However the goal of higher production must not come at the cost of heavy exploitation of natural resources. In order to attain higher yields, need of the hour is to develop and promote new technologies and reform agricultural research. Nanotechnology holds promise in improving the fertilizer use efficiency of fertilizers. The unique properties can be exploited beneficially for improving the nutrient use efficiency. Since the research work on nanotechnology in agriculture is at nascent stage there is a dearth of information on the response of nanomaterials application in crops. An effort has been made to review and extend the work done worldwide on these minerals which can efficiently deliver fertilizers, herbicides, pesticides, plant growth regulators etc.

Key words : *Nano sensor, efficiency, nanorays, yield, fertilizer etc.*

Introduction

Agriculture acts as the primary pillar of the developing economy and provides food for a better life. In the current scenario, the field of agriculture has been facing a wide range of challenges, including unpredictable climate change, contamination of soil with various harmful environmental pollutants such as fertilizers and pesticides, and majorly elevating food demands with a growing global population. A recent report by the United Nations projected that the global population would become 8.5 billion by 2030 and approximately 9 billion by 2050). Therefore, to meet the demands of the relentlessly growing population, there is an urgent need to increase food production more than 50%. On the contrary, industrialization leads to depletion of natural resources on which the population's livelihood depends, such as oceans, forests, and ecological biodiversity, at an alarming rate. Thus, it advocates the need for increased crop production and better food security. Ecological biodiversity plays an essential role in maintaining the delicate balance of the environment and food production as it strengthens agricultural resilience toward the environmental stress that potentially leads to crop failure. More specifically, the biodiversity for food and agriculture comprises livestock, crops, forestry, and aquaculture

systems by which human beings are sustained. Oceans and forests are home to numerous animal and plant species that majorly withstand world population for food, fodder, fuel, and fiber. Thus, any issues that could cause ecological disequilibrium significantly affect food security

In order to deal with these pertinent issues, newer techniques and strategies are continuously evolving. Given this, one such step taken is the introduction of nanomaterial (NM) based products for revolutionizing modern agriculture practices. These materials bear high reactivity due to their large surface area-to-volume ratio and novel physicochemical properties that provide the clear advantage of required modification according to elevating demand.

NP Interaction With Plants : The agricultural sector is benefiting from advancements in science and technology, which give us new ideas and solutions to combat severe problems. With the advent of nanotechnology, more efficient and fewer contaminant nanoformulations are continuously produced for sustainable agriculture. These new-age materials have the potential to alter the physiology of plants right after entering the complex plant-soil system that can be easily exploited to understand the aftereffects). Moreover, for controlled delivery of active compounds, critical knowledge of the

interaction of these NMs with plants, either positive or negative, is required. Thus, they could provide novel avenues toward developing better nanomaterial-based products. It is also believed that the concentration of NMs in the natural environment is much lower than levels considered harmful. However, still, some gaps are left to be filled with comprehensive safety assessments.

The agricultural sector is dealing with enormous challenges such as rapid climatic changes, a decrease in soil fertility, macro and micronutrient deficiency, overuse of chemical fertilizers and pesticides, and heavy metal presence in the soil. However, the global population increase has subsequently escalated food demand. Nanotechnology has immensely contributed to sustainable agriculture by enhancing crop production and restoring and improving soil quality.

Nanotechnology is applied in various aspects of agriculture, for example :

Nano-pesticide delivery.

Slow and controlled release of nanoparticles containing biofertilizers.

Transport of genetic materials for crop development.

Application of nano biosensors for rapid detection of phytopathogen and other biotic and abiotic stresses.

Nanoparticles Commonly Used in the Agricultural Sector : Several nanoparticles are commercially used in agriculture. Some of the commonly used nanoparticles are mentioned below :

Polymeric nanoparticles : In the agricultural sector, polymeric nanoparticles are used in the delivery of agrochemicals in a slow and controlled manner. Some of the advantages of polymeric nanoparticles are their superior biocompatibility and minimal impact on non-targeted organisms.

Some of the polymeric nanomaterials used in agriculture are polyethylene glycol, poly (epsilon-caprolactone), poly(lactide-co-glycolides), and poly (alpha-glutamic acid).

Silver nanoparticles : Silver nanoparticles are extensively used for their antimicrobial property against a wide range of phytopathogens. Scientists have also reported that silver nanoparticles enhance plant growth.

Nano alumino-silicates : Many chemical companies use nano alumino-silicate formulations as an efficient pesticide.

Titanium dioxide nanoparticles : These nanoparticles are biocompatible and are used as a disinfecting agent for water.

Carbon nanomaterials : Carbon nanoparticles such as

graphene, graphene oxide, carbon dots, and fullerenes, are used for improved seed germination.

Some of the other nanoparticles that are used in agriculture are zinc oxide, copper oxide nanoparticles, and magnetic nanoparticles.

Agricultural Nanotechnology for the Enhancement of Crop Productivity

Nanopesticides and nanoherbicides : The application of nanoherbicides and nanopesticides for the management of weed and pests have significantly increased crop productivity. Different types of nanoparticles such as polymeric nanoparticles and inorganic nanoparticles are utilized for the nanoherbicide formulations.

Scientists have developed various routes for the efficient delivery of herbicides. For example, poly (epsilon-caprolactone) nanoparticles encapsulate atrazine, a herbicide. This nanocapsule showed strong control of the targeted species, reduced genotoxicity level, and could also significantly decrease the atrazine mobility in the soil.

Nanomaterials for disease management : Huge agricultural losses are incurred annually owing to microbial (virus, fungus, and bacteria) infections.

Nanomaterials with specific antimicrobial properties help prevent microbial infestations. Some of the common pathogenic fungi that cause diseases are *Colletotrichum gloeosporioides*, *Fusarium oxysporum*, *Fusarium solani*, and *Dematophora necatrix*.

Several nanoparticles such as nickel ferrite nanoparticles and copper nanoparticles, have a strong antifungal property and are effectively used in disease management. In the case of viral infection treatment, chitosan nanoparticles, zinc oxide nanoparticles, and silica nanoparticles are effective against viral diseases such as mosaic virus for tobacco, potato, and alfalfa.

References

1. Abdel Latef, A.A.H., Srivastava, A.K., El-sadek, M.S.A., Kordrostami, M., and Tran, L. S.P. (2018). Titanium dioxide nanoparticles improve growth and enhance tolerance of broad bean plants under saline soil conditions. *Land. Degrad. Develop.* 29, 1065–1073.
2. Acharya, A., and Pal, P.K. (2020). Agriculture nanotechnology: Translating research outcome to field applications by influencing environmental sustainability. *Nano Impact*, 19, 100232.
3. Prasad, R. (2017). Nanotechnology in Sustainable Agriculture: Recent Developments, Challenges, and Perspectives. *Frontiers in Microbiology*. 8, 1014.
4. Pandey, G. (2018). Challenges and future prospects of agri-nanotechnology for sustainable agriculture in

- India. *Environmental Technology & Innovation*. 11, 299-307.
5. Adisa, I.O., Reddy Pullagurala, V.L., Rawat, S., Hernandez-Viezcas, J.A., Dimkpa, C. O., Elmer, W.H. (2018). Role of cerium compounds in Fusarium wilt suppression and growth enhancement in tomato (*Solanum lycopersicum*). *J. Agricul. Food. Chem.* 66, 5959-5970.
 6. Adrees, M., Khan, Z.S., Ali, S., Hafeez, M., Khalid, S., Ur Rehman, M.Z. (2020). Simultaneous mitigation of cadmium and drought stress in wheat by soil application of iron nanoparticles. *Chemosphere* 238: 124681.
 7. Aghdam, M.T., Mohammadi, H., and Ghorbanpour, M. (2016). Effects of nanoparticulate anatase titanium dioxide on physiological and biochemical performance of *Linum usitatissimum* (Linaceae) under well-watered and drought stress conditions. *Braz. J. Bot.* 39, 139-146.
 8. Ahmad, B., Shabbir, A., Jaleel, H., Khan, M.M.A., and Sadiq, Y. (2018). Efficacy of titanium dioxide nanoparticles in modulating photosynthesis, peltate glandular trichomes and essential oil production and quality in *Mentha piperita* L. *Curr. Plant. Biol.* 13, 6â€“15.
 9. Ahmed, B., Khan, M.S., and Musarrat, J. (2018). Toxicity assessment of metal oxide nano-pollutants on tomato (*Solanum lycopersicon*): a study on growth dynamics and plant cell death. *Environ. Poll.* 240, 802-“816.
 10. Akanbi-Gada, M.A., Ogunkunle, C.O., Vishwakarma, V., Viswanathan, K., and Fatoba, P.O. (2019). Phytotoxicity of nano-zinc oxide to tomato plant (*Solanum lycopersicum* L.) : Zn uptake, stress enzymes response and influence on non-enzymatic antioxidants in fruits. *Environ. Technol. Innov.* 14:100325.



Stability Analysis for Selecting Promising Greengram (*Vigna radiata* L. Wilczek) Genotypes over the Seasons Through AMMI Analysis

Nitesh S.D.*, Manoj Katiyar, Sarvendra Kumar, Mahak Singh, Lokendra Singh, Bajpai V.P., Anjani Kumar Singh, Amar and Yashwanth R.D.

Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh

*Email : mail@niteshgpb.in

Abstract

Genotype×Environment interaction (GEI) effects are of special interest for plant breeders to identify stable genotypes. Present experiment was conducted for three growing seasons viz., kharif 2019, spring summer 2020 and summer 2021 at Research Farm, C.S. Azad University of Agriculture and Technology, Kanpur to assess the stability of 40 homozygous greengram genotypes for seed yield per plant. In AMMI1 biplot for seed yield per plant, the genotypes viz., KM2241, NM115, MH1142, KM 2352, and PUSA 1671 had IPCA1 score close to zero with high main effects indicating that these genotypes were less influenced by environments and high yielders. SML 1811, IPM 147, and KM 2328 genotypes were found to be high yielders with high interaction with environment. Among environments, *Kharif* and *Summer* seasons are highly interacting environments. Finally the genotypes viz., PDM139, KM2342, and IPM147 were found less interacting genotypes with high seed yield per plant. These genotypes may be recommended and used in further crop improvement program for all the three growing seasons of greengram.

Introduction

Genotype×Environment (GE) interaction is most commonly used statistical analysis for the evaluation of genotypes for yield performance over multi-environments for selection of stable genotypes. Greengram is an important grain legume crop grown in India and has its origin from Indian region. Adaptability of the genotype to perform well over diverse environmental condition is a requirement for the present era (Abheysiriwardena *et al.*, 1991). Genotypes with low G×E interaction and high yield are desirable for crop breeders as well as farmers, because it indicate that the environments have less effect on the performance of genotypes and yield is greatly contributed by genetic component (Linnemann *et al.*, 1995). Several methods have been put forth for analyzing genotypexenvironment interaction (GEI) and selection for phenotypically stable promising lines (Tarakanovas and Ruzgas, 2006). Two prominent and most commonly used statistical method have been proposed by to analysis the G×E interaction are univariate and multivariate stability statistics (Lin *et al.*, 1986). A combined analysis of variance can quantify the interaction and describe the main effects, but it is not informative in explaining G×E interaction. Hence, among the multivariate methods, the additive main effect and multiplicative interaction analysis (AMMI) has been extensively applied in the multi-environment stability analysis. This method has been found effective as it captures a large portion of the interaction sum of squares; at the same time separates main as well as interaction effects (Farshadfar and Sutka, 2006).

AMMI is a hybrid model involving both additive and multiplicative components in two-way data structure. It separates the additive variance from the multiplicative variance followed by implementation of principal component analysis (PCA) to extract a new set of coordinate axes to discover the interaction pattern of genotype and environment. Effectiveness of AMMI model was undoubtedly demonstrated in various studies like Zobel *et al.*, (1998) in soybean, Crossa *et al.*, (1990) in maize, Kumar *et al.*, (2017) in chickpea and Mahalingam *et al.*, (2018) in greengram using multi-environment trails. The AMMI model has been used extensively to analyze and interpret genotypexenvironment interactions and results can be displayed graphically (Crossa *et al.*, 1990; Purchase *et al.*, 2000).

Greengram (*Vigna radiata* L.) is an important short-duration grain legume, well suited to small holder production under adverse climatic conditions. Identify genotype with stable grain yield under different growing season. The objectives of the present study were to investigate the performance and consistency of forty homozygous greengram genotypes for seed yield per plant over different greengram growing seasons of Uttar Pradesh, India using AMMI model.

Materials and Methods

Forty genotypes of greengram were evaluated in randomized block design (RBD) with three replications. Field trials were conducted during *Kharif* 2018, *spring summer* 2019 and *summer* 2020 at Research farm, C.S. Azad University of Agriculture and Technology, Kanpur,

Table-1 : Analysis of variance for seed yield per plant (g) in greengram.

Source	Accumulated Value	DF	Sum of Squares	Mean sum of square
Env	7.27	2	66.3645	33.1823***
Gen	70.25	39	641.0582	16.4374***
Env × Gen	22.48	78	205.1562	2.6302**
IPCA1	58.78	40	120.5946	3.0149**
IPCA2	41.22	38	84.5616	2.2253
IPCA3	0.00	36	0.0000	0.0000
Error	-	240	416.9981	1.7375

Uttar Pradesh, India representing three different growing seasons of greengram. Each genotype was sown in plot with three lines planted with spacing of 30×10cm. All the recommended package of practices was followed for raising healthy crop in all the three seasons. Data was collected from five randomly selected plants from each genotype per replication. The data was recorded for all agro-morphological traits, but seed yield per plant (g) were subjected to statistical analysis. Replicated data on seed yield per plant were analyzed as individual location-wise followed by pooled analysis. Further the data were subjected to stability analysis by AMMI model as per the standard method. AMMI analysis was conducted using R software package *ammistability* (Ajay *et al.*, 2019).

Equation of AMMI model is as under :

$$Y_{ger} = \mu + \alpha_g + \alpha_e + \sum_{n=1}^N \lambda_n \alpha_{gn} + \sum_{e=1}^E \lambda_e \alpha_{ge} + \epsilon_{ger}$$

Where, Y_{ger} is the trait of genotype g in environment e ; μ is the grand mean, α_g is the genotypes deviation from grand mean; α_e is the environment deviation from grand mean. λ_n is the eigen value of the PCA axis n ; and α_{gn} and α_{ge} are the genotype and environment PCA scores for PCA axis n . ϵ_{ger} is the residual of AMMI model and is the random error. AMMI analysis first fits additive effects for the genotypes and environments by the usual additive ANOVA (Analysis of variance) procedure and then fits multiplicative effects for G×E (Genotype × Environment) by principal component analysis (PCA). AMMI uses ordinary ANOVA to analyze main effects and principal component to analyze the non-additive (interaction) left over by the ANOVA model. PCA decomposes the interaction into PCA axes 1 to n and residual remains if all the axes are not used. The interaction between genotype and environment can be estimated by multiplying the score of the interaction principal component axis (IPAC) of genotype by an environmental IPCA score.

Results and Discussion

Among the many statistical methods adopted for analysis of genotypes by environment interaction (GEI) and phenotypic stability (Crossa *et al.*, 1990). Regression based technique was widely used (Eberhart and Russell, 1966; Perkins and Jinks, 1968) due to its simplicity and the

Table-2 : Performance of greengram genotypes and their IPC score for seed yield per plant.

Sl. No	Genotypes	Seed Yield per plant	IPCA-1	IPCA-2
1	KM 2241	6.2933	-0.0129	0.2271
2	KM 2352	8.7122	0.0435	0.1360
3	PDM 139	7.5078	0.1153	0.0528
4	PM 1125	8.1122	0.1227	0.0849
5	KM 2342	7.4767	0.0534	0.0601
6	KM 2328	8.4122	0.7393	0.8438
7	SML 1811	8.7467	0.6176	0.7286
8	IPM 147	8.4744	0.0669	0.0159
9	IPM 147-1	7.9111	0.4074	0.3624
10	KM 2360	8.3144	0.1392	-0.0201
11	KM 2348	4.5389	0.2906	-0.5465
12	IPM 02-3	4.8422	0.2827	-0.5281
13	PUSA 1671	5.5611	0.0455	0.0093
14	KM 2368	4.8833	0.3800	-0.5769
15	KM 2362	5.0133	0.1967	-0.4075
16	KM 2364	4.8878	0.2471	-0.4372
17	PM 1126	7.6789	0.1603	0.0567
18	KM 2355	5.5222	0.3077	0.0306
19	MH 1142	6.6544	0.0250	0.0459
20	VBG 2	4.9922	-0.2937	0.2825
21	MH 1115	5.6722	-0.6192	-0.2100
22	NM 115	4.8578	0.0050	0.1811
23	NM 159	5.7622	-0.4515	0.0471
24	LGG 544	5.3456	0.0646	0.3964
25	SML 1623	4.9111	0.6850	-0.2492
26	BM 4	5.4622	0.2864	-0.3067
27	SML 1681	6.0500	-0.3477	-0.0188
28	IPM 312	5.8822	-0.2675	-0.0040
29	IPM 501	5.4378	-0.4185	-0.4697
30	IPM 512	4.0500	0.5788	-0.2539
31	PDM 11	5.2878	-0.2146	-0.0875
32	KM 2252	7.1756	-0.2371	-0.3121
33	KM 2260	4.8878	-0.1685	0.5510
34	KM 2268	5.5411	-0.5415	0.1310
35	KM 2272	5.5000	-0.3321	0.2555
36	RMG 1087	6.0156	-0.5163	-0.2125
37	KM 2310	6.8600	-0.4610	-0.5246
38	KM 2312	4.2000	0.2233	0.1608
39	RMG 1092	5.8089	-0.2018	-0.1552
40	KM 2320	6.7378	-1.0000	0.6608
E1	Kharif 2019	6.5621	-1.0000	0.1652
E2	Spring Summer 2020	6.3291	0.3437	-0.8751
E3	Summer 2020	5.5574	0.6563	0.7099

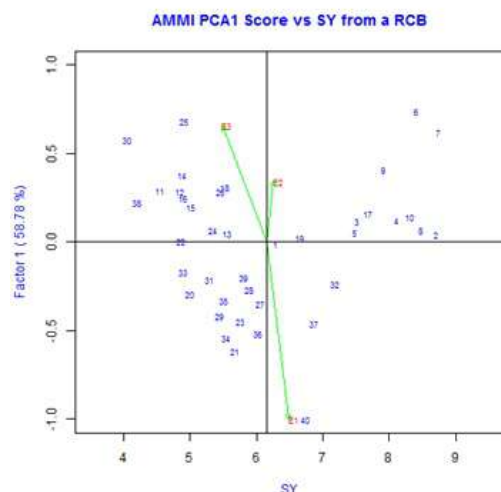


Figure-1 : AMMI 1 Biplot for seed yield.

fact that the information on adaptive response was easily applicable to locations (Annicchiarico, 1997). Zobel *et al.*, (1988) compared the traditional statistical models such as analysis of variance (ANOVA), principal component analysis (PCA) and linear regression with AMMI analysis and showed that traditional analysis was not always effective in the interpretation of the multi-environment trait data structure.

Understanding of G×E interaction in plant species is of importance because it has implications for economic yield. In present study, ANOVA on individual location indicated the presence of significant difference among genotypes. The significant of variance due to G×E in pooled analysis indicated the presence of genotype × environment interaction. Hence, the data were analyzed for further AMMI analysis. AMMI analysis indicated significant difference among the genotypes, among seasons and also genotype × environment interaction for seed yield per plant. In the present investigation, the analysis of variance showed significant for IPCA1 and IPCA2. Among these IPCA1 along recorded for 58.78 percent of total variance. Hence IPCA1 alone may decide the G×E interaction within study.

Biplot analysis is probably the most powerful interpretive tool for AMMI models. Biplots are graphs where both genotype and environment mean are plotted on the same axes (X-axis) so that their inter-relationship can be easily visualized. There are two basic AMMI biplots, the AMMI1 biplot where the main effects (genotype mean and environment means) and IPCA1 scores for both genotypes and environments are plotted against each other and the AMMI2 biplot where scores for IPCA1 and IPCA2 are plotted. AMMI2 biplots do not show genotype or environment main effects and hence do not show adaptation (Table-2.).

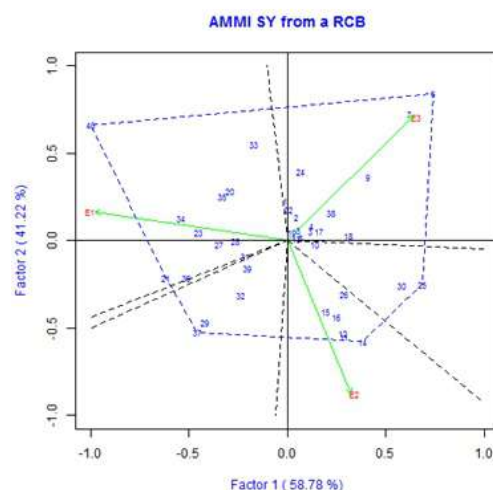


Figure-2 : AMMI 2 Biplot of Seed Yield per plant.

Among the high yielding genotypes *viz.*, KM2241, NM115, MH1142, KM 2352, and PUSA 1671 had IPCA 1 score close to zero indicating that these genotypes were less influenced by environment (Fig.-1). Hence, the above said genotypes were stable and had general adaptability in all the three seasons *viz.*, Kharif, Spring summer and Summer. The genotype SML 1811, IPM 147, and KM 2328 were found to be high yielders with high interaction with environment. Hence, these genotypes are not stable. Genotype KM 2241 and KM 2342 were high yielders and moderated interacting with environment. Hence, these genotypes can be recommended for all growing seasons. Among the environment, *Kharif* season was the high yield environment, whereas *spring summer* season had relatively less interaction among others.

In AMMI 2 biplot, IPCA1 and IPCA2 values were plotted (Fig. 2.). In this graph, sites with short spokes do not exert strong interactive forces, while those with longer spokes exerted strong interaction. All the three seasons – E1, E2 and E3 had long spokes and hence exerted strong interaction. Among the three environment – E3 (*Spring summer* season) had short spoke with the origin and hence it has less interactive effect. Genotypes PDM139, KM2342, IPM147, PUSA1671 and MH1142 were very close to the center of the origin. Genotypes nearer to the origin were non-sensitive to environmental interaction forces. Hence, these genotypes can be classified as stable and those distant from the origin were sensitive and had large interactions.

Based on the foregoing discussion, it can be concluded that genotypes PDM139, KM2342, and IPM147 were found less interacting with high seed yield per plant. These genotypes may be recommended for growing in all the three seasons *viz.*, *kharif*, *spring summer* and *summer*.

References

1. Abeysiriwardena, D.S., Deze Burs, G.R. and Jr Rase, P.E. 1991. Analysis of multi environment yield trails for testing adaptability of crop genotypes. *Tope. Agriculturist* 147: 85-97
2. Anandan A. 2011. AMMI analysis to comprehend genotype-by environment (G×E) interaction in rainfed gown mungbean *AJCS* 5(13): 1767-1775
3. Annicchiarico P. 1997. Additive main effects and multiplicative interaction (AMMI) analysis of genotype-location interaction in variety traits repeated over years. *Theoretical Applied Genetics* 94: 1072-1077
4. Ajay, BC., Aravind, J., and Abdul Fiyaz, R. 2019. Ammistability : R package for ranking genotypes based on stability parameters derived from AMMI model. *Indian Journal of Genetics and Plant Breeding*, 79(2), 460-466
5. Crossa, J., Gauch, GH. and Zobel, RW. 1990. Additive main effects and multiplicative interaction analysis of two international maize cultivar traits. *Crop Sciences*. 30: 493-500.
6. Eberhart, SA. and Russell, WA. 1996. Stability parameters for comparing varieties. *Crop Sciences* 6: 36-40
7. Farshadfar, E and Sutka J. 2006. Biplot analysis of genotypes environment interaction in durum wheat using the AMMI model. *Acta Agronomica Hungarica* 54:459-467
8. Kumar Hemant, Dixit GP, Srivastava AK and Singh NP. 2017. Simultaneous selection using AMMI procedure for yield and stability of chickpea genotypes in northwest plain zone of India. *Journal of Food Legume* 31: 15-17
9. Lin, CS., Binns, MR. and Lefkovitch, LP. 1986. Stability analysis: Where do we stand?. *Crop Sciences* 26: 894-900.
10. Linnemann, A., Westphal, E. and Wessel, M. 1995. Photoperiod regulation of development and growth in bambara ground (*Vigna subterranean*). *Field Crops Research* 40:39-47
11. Mahalingam A, N. Manivannan, S. Lakshmi Narayanan and S. Sowmya Sree. 2018. AMMI analysis of phenotypic stability in greengram (*Vigna radiata* (L.) Wilczek) genotypes over seasons. *Crop Research* 53 (3&4): 131-134
12. Perkins, JM and Jinks, JL. 1968. Environmental and genotype environmental components of variability. 111. Multiple line and crosses. *Heredity* 23: 339-56
13. Purchase, JL., Hatting, H., and van Deventer, CS. 2000. Genotype × environment interaction of winter wheat (*Triticum aestivum* L.) in South Africa: AMMI analysis on yield performance. *South African Journal of Plant and Soil* 17: 95-100
14. Tarakanovas, P and Ruzgas, V. 2006. Additive mean effect and multiplicative interaction, analysis of grain wheat varieties in Lithuania. *Agronomy Research* 4:91-98
15. Zobel, RW., Wright MJ. and Gauch, HG. 1988. Statistical analysis of yield trial. *Agronomy Journal* 80: 388-93.



Piper Betle – The Golden Leaves

P. Geetha

Centre for Post Harvest Technology, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003

Email : geethapadmanaban2@gmail.com

Abstract

Piper betel is a member of the family Piperaceae, commonly known as Sirih (Malaysia and Indonesia), Paan (India and Bangladesh), Betel (English) and Phlu (Thailand). It is widely found and grown in India, Sri Lanka, Malaysia, Indonesia, Philippines, other Southeast Asian and East African countries. Piper betel is widely used throughout the world even in modern days due to its known medicinal properties. Betel plant contains various biologically active compounds, which are responsible for its numerous pharmacological actions. The therapeutic profile reveals Piper betel to have a high potential for treating many diseases and conditions such as chronic renal disease, atherosclerosis, and diabetes mellitus. Further studies of betel plant are recommended to focus on the variety of metabolic activities in human, thus, improving its usage medically that will be beneficial to humanity.

Key words : *Piper betel*, bio active compounds, medicinal and therapeutic use.

Introduction

Betel vine (*Piper betle* L) is known by its many names across the country and abroad. In Indian subcontinent it is known as pan in Hindi, Tambula in Sanskrit, Villayadela in Kannada, Vettillakkoti in Malayalam, Vetrilai in Tamil, Tamalapaku in Telugu, Videch-pan in Marathi, Nagarbel in Gujarati and pan in Bangala. In foreign languages it is known as Tanbol in Arabic and Burg-e-Tanbol in Persian. It belongs to piperaceae family and is a perennial climber cultivated for its leaf. It is a shed loving plant and originated from Malaysia according to De Cando. Historically, the word pan in Hindi and other Indian languages is probably a derivative of the Sanskrit word 'pan' meaning leaf. It has been very intimately connected with the ancient Indian history, religion and culture as is evident by many references in the early Sanskrit literature (3000 BC), like Vedas, Ramayana, Mahabharata, Mahavansha, etc. From ancient time betel are chewed along with areca nut, slaked lime, cardamom and clove in many Asian countries (Walter and Sofia, 2007) Marcopolo (1295 AD) took notice of the pan chewing habit of the people in south India. Over the centuries, pan chewing had become so prevalent that serving and chewing of pan had been raised to the level of a fine art at the Mughal Darbar, particularly during the Akbar's regime. In course of time, offering the 'bida' of betel vine has become a symbol of offering and acceptance of mutual love and friendship. Betel vine has been under cultivation in India for centuries. In fact, no Hindu religious ceremony is complete without pan. It is also offered after lunch and dinner and also during other social get together. In India, Tamil Nadu ranks fourth place in the total area of cultivation of betel

vine. The area of betelvine cultivation of Tamil Nadu was estimated as 3298 hectares. Tamil Nadu's share amounted to 46.5 per cent. In Tamil Nadu, 12.67 per cent of production of betel leaves is done in Namakkal Taluk and Paramathi Velur Taluk areas of Namakkal District. The important varieties of betelvines are : Vellaikodi, Pachaikodi, Karpurakodi and SGM-1. Among all the varieties, majority of farmers cultivate Vellaikodi Variety. Betel leaf is an aromatic leaf belonging to the Piperaceae family commonly used as a masticatory as it is rich nutritionally and is known medicinally as a stimulant and carminative, an antiseptic and an expectorant .

Nutritional value : *Piper betel* leaves contained macro and micro nutrients as well as phytochemical. Its chlorophyll is beneficial in maintaining healthy teeth, clearing the mouth and throat and helping in digestion by encouraging salivation and neutralizing excess acid, the flavor of the leaf is due to the presence of essential oils (0.7–2.6%) and the other constituents are moisture (80–85.4%), carbohydrate (6.1%), protein (3%), fiber (2.3%), minerals and vitamins (2.3%), sugar (2.4–5.6%) and fat (0.8%). The leaves contain vitamins and significant amount of all essential amino acid except lysine, histidine and arginine which occurs in traces.

Bio active components : *Piper betel* is one of the invaluable medicinal plants where its leaves have been used for many medicinal purposes. Various properties of betel leaf include antioxidant, antifungal, antiulcerogenic, antiplatelet, antidiabetic, immunomodulatory, antileishmanial, antiamebic, anti-inflammatory, antifilarial and antimicrobial [Nagori *et al.*, 2011], antifertility [Sharma *et al.*, 2007], antihyperglycemic [Shantakumari *et al.*,

2006], antidermatophytic [Trakranrungsie *et al.*, 2008], antinaceptive [Arambewala *et al.*, 2005] and radioprotective properties [Bhattacharya *et al.*, 2005]. The leaf produces an aromatic volatile oil contains aphenol called chavicol, which has a powerful antiseptic properties. The alkaloid arakene has properties resembling cocaine in some respect. Pharmacological effects of betel chewing include abundant flow of saliva, temporary dulled of taste perception, stimulation of muscular and mental efficiency.

Scientific research on the leaf of this plant reveals that it possesses many beneficial bioactivities and its extract from betel leaves has a great potential to be used in developing commercial products. In a study, cancer was induced in Swiss male mice with tobacco carcinogens. The study group which was treated with betel leaf extract showed resistance to cancer. This study proved that contents in the betel leaf extract had certain antioxidant products that neutralized the tobacco carcinogen-induced damage (Padma *et al.*, 1989). Levels of several serum antioxidants like ascorbic acid, vitamin E, superoxide dismutase, catalase and glutathione peroxidases were increased when we consume betel leaf extract (Saravanan *et al.*, 2003).

Piper betel contains a wide variety of biologically active compounds whose concentration depends on the variety of the plant, season and climate. The aroma of betel leaf is due to the presence of essential oils, consisting of phenols and terpenes. The various phytochemicals found in the betel plants are chavibetol, chavicol, hydroxychavicol, estragole, eugenol, methyl eugenol, hydroxycatechol, caryophyllene, eugenol methyl ether, cadinene, α -lactone, allyl catechol, p-cymene, cephadione A, dotriacontanoic acid, tritriacontane, p-cymene, terpinene, eucalyptol, carvacrol, sesquiterpenes, cadinene, caryophyllene, dotriacontanoic acid, hentriacontane, pentatriacontane, stearic acid, n-triacontanol, triotriacontane, piperlonguminine, allylpyrocatechol diacetate, isoeugenol, 1, 8-cineol, α -pinene, β -pinene, sitosterol, β -sitosterol palmitate, β -sitosterol, stigmasterol, ursolic acid, ursolic acid 3 β -acetate [Rao *et al.*, 1985]

Many studies identified that sixty-five chemical constituents from betel leaves essential oil, extracted using hydro-distillation method. The predominant chemical constituents are 5-(2-propenyl)-1,3 benzodioxole (25.67%) followed by eugenol (18.27%) and 2-methoxy-4-(2-propenyl) acetate-phenol (8.0%). Previous efforts by Rimando *et al.*, (1986) and Ghosh & Bhattacharya (2005) discovered fourteen chemical constituents from the essential oil and ether-soluble fraction from the leaves. Major chemical constituents

recognized are chavibetol (53.1%) and chavibetol acetate (15.5%). Other constituents were allylpyrocatechol diacetate (0.71%), camphene (0.48%), chavibetol methyl ester (methyl eugenol 0.48%), eugenol (0.32%), α -pinene (0.21%), β -pinene (0.21%), α -limonene (0.14%), safrole (0.11%), 1,8-cineole (0.04%) and allylpyrocatechol monoacetate. Hexane fraction of Piper betel (leaf stalk) yields four aliphatic compounds in pure forms; Pentadecyl 6-hydroxytridecanoate, Pentatriacontanol, Methyl hexacos-7-enoate and 6, 9- heptacosa diene. These compounds were isolated and purified by repeated silica gel, reverse phase silica gel, column chromatography and thin layer chromatography (Dwivedi and Mehta, 2011). A gas chromatography-mass spectrometry (GCMS) analysis performed by Deshpande & Kadam (2013) identified the presence of 4-chromanol (27.81%) as a primary compound in Piper betel aqueous extract while phenol two methoxy 4-(2-propenyl) acetate (61.15%) as a primary compound in ethanol extract. Eugenol (20.37%) and four-chromanol (27.81%) were present in both extracts. However, Squalene (21.78%) and Tocopherol (12.62%) were found only in the aqueous extract. Allylpyrocatechol is known as the significant antioxidant chemical constituent of Piper betel and can protect indomethacin-induced gastric ulceration due to its antioxidative and mucin preserving properties (Bhattacharya *et al.*, 2007). Hydroxychavicol and eugenol have been regarded as the significant compounds belonging to the propenylphenol group. Eugenol is the principal constituent of betel leaf that shown to possess antifungal and anti-inflammatory effects (Akhtar and Naveed, 2012). Chavibetol is another organic chemical compound, the primary parts of betel essential oil that contribute to its spicy odour (Tripathi *et al.*, 2011).

Immunomodulatory activity : Many of the disorders today are based on the imbalances of immunological processes. This necessitates the search for newer and safer immunomodulators. The methanolic extract has lymphocyte proliferation, interferon- γ receptors and the production of nitric oxide were measured in vitro. Further, the extract at different dose levels was studied in vivo for the humoral and cellular immune responses on mice immunized with sheep red blood cells. The result showed that it significantly suppressed haemagglutinin stimulated peripheral blood lymphocyte proliferation in a dose-dependent manner. The decrease in antibody titre and increased suppression of inflammation suggests possible immunosuppressive effect of extract on cellular and humoral response in mice (Kanjwani *et al.*, 2008). From literature it concludes that betel leaf is a novel candidate for immunosuppressive activity. The same could be further evaluated for its anticancer activity or as a potential candidate in the treatment of autoimmune disorders such

as rheumatoid arthritis, systemic lupus erythematous or emphysema. In the current situation like COVID pandemic it will act as a good source of antioxidants and work as an immunomodulatory food.

Traditional uses : The intense spicy aromatic flavored betel leaves are traditionally used by the folks for being masticate in their natural raw condition, along with other ingredients such as sliced areca nut, slaked lime, coriander, aniseed, clove, cardamom, sweetener, coconut scrapings, ashes of diamond, pearl, jelly, peppermint, flavoring agent, fruit pulp, gold and silver (CSIR, 1969). The betel leaves are usually used in conventional medicine as carminative, aphrodisiac, stimulant, analgesic and cooling properties, antiseptic, wound healing, anti-parasitic, antifungal, and antibacterial agent (Caburian and Osi, 2010). The leaf is also useful for the treatment of various diseases; bad breath, boils and abscesses, ulcers, conjunctivitis, constipation, headache, hysteria, itches, mastitis, mastoiditis, leucorrhoea, catarrh, diphtheria, ringworm, swelling of gum, rheumatism, abrasion, cuts and injuries (Jayaweera, 1982). According to the Unani system, the sharp taste and pleasant smell of the leaves help to improve appetite. It acts as a tonic to the brain, heart, and liver. Piper betel also helps to promote healthy teeth and skin (Santhanam *et al.*, 1990). The leaf is chewed to relieve constipation in children, used as a poultice for cuts and ulcerated noses, heated and applied to the chest to reduce a cough and asthma by expelling out the mucus (Kirtikar *et al.*, 2005). The leaf is rolled up and covered with oil as a suppository and purgative in newborns. The foliage also is known to have a diuretic property. A previous study conducted by Arambewela *et al.*, (2004) found that betel leaf juice with milk or honey helps to ease urination. Other parts of the plant such as the fruits of Piper betel are used to treat a cough and indigestion in children, while its root is used as a long-lasting female oral contraceptive (Agarwal *et al.*, 2012).

Medicinal value : Indian system of medicine and health has adopted the use of betel leaves in various ways. In Indian folkloric medicine, betel leaf is popular as an antiseptic and is commonly applied on wounds and lesions for its healing effects. Essential oil extracted from betel leaf may be used as an industrial raw material for manufacturing medicines, perfumes, mouth fresheners, tonics, food additives etc [Guha, 2006].

The leaf poses the broad spectrum antimicrobial activity against various bacterial strains including *Bacillus cereus*, *Enterococcus faecalis*, *Listeria monocytogenes*, *Micrococcus luteus*, *Staphylococcus aureus*, *Aeromonas hydrophila*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella Enteritidis*, *Streptococcus mutans*,

Streptococcus pyogenes, *Enterococcus faecium*, *Actinomyces viscosus*, *Streptococcus sanguis*, *Fusobacterium nucleatum*, *Prevotella intermedia* beside this, the leaves also poses the antifungal and antiprotozoal activity against pathogen, which causing typhoid, cholera, tuberculosis, etc. The leaf extract shows the gastroprotective activity by enhancing the mucus rather than decrease the acid production. Chewing of betel leaf not only accelerating the salivation but also enhances the gastric juice, pancreatic lipase secretion which aids in digestion process. This may be the reason for which traditionally pan was chewed after eating. The aqueous extract possess oral protective action against different acid-producing oral pathogens which changes in the ultra-structure of the enamel and its properties like *Streptococci*, *Lactobacilli*, *Staphylococci*, *Corynebacteria*, *Porphyromonas gingivalis* and *Treponema denticola*. Chewing of betel leaf increase salivation which increases the contains of peroxidase, lysozyme and antibodies to combat bacterial growth in the oral cavity. It is the best choice for oral hygiene because while chewing bio-active phytochemicals are released into the oral cavity. The betel leaves are also reported to possess anti-mutagenic and anticarcinogenic properties particularly against the tobacco carcinogens due to presence of phytoconstituents like hydroxychavicol and chlorogenic acid, the latter compound is also reported to kill the cancerous cell without affecting the normal cells unlike the common anticancer drugs. The chewing of betel leaf results cardio-tonic action by accelerating catecholamine from adrenal cortex contributing to increase the stamina of the cardiac muscles, heart rate, blood pressure and sympathetic neural activity. It has also the platelet inhibition activity leads vasorelaxation effect mediated through endothelium dependent and nitric oxide pathways. Hence, betel leaf is beneficial for different cardiovascular disorders like Congestive heart failure, Coronary artery disease, acute myocardial infarction, atherosclerosis etc. The aqueous leaf suspension has significant reduction in blood glucose level, act same as insulinomimetic. The methanolic extract of the betel leaf decrease the antibody titre and increase the suppression of inflammation suggests possible immunosuppressive effect of extract on cellular and humoral response. Considering the above properties, it comes to conclusion that betel leaf place its position in nature same as our heart in our body and role the same with lots of biological activities and has a tremendous strength to come out as a future green medicine, hence Piper betle. L. leaf regard as "Golden heart of Nature".

Conclusion

Betel (*Piper betle*) is a type of plant from the Piperaceae

family which has traditionally been widely used as a mouth freshener, wound healing, for the prevention of cataracts, bleeding, and stimulants. In Ayurveda, the betel leaf extract is often used as an adjuvant, aromatic, beneficial for sound, laxative, appetizer, aphrodisiac effect, and helps increase taste and appetite, stop nose bleeds, fever, sores, and eye infections. Chemical content in betel includes saponins, flavonoids, polyphenols, and triterpenoid essential oils, essential oils (consisting of chavicol, chavibetol, carvacrol, eugenol, estragol), sesquiterpenes, sugar, and starch. Based on studies, Piper betle has bioactivity as antibacterial, antimicrobial, analgesic, antiinflammatory, antioxidant, antidiabetic, antiproliferative, and hepatoprotective. It is used for many traditional and ayurvedic medicines

References

1. Agarwal T., Singh R., Shukla A.D., Waris I. & Gujrati, A. (2012). Comparative analysis of antibacterial activity of four Piper betel varieties. *Adv Appl Sci Res*, 3(2), 698-705.
2. Arambewala LSR, Arawwawala LDAM, Ratansooriya WD. Antinoceptive activities of aqueous and ethanol extract of *Piper betle* leaves in rats. *Journal of ethanopharmacology*. 2005; 102(2): 239- 245.
3. Arambewela L.S.R., Arawwawala L.D.A.M. & Ratnasooriya W.D. (2004). Gastroprotective activities of Sri Lankan Piper betle leaf extracts in rats. SLAAS, 60th Annual Session, 117.
4. Bhattacharya S, Subramaniam M, Roychaudhary S, Bauri AK, Chattopadhyay S, Bandyopadhyay SK. *et al.* Radioprotective property of ethanol extract of *Piper betle* leaf. *J. Radiat. Res.* 2005; 46(2): 165-171.
5. Caburian A. B. & Osi M. O. (2010). Characterization and Evaluation of Antimicrobial Activity of the Essential Oil from the Leaves of *Piper betle* L. *Int Sci Res J*, 2, 1-13.
6. Chopra *Chopra's Indigenous Drugs of India* Academic Publisher 1946 pg 47-52.
7. Chopra R.N., Nayar S.L. and Chopra I.C. "Glossary of Indian Medicinal Plants". CSIR, New Delhi, 1956 pp.194.
8. CSIR. "The Wealth of India". (Council of Scientific and Industrial Research, New Delhi), 1969, 8, 84-94.
9. Jayaweera D.M.A. (1982). Medicinal Plants Used in Ceylon. National Science Council of Sri Lanka, Colombo, 201.
10. Kanjwani D.G., Marathe T.P., Chiplunkar S.V., Sathaye S.S., "Evaluation of immunomodulatory activity of methanolic extract of *Piper betel*", *Scand J. Immunol.*, 2008, 67(6), pp. 589-93.
11. Kirtikar K. R and Basu B. D. (2005). Indian Medicinal Plants. Utteranjai, *Interational Book Distributors*, 3 (2).
12. Nagori K, Singh MK, Alexander A, Kumar T, Dewangan D, Badwaik H *et al.* *Piper betle* L.: A review on its ethnobotany, phytochemistry, pharmacological profile and profiling by new hyphenated technique DART-MS (Direct Analysis in Real Time Mass Spectrometry). *Journal of Pharmacy Research*. 2011; 4(9): 2991-2997.
13. Rao AR, Sinha A, Selvan RS. Inhibitory action of Piper betle on the initiation of 7.12-dimethylbenz[a] anthracene-induced mammary carcinogenesis in rats. *Cancer Lett* 1985; 26: 207-14.
14. Shantakumari P, Prakasam A, Pugalendi KV. Antihyperglycemic activity of *P. betle* on streptozotocin induces diabetic rats. *Journal of Medicinal Food*. 2006; 9(1): 108-112.
15. Sharma JD, Sharma L, Yadav P. Antifertility efficacy of *Piper betle* Linn (petiole) on male albino rats. *Asian j. exp. Sci*. 2007; 21(1): 145- 150.
16. Trakranrungsie N, Chatachawanchonteera A, Khunkitti W. Ethanoveterinary study for antidermatophytic activity of *P. betle*, *Alpinia galanga* and *Allium ascalonicum* extract in vitro. *Research in veterinary sciences*. 2008; 84(1): 80-84.
17. Walter TM, Sofia HN. Effect of consumption of thamboolam (conventional betel chewing) intraditionalsiddha medicine. <http://openmed.nic.in/2223/01/ Thamboolam.pdf>. 9 July, 2007.



Critical Period of Crop Weed Competition in rice (*Oryza sativa* L.)

N.S. Kular and U.S. Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab

Abstract

A field experiment was carried out during *kharif* season of 2019 at the Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) to study the effect of crop weed competition on yield of rice. The experimental field tested was low in organic carbon (0.48%) and low in available nitrogen (144.6 kg N/ha) medium in available phosphorus (17.3 P₂O₅/ha) and available potassium (168 kg K₂O/ha). Treatments consisted of weed free up to 45 days, weed free up to 30 days, weed free up to 15 days, weedy up to 45 days, weedy up to 30 days, weedy up to 15 days, weed free and unweeded control. The field experiment was laid out in randomized complete block design (RCBD) with eight treatments in three replications. The crop was sown by broadcast on May 26 and transplanted on 1 July 2019 and at row to row spacing of 20 cm with plant to plant distance of 15 cm. The highest weed density and weed dry weight were recorded in weedy check treatment (71.7 plants/m² and 227.3 g/m² respectively), whereas, the corresponding value in weedy up to 15 days treatment were 8.7 plants/m² and 12.7 g/m², respectively. The weed control efficiency was maximum in weed free treatment (100%) followed by weedy up to 15 days (94.3%). The growth parameters, yield attributes and grain yield were significantly influenced by the period of crop weed competition. The highest grain yield was recorded in weed free throughout (83.3 q/ha) but at par with weedy up to 15 days (80.0 q/ha) and weed free up to 45 days (77.4 q/ha) but was significantly higher than the rest of the treatments. Similar trend was also observed in growth parameters and yield attributes. The critical period of crop weed competition was found to be 15-45 days after transplanting.

Key words : Rice, crop weed competition, growth, yield attributes and yield.

Introduction

Rice (*Oryza sativa* L.) is the leading cereal of the world (Juraimi *et al.*, 2013) and the most important and extensively grown in tropical and subtropical regions and is staple food for more than 60 per cent of the world population (Parameswari and Srinivas, 2017). It can grow well on soils with low permeability and over a wide range of soil reaction viz. pH 5 to 9. Generally, the loamy soils are the best for rice cultivation (Anonymous, 2020a). The critical period of crop-weed competition varies considerably with the crop cultivar, weed flora, weed incidence, climatic and edaphic condition. The most critical period for competition between the paddy and weeds is when the paddy is in the vegetative phase. In general, critical period of crop-weed competition remains throughout crop growth period from 15 to 45 days after transplanting. In general, larger the duration of crop-weed competition, higher the reduction in grain yield (Singh *et al.*, 2013).

Materials and Methods

The present investigation was carried out during the autumn season of 2019 at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab). Geographically it is located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The

experimental field tested was low in organic carbon (0.38 %) and available soil nitrogen (144.6 kg N/ha), medium in available soil phosphorus (17.3 P₂O₅/ha) and high in available soil potassium (168 kg K₂O/ha).

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and eight treatments as: T₁ - Weed check, T₂ - Weed free throughout, T₃ - Weed free up to 45 days, T₄ - Weed free up to 30 days, T₅ - Weed free up to 15 days, T₆ - Weedy up to 45 days, T₇ - Weedy up to 30 days, T₈ - Weedy up to 15 days. The gross plot size was 4.40 m × 2.55 m and net plot size was 4.20 m × 2.40 m. The crop was sown by broadcast on June 12 and transplanted on 25 July 2019 and at row to row spacing of 20 cm with plant-to-plant distance of 15 cm. The recommended dose of fertilizer 105 kg N/ha was applied through urea into two equal splits, one after three weeks of transplanting and another at six weeks after transplanting. The crop was sown on July 1, 2019 and harvested on October 17, 2019.

Results and Discussion

Weed studies : Major weed flora observed in the experimental field were *Echinochloa colona*, *Echinochloa crusgalli*, *Cyperus difformis*, *Cyperus irri* and *Cyperus rotundus*. Weed density was significantly influenced by crop weed competition treatments (Table-1). Weedy check treatment recorded the highest number of weed density (71.7 plants m⁻²) and dry matter of weed (227.3 g

Table-1 : Effect of crop weed competition on the weed density, weed dry weight, weed control efficiency in rice.

Treatments	Weed density (m ⁻²)	Weed dry weight (g/m ⁻²)	Weed control efficiency (%)
Weedy check	8.50 (71.7)	15.1 (227.3)	-
Weed free throughout	0.71 (0.00)	0.71 (0.00)	100
Weed free up to 45 days	3.98 (15.3)	5.21 (26.7)	88.3
Weed free up to 30 days	4.26 (17.7)	6.84 (46.6)	79.6
Weed free up to 15 days	8.13 (65.7)	13.41 (179.3)	20.9
Weedy up to 45 days	6.70 (44.3)	13.12 (171.7)	24.2
Weedy up to 30 days	5.90 (34.3)	11.99 (143.3)	36.7
Weedy up to 15 days	3.03 (8.7)	3.63 (12.7)	94.3
C.D.	2.11 (3.96)	3.47 (11.5)	5.00

Data were subjected to square root ($\sqrt{x} + 0.5$) transformation and the figures in parentheses are the original values.

Table-2 : Effect of crop weed competition on the growth parameters, yield attributes and yield of rice.

Treatments	Plant population (m ⁻²)	Plant height (cm)	Tillers/hill	Panicles hill ⁻¹	Test weight (g)	Grain yield (q/ha)	Straw weight (q/ha)	Harvest index (%)
Weedy check	30.0	77.4	11.07	9.80	20.7	57.9	87.0	40.8
Weed free throughout	31.3	89.9	15.07	14.3	24.0	83.3	99.5	45.6
Weed free up to 45 days	29.3	84.9	13.7	12.9	23.0	77.4	97.9	45.3
Weed free up to 30 days	28.0	82.1	13.0	12.1	22.3	72.1	93.6	43.9
Weed free up to 15 days	29.0	78.8	12.07	11.1	21.7	65.5	86.6	43.4
Weedy up to 45 days	28.0	79.3	12.13	10.7	22.0	68.5	89.3	43.7
Weedy up to 30 days	29.3	81.6	12.73	11.9	21.7	73.4	94.6	44.5
Weedy up to 15 days	30.0	87.7	14.3	13.1	23.3	80.0	96.6	45.2
C.D.	NS	7.4	1.17	1.11	NS	8.80	8.4	NS

m⁻²) as compared with rest of the treatments. The highest weed control efficiency was recorded in weed free treatment (100%) followed by weedy up to 15 days (94.3 %). The losses caused by weeds increased linearly with the increased weed-infestation duration from 15 to 45 days and decreased with the increased weed-free duration. Similar results have also been reported by Khaliq and Matloob (2011).

Growth parameters : The plant population of rice was not influenced significantly by the crop weed competition treatments (Table-2). Different crop weed competition treatments significantly influenced the plant height. The higher plant height of rice (89.9m cm) was obtained with weed free throughout which was at par with weedy up to 15 days (87.7 cm) and weed free up to 45 days (84.9 cm). whereas, minimum plant height was noticed in weedy check treatments (77.4 cm). Rahman *et al* (2014) also obtained significantly taller plant (138.8 cm) under height weed free condition and it was followed (136.1 cm) by 10 days for weed competition.

Tiller is the vital morphological character related with vegetative growth. Tillers hill⁻¹ at harvest was also influenced significantly with weed control treatments (Table 2). Significantly higher tillers hill⁻¹ (15.7) were observed in weed free treatment which was at par with weedy up to 15 days (14.3) and weed free up to 45 days

(13.7) the minimum tillers hill⁻¹ were noticed in weedy check treatment (11.1). The higher tillers in weed free treatment was might be due to less competition between the crop and the weeds. Mukherjee *et al.*, (2008) also found similar result.

Yield and yield attributes : 1000 grain weight (g) were also influenced significantly by different crop weed competition treatments (Table-2). All the crop weed competition treatments recorded significantly more number of panicles per hill as compared to weedy check. Weed free treatment recorded significantly higher panicles per hill (14.3) which was at par with weedy up to 15 days (13.1) and weed free up to 45 days (12.9) and was significantly higher than rest of the treatments. Mukherjee *et al.*, (2008) also noticed similar results.

The grain yield of rice was affected significantly by crop weed competition. The significantly higher grain yield of rice (83.3 q/ha) was obtained with weed free throughout which was at par with weedy up to 15 days (80 q/ha) and weed free up to 45 days (77.4 q/ha). The higher yield under weed free throughout, weedy up to 15 days and weed free up to 45 days treatments could be ascribed to better control of weeds which might have favored higher uptake of nutrients and water, might have helped the crop to put optimum growth characters. Further, it might have enhanced photosynthetic activity and partitioning of

assimilates resulting in improvement of yield. Juraimi *etal.*, (2009) also obtained significantly higher rice grain yields (54.0 and 52.0 q/ha) in weed free treatment throughout sowing to maturity.

Conclusions

It may be concluded that higher grain yield of rice can be obtained by keeping the crop weed free during the period of 15 to 45 days after transplanting which is the critical period of crop weed competition in rice.

References

1. Anonymous (2020). Package of Practice for the Crop of Punjab Kharif, *Punjab Agricultural University Ludhiana*. 37(1): 1-17.
2. Juraimi A.S., Saiful A.H.M., Uddin M.K., Anwar M.P., Azmi M. (2013). Sustainable weed management in direct seeded rice culture: A review. *Australia. Journal Crop Science*, 7(7): 989-1002.
3. Juraimi A.S., Mohamad Najib M.Y., Begum M., Anura A.R., Azmi M. and Puteh A. (2009). Critical period of weed competition in direct seeded rice under saturated and flooded condition. *Pertanika Journal Tropical Agriculture Science*, 32(2): 305-16.
4. Khaliq A and Matloob A. (2011). Weed-crop competition period in three fine rice cultivars under direct-seeded rice culture. *Pakistan Journal of Weed Science Research* 17(3): 229-243
5. Mukherjee P.K., Sarkar A. and Maity S.K. (2008). Critical period of crop-weed competition in transplanted and wet-seeded *kharif* rice (*Oryza sativa* L.) under Terai conditions. *Indian Journal Weed Science*, 40:147–52.
6. Parameswari Y.S., and A. Srinivas A. (2017). Weed management in rice. *International Journal of Applied and Pure Science and Agriculture*, 3(1): 75-80.
7. Rahman M.T, Ahmed S., Lipi N.J., Rashid M.H. and Hoque M.I. (2014). Critical period of weed competition in transplant aus rice cv. brri dhan27 under non-saline agro-ecosystem. *Bangladesh Agronomy Journal*, 17(1): 95-102.
8. Singh, T., Lal, B. and Satapathy, B.S. (2013). Weed management in paddy. *Popular Kheti*, 1(2): 10-15.



Effect of Drought Stress on Germination of Sesame Germplasm under Laboratory Conditions

Roshni Sahu*, Rajani Bisen, Anand Pandey and Surabhi Jain

Project Coordinating Unit Sesame and Niger, JNKVV, Jabalpur, M.P.

Email : roshnisahujbp@gmail.com

Abstract

Drought is one of the most disturbing environmental stresses and it is multidimensional stress effecting plants at various levels of their organization and one of the most important environmental factors in reduction of growth, development and production of plants. Drought stress causes loss of water use efficacy, induction of heat stress and reduces stem extension. About one third of the world potentially arable land facing water shortage problem and mostly crop yields are often reduced by drought. Drought stress with osmotic materials for producing osmotic potential are one of the important approaches to study the drought stress effects on germination. Polyethylene glycol helps in making semi natural environment under laboratory conditions, used for adjusting water potential at germination stage. Experimental treatments included osmotic potential in 4 levels (0, -0.15, -0.49, -1.03 and -1.76 bar) which was produced by polyethylene glycol 6000 and 30 sesame white germplasm accessions having high oil content were tested against four levels of PEG 6000 in factorial completely randomized design with three replication. Fifty seeds of each germplasm accessions were allowed to germinate in a petridish containing 10 ml of appropriate levels of PEG 6000. On considering the different genotypes the values of germination percent were found significantly higher 79.3, 77.5, 75.9, 75.1 and 74.4% with SI-266 followed by NIC-8080-A, SP-1162, KMR-48-A and IC-132181 respectively from rest of the genotypes. Root length were observed numerically maximum 1.34, 1.32, 1.30 and 1.29 cm with SI-266 followed by NIC-8080-A, SP-1162 and C-132410. The statistically significant reductions were recorded in mean value of shoot length from 2.77 to 0.31cm with an increasing level of PEG 6000.

Introduction

Plants respond to fluctuations in environmental stress through a number of ways which enable them adjust in order to cope with such stresses. These include anatomical, morphological or physiological responses. Water is one of the major limiting resources in the semiarid and regions of the world, and the available water resources also determine the extent to which other resources could be developed or efficiently utilized. One of the measurements that relate directly to plant responses to water deficit is germination of seeds in solutions of high osmotic tension. A direct and inseparable relationship is known to exist between salts such as sodium chloride, calcium chloride and potassium sulphate and water stress. Solutions of polyethylene glycol have been used widely to provide a range of water potentials to simulate osmotic stress (Sharma, 1973; Mensah and Okpere, 2000). In the field, plants respond to water deficit by decreasing stem number/branches, internode and leaf size but increase in root mass (Hall *et al.*, 1988). Plants also adapt to water stress through changes in leaf area, chlorophyll content and relative water content of the leaves. The aim of the present study is to fill the gap in our knowledge about the changes in agronomic and yield parameters of sesame in respect of drought stress.

Materials and Methods

Drought stress with osmotic materials for producing osmotic potential are one of the important approaches to study the drought stress effects on germination. Polyethylene glycol helps in making semi natural environment under laboratory conditions, used for adjusting water potential at germination stage. Experimental treatments included osmotic potential in 4 levels (0, -0.15, -0.49, -1.03 and -1.76 bar) which was produced by polyethylene glycol 6000 and 30 sesame white germplasm accessions having high oil content were tested against four levels of PEG 6000 in factorial completely randomized design with three replication. Fifty seeds of each germplasm accessions were allowed to germinate in a petridish containing 10 ml of appropriate levels of PEG 6000. The emergence of radicle from the seeds was used to score for germination (ISTA, 1976), whereas measurements of radicle and shoot length were taken from 10 day old seedlings grown in petri plates.

Results and Discussion

Germination percentage : The impact of drought on germination percent of different genotype were depicted in Table 6.7 (a). The mean germination (%) reduced from 97 to 44% with an increased level of drought stress which was significantly higher germination (97%) in controlled condition and lowest germination (44%) were recorded

Table-1 : Effect of Osmotic potential induced by PEG 6000 on seed germination (%)

S.No.	Germplasm	Osmotic potential (Mpa)					Mean
		0	-0.15	-0.49	-1.03	-1.76	
1	SI-266	98.3	91.7	81.0	67.7	58.0	79.3
2	NIC-8080-A	98.7	95.0	83.3	65.4	45.3	77.5
3	SP-1162	97.0	95.0	81.3	62.2	44.2	75.9
4	KMR-48-A	96.3	92.3	80.0	62.5	44.2	75.1
5	IC-132181	97.7	92.3	80.7	58.1	43.3	74.4
6	IS-56-B	96.0	93.3	77.7	57.2	41.7	73.2
7	KMS-5-361	96.3	91.3	75.7	60.1	45.3	73.7
8	C-132410	96.0	92.0	72.7	56.5	44.2	72.3
9	SP-41	98.7	91.0	75.0	55.8	44.2	72.9
10	SI-506-A	96.3	91.3	74.3	54.7	43.3	72.0
11	KMS-4-278	97.3	88.7	73.7	56.8	45.3	72.3
12	IS-347-1	97.3	90.3	72.0	53.8	44.2	71.5
13	NIC-8554	95.3	91.0	75.3	52.6	40.9	71.0
14	IS-562-A	95.3	90.7	74.3	53.9	38.9	70.6
15	IS-491-A	96.0	87.0	74.0	52.2	37.7	69.4
16	SI-7650	98.3	91.3	75.7	62.0	41.7	73.8
17	IC-32-C	96.0	88.7	75.7	53.1	45.3	71.7
18	S-0320	97.0	88.3	74.0	56.7	44.2	72.0
19	KM-40	95.3	91.0	75.0	50.7	44.2	71.3
20	IC-56162	96.3	92.7	73.0	49.9	43.3	71.0
21	T-1-A	96.0	93.7	75.7	60.0	41.7	73.4
22	IS-157-A-1	96.3	90.3	74.7	59.0	45.3	73.1
23	KMS-5-332	96.3	89.3	78.0	59.0	44.2	73.4
24	GAG-15-A	98.0	90.3	70.7	56.0	44.2	71.8
25	NIC-9852-A	96.3	89.3	73.0	55.6	43.3	71.5
26	KMS-5-368	98.3	87.3	70.3	56.6	45.3	71.6
27	EC-303304-A	97.7	88.7	70.7	54.3	44.2	71.1
28	IS-187	97.0	87.0	71.7	53.5	40.9	70.0
29	S-0022	95.7	89.7	69.3	50.2	38.9	68.8
30	ES-108-3-84-A	98.0	91.0	70.7	50.2	43.3	70.6
	Mean	96.8	90.7	75.0	56.5	43.7	72.5
SEm ($\pm$) for condition			0.80	LSD (p=0.05)for Condition			2.22
SEm ($\pm$) for Germplasm			1.96	LSD (p=0.05) for Germplasm			5.43
SEm ($\pm$) for GermplasmXCondition			4.38	LSD (p=0.05) for GermplasmXCondition			12.15

with osmotic potential -1.76 MPa. On considering the different genotypes the values of germination percent were found significantly higher 79.3, 77.5, 75.9 75.1 and 74.4% with SI-266 followed by NIC-8080-A, SP-1162, KMR-48-A and IC-132181 respectively from rest of the genotypes.

The interactions between genotype and drought conditions were found significantly higher (95 to 98%) with the control condition from 69.3 to 83% with Osmotic potential -0.49Mpa was applied. While the germination percentage of various genotypes were found at par when Osmotic potential -0.15 Mpa was applied. However, the lowest values 37.7 to 58% were recorded with Osmotic potential -1.76 Mpa. Water absorption and seed swelling considered as the first step in germination, while cell division and elongation are last steps. By decreasing

osmotic potential, water absorption will decrease as well as cell division (Zaefizadeh *et al.*, 2011).

Root length (cm) : The root length of sesame germplasms were affected with increasing dose of osmotic potential induced by PEG 6000. The statistically significant reductions were obtained in mean value of root length (cm) significantly from 2.31 to 0.33 cm with an increased level of drought stress. The maximum mean root length (2.30 cm) were recorded without PEG solution while lowest value was found with the application of osmotic potential -1.76 Mpa solution. On considering the different germplasms the values of mean root length were observed numerically maximum 1.34, 1.32, 1.30 and 1.29 cm with SI-266 followed by NIC-8080-A, SP-1162 and C-132410 respectively over rest of the germplasms length. The interactions between germplasm and drought

Table-2 : Effect of Osmotic potential induced by PEG 6000 on Root length (cm).

S.No.	Germplasm	Osmotic potential (Mpa)					Mean
		0	-0.15	-0.49	-1.03	-1.76	
1	SI-266	2.17	2.07	1.27	0.97	0.20	1.34
2	NIC-8080-A	2.13	1.90	1.30	1.13	0.13	1.32
3	SP-1162	2.20	1.67	1.23	1.13	0.27	1.30
4	KMR-48-A	2.13	1.50	1.33	0.67	0.17	1.16
5	IC-132181	2.20	1.43	1.23	0.87	0.17	1.18
6	IS-56-B	2.40	1.43	1.23	0.97	0.23	1.25
7	KMS-5-361	1.47	1.57	1.30	0.90	0.23	1.09
8	C-132410	2.43	1.50	1.20	0.87	0.43	1.29
9	SP-41	2.37	1.47	1.30	0.87	0.27	1.26
10	SI-506-A	2.30	1.50	1.10	1.00	0.23	1.23
11	KMS-4-278	2.23	1.57	1.10	1.03	0.37	1.26
12	IS-347-1	2.30	1.57	0.90	1.10	0.23	1.22
13	NIC-8554	2.13	1.63	0.83	1.10	0.40	1.22
14	IS-562-A	2.07	1.57	0.80	1.00	0.33	1.15
15	IS-491-A	2.27	1.57	0.90	0.93	0.33	1.20
16	SI-7650	2.30	1.63	0.90	0.83	0.47	1.23
17	IC-32-C	2.40	1.53	0.94	0.77	0.57	1.24
18	S-0320	2.37	1.30	0.97	0.93	0.40	1.19
19	KM-40	2.50	1.40	0.77	0.87	0.30	1.17
20	IC-56162	2.43	1.33	0.77	0.80	0.47	1.16
21	T-1-A	2.43	1.20	0.97	0.97	0.23	1.16
22	IS-157-A-1	2.50	1.40	1.00	0.93	0.33	1.23
23	KMS-5-332	2.40	1.40	1.07	0.87	0.30	1.21
24	GAG-15-A	2.60	1.47	0.90	0.70	0.43	1.22
25	NIC-9852-A	2.47	1.23	0.97	0.67	0.23	1.11
26	KMS-5-368	2.63	1.33	1.00	0.77	0.30	1.21
27	EC-303304-A	2.57	1.13	1.03	0.77	0.37	1.17
28	IS-187	2.30	1.08	0.83	0.83	0.43	1.09
29	S-0022	2.33	1.30	1.00	0.80	0.30	1.15
30	ES-108-3-84-A	2.27	1.27	0.83	0.77	0.23	1.07
	Mean	2.31	1.47	1.03	0.89	0.31	1.20
SEm ($\pm$) for condition			0.08	LSD (p=0.05) for Condition			0.23
SEm ($\pm$) for Germplasm			0.20	LSD (p=0.05) for Germplasm			0.57
SEm ($\pm$) for GermplasmXCondition			0.46	LSD (p=0.05) for GermplasmXCondition			1.27

conditions were found statistically higher (2.63 to 1.47cm) without application of PEG solution over 1.27 to 0.80cm when Osmotic potential -0.49Mpa was applied. The concentration of Poly Ethylene -0.49, -1.03 and -1.76 Mpa significantly reduced the root length of germplasms. It means these concentrations were found suitable to create desired stress condition in various sesame germplasms. Another important feature for drought stress is root length, because it has direct contact with soil and water absorbance. As result, root length make important clue to a plants response to drought stress (Mostafavi *et al.*, 2011). The primary organ of young plant extension is hypocotyls, which after emergence of radicle emerge; in drought stress, radicle will develop faster than hypocotyls to compensate for water stress (Zhu *et al.*, 2005). So at germination stage growth of hypocotyls and radicle

reflects tolerance of shoot to drought (Shi and Ding 2000). From aforementioned studies can conclude that reduction of root and shoot could be referred to reduction of cell division which is caused by water stress. In addition, cause of root and shoot dry weight's reduction is reductions in root and shoot lengths.

Shoot length (cm) : The data of shoot length of sesame germplasms were recorded with increasing level of osmotic potential induced by PEG 6000 . The statistically significant reductions were recorded in mean value of shoot length from 2.77 to 0.31cm with an increasing level of PEG 6000 (0, -0.15, -0.49, -1.03 and -1.76 respectively). The mean shoot length of various germplasms were critically observed and found that numerically maximum 1.33, 1.32, 1.30, 1.29 and 1.26 cm with SI-266 followed by NIC-8080-A, SP-1162 C-132410

Table-3 : Effect of Osmotic potential induced by PEG 6000 on shoot length (cm).

S.No.	Germplasm	Osmotic potential(Mpa)					Mean
		0	-0.15	-0.49	-1.03	-1.76	
1	SI-266	2.70	2.10	1.33	1.33	1.33	1.33
2	NIC-8080-A	2.73	2.03	1.23	1.23	1.23	1.23
3	SP-1162	2.70	1.70	1.21	1.21	1.21	1.21
4	KMR-48-A	2.60	1.80	1.21	1.21	1.21	1.21
5	IC-132181	2.73	1.30	1.22	1.22	1.22	1.22
6	IS-56-B	2.73	1.90	1.24	1.24	1.24	1.24
7	KMS-5-361	2.67	1.90	1.21	1.21	1.21	1.21
8	C-132410	2.63	1.80	1.21	1.21	1.21	1.21
9	SP-41	2.73	1.63	1.13	1.13	1.13	1.13
10	SI-506-A	3.17	1.63	1.26	1.26	1.26	1.26
11	KMS-4-278	3.07	1.73	1.26	1.26	1.26	1.26
12	IS-347-1	2.93	1.77	1.27	1.27	1.27	1.27
13	NIC-8554	2.70	1.13	1.25	1.25	1.25	1.25
14	IS-562-A	2.53	1.80	1.11	1.11	1.11	1.11
15	IS-491-A	2.43	1.80	1.13	1.13	1.13	1.13
16	SI-7650	2.50	1.70	1.14	1.14	1.14	1.14
17	IC-32-C	2.50	1.73	1.09	1.09	1.09	1.09
18	S-0320	2.53	1.83	1.15	1.15	1.15	1.15
19	KM-40	2.47	1.77	1.09	1.09	1.09	1.09
20	IC-56162	2.50	1.63	1.09	1.09	1.09	1.09
21	T-1-A	2.60	1.90	1.14	1.14	1.14	1.14
22	IS-157-A-1	2.50	2.10	1.14	1.14	1.14	1.14
23	KMS-5-332	2.43	2.17	1.17	1.17	1.17	1.17
24	GAG-15-A	2.40	2.23	1.15	1.15	1.15	1.15
25	NIC-9852-A	2.50	2.37	1.24	1.24	1.24	1.24
26	KMS-5-368	2.60	1.90	1.16	1.16	1.16	1.16
27	EC-303304-A	2.80	1.87	1.22	1.22	1.22	1.22
28	IS-187	2.77	1.37	1.15	1.15	1.15	1.15
29	S-0022	2.80	1.60	1.19	1.19	1.19	1.19
30	ES-108-3-84-A	2.77	1.53	1.12	1.12	1.12	1.12
	Mean	3.20	2.21	0.73	0.36	0.18	1.34
SEm ($\pm$) for condition			0.04	LSD (p=0.05)for Condition			0.11
SEm ($\pm$) for Germplasm			0.09	LSD (p=0.05) for Germplasm			0.26
SEm ($\pm$) for GermplasmXCondition			0.21	LSD (p=0.05) for GermplasmXCondition			0.59

and KMS-4-278 respectively over rest of the sesame germplasms. On looking to the interactions, it was noticed that the shoot length of germplasm associated with osmotic potential induced by PEG levels statistically differ from control condition to higher level of stress conditions (-1.76). The maximum shoot length (3.17 to 2.43 cm) were obtained without application of PEG solution while lowest value of shoot length of all the germplasms were found with the Osmotic potential -1.76 Mpa ranged from 0.17 to 0.43 cm. The condition was highly stress to the shoot elongation.

References

1. Abnos M. (2001). Study of physiological effects of drought stress on germination and seedlings of lentil spices, M.Sc. dissertation of plants physiology, Science College, Ferdosi University, Mashhad. 147 Pp.
2. Bahrami, H,J, Razmjoo, and A, Ostadi Jafari, (2012). Effect of drought stress on germination and seedling growth of sesame cultivars (*Sesamum indicum* L.). International Journal of Agri Science 2(5): 423-428.
3. Hadas, A, (1976). Water uptake and germination of leguminous seeds in soils of changing matrix and osmotic water potential. *J Exp Bot.* 28: 977-985.
4. Hall MH, Sheaffer CC, Heichel GH (1988). Partitioning and Mobilization of Phytoassimilates in Alfalfa Subjected to water deficit. *Crop Sci.* 8: 879-159.
5. Heikal, M.M, M.A, Shaddad, and A.M, Ahmed, (1982). Effect of water stress and gibberellic acid on germination of flax, sesame and onion seed. *Biol Plant* 24:124-129.
6. Mensah, J.K, B.O, Obadoni, P.G, Eroutor, and F, Onome-Irieguna, (2006). Simulated flooding and drought effects on germination, growth, and yield parameters of sesame (*Sesamum indicum* L.). *Afr J Biotechnol.* 5(13): 1249-1253.

7. Michel, B.E, and M.R, Kaufmann, (1973). The osmotic potential of Polyethylene glycol 6000. *Plant physiology* 51: 914-916.
8. Mostafavi, K, H, Sadeghi Give, M, Dadresan and M, Zarabi, (2011). Effects of drought stress on germination indices of corn hybrids (*Zea mays* L.) *Int. J. Agri. Sci.* 1(2): 10-18.
9. Orruno, E, and M.R.A, Morgan, (2007). Purification and characterization of the 7S globulin storage protein from sesame (*Sesamum indicum* L.). *Food Chem.* 100: 926-934.
10. Rade, D, And R.K. Kar, (1995). Seed germination and seedling growth of mange bean under water stress induced by PEG 6000. *Seed Sci and Technol.* 23: 301-308.
11. Sediyma, T., A.A, Cardoso, and C. Vieira, (1972). Tests Preliminares sobre os efeitos do retardamento da colheita da soja cultivar vicoja. *Rev. Ceres* 19: 306-310.
12. Shi, J.Y, and G.J, Ding, (2000). Effects of water stresses on *Pinus massoniana* seeds from different provenances. *J Mountain Agr Bio.* 19: 332-337.
13. Sharma ML. (1973). Stimulation of drought and its effects on germination of five pasture species. *Argon. J.* 68: 619-622.
14. Turk, M.A, A, Rahmsn, and M Lee K.D, Tawaha, (2004). Seed germination and seedling growth of three lentil cultivars under moisture stress. *Asian J Plant Sci.* 3: 394-397.
15. Zaefizadeh, M, S, Jamaati-e-Somarin, R, Zabihi-e-Mahmoodabad, and M, Khayatnezhad, (2011). Discriminate analysis of the osmotic stress tolerance of different sub-cultivars of durum wheat during germination. *Adv Environ Biolo.* 5(1): 74-80.
16. Zhu, J.J, H.Z, Kang, H, Tan, M.L, Xu, and J,Wang, (2005). Natural regeneration characteristics of natural *Pinus Sylvestris* var. *Mongolia* forests on sunny land in Honghuaerji. *China J For Res.* 16: 253-259.



Evaluation of Reproduction Traits in Halfbred and Three Breed Crosses of Gir

S.R. Garudkar¹, S.D. Mandakmale² and C.A. Nimbalkar³

¹College of Agric. Biotech., Dept. Animal Biotech., Ahmednagar, Affiliated to MPKV, Rahuri

²AICRP on Sangamneri Goat Imp., MPKV, Rahuri, M.S.

³Dept. of Statistics, MPKV, Rahuri-413 722 M.S.

Email : mailmesuwarna@rediffmail.com

Note : A Part of the Ph.D. Thesis submitted by the First author to MPKV, Rahuri, M.S.

Abstract

Till today, improvement of milk production was given major importance in crossbreds without giving due attention to reproductive traits. This study was conducted to compare reproduction traits and effect of some factors on pure (FG and FJG) versus their interbreds (IFG and IFJG) in halfbred and three breed crosses of Gir. Data pertaining to 855 halfbred and 808 three breed crosses of Gir cows spread over a period of 41 years (1972-2012) maintained at Research Cum Development Project on Cattle, MPKV, Rahuri were analyzed by linear models of least-squares means (SAS, 2011). The results indicated significant effect of period of birth on age at first calving in all genetic groups. Period of calving had significant effect on waiting period in IFJG and FJG, respectively. Pregnancy rate one of the most important reproductive traits non-significantly affected by all genetic and non-genetic factors in both genetic groups. From the results it could be concluded that the halfbreds performed better than the three breed crosses of Gir.

Key words : Age at first calving, waiting period, service period, pregnancy rate

Introduction

The crossbreeding of cattle programme was initially started at military dairy farms. Afterward systemic crossbreeding was planned at six centers as All India Co-ordinated Research Projects (AICRP) on Cattle during 1970. In Maharashtra, one of the projects was started at Mahatma Phule Krishi Vidyapeeth, Rahuri. The Indian Council of Agricultural Research (ICAR) terminated this programme in 1986. Later on the AICRP on Cattle is designated as Research-Cum-Development Project (RCDP) on Cattle. Gir cow was used as foundation stock, to produce crossbreds. Consequently number of halfbreds and three breeds from two exotic breeds were produced. The promising grades, FG (Holstein Friesian-Gir) and FJG (Holstein Friesian-Jersey-Gir) had been bred *interse* followed by rigorous selection and their performances were tested.

The impact of progeny testing programme was assessed on the basis of milk yield only; however the impact on fertility status of cattle was not assessed so far under RCDP on cattle.

Long term intense selection of dairy animals for milk production will exacerbate the decline on reproductive traits (Pryce *et al.*, 1999; Lucy, 2001; Scott McDougall, 2006; Kadarmideen *et al.*, 2007). To overcome the deterioration in reproductive traits, more emphasis needs to be given on reproductive traits. There is a scope for improving the reproductive traits by means of selection.

Many countries have incorporated fertility where they have used pregnancy rate (PR) and daughters pregnancy rate (DPR) for genetic evaluation of their male and female animals (Van Raden, 2001; Pearson, 2006; De Vries, 2010; Cabrera, 2011).

Pregnancy rate is defined as the percentage of non pregnant cows that become pregnant during each 21-d period, because each oestrus cycle represents one chance for a cow to become pregnant. In recent years, many reports have recommended this measure of reproductive success over the service period. Pregnancy rate encompasses a cow's ability to return to normal reproduction status after calving, to display visible signs of oestrus, to conceive when inseminated and to maintain the pregnancy. Better pregnancy rates reduce semen usage and can be an important part of efforts to reduce days open. Pregnancy rate calculations assume that the voluntary waiting period (VWP) is the initial phase of lactation during which no insemination occur.

The present study was under taken to evaluate reproduction performance traits in halfbred and three breed crosses of Gir.

Materials and Methods

Data pertaining to 855 halfbred and 808 three breed crosses of Gir cows spread over a period of 41 years (1972-2012) maintained at Research Cum Development Project on Cattle, MPKV, Rahuri were analyzed to

Table-1 : ANOVA for factors affecting on Age at first calving, Waiting period, Service period and Pregnancy rate in halfbred and three breed crosses of Gir.

Trait	Age at first calving							
Source of variation	Genetic group							
	FG		IFG		FJG		IFJG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
POB	2	48446.60**	1	64515.35**	4	215972.83**	5	374373.52**
SOB	2	4434.23	2	2285.75	2	38206.32	2	17751.04
Error	162	5894.40	113	4237.89	325	19429.23	372	16658.35
Trait	Waiting period							
Source of variation	Genetic group							
	FG		IFG		FJG		IFJG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
POB	1	2189.03*	4	2553.10*	1	212.75	5	6146.24**
SOB	2	1530.58	2	147.77	2	52.08	2	637.70
LO	5	684.13	5	1658.80	5	1573.51	5	1058.37
AFCG	5	712.30	5	2078.66	5	792.86	5	1836.85
Error	455	640.85	663	955.71	217	953.48	732	1781.23
Trait	Service period							
Source of variation	Genetic group							
	FG		IFG		FJG		IFJG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
POB	1	5641.12	4	6611.66	1	1773.17	5	11307.62
SOB	2	8295.11	2	7582.39	2	4324.42	2	8503.42
LO	5	3670.90	5	6011.95	5	2350.55	5	2372.71
AFCG	5	2340.38	5	1768.39	5	3371.47	5	1746.01
Error	323	4839.10	576	5482.11	183	5043.02	689	6604.10
Trait	Pregnancy rate							
Source of variation	Genetic group							
	FG		IFG		FJG		IFJG	
	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.	d.f.	M.S.S.
POB	1	0.0330	4	0.0269	1	0.0114	5	0.0237
SOB	2	0.8622	2	0.0958	2	0.0423	2	0.0098
LO	5	0.0468	5	0.0573	5	0.0242	5	0.0324
AFCG	5	0.1712	5	0.0455	5	0.0258	5	0.0433
Error	323	0.0532	576	5482.11	158	0.0488	689	6604.10

** : P < 0.01 * : P < 0.05

evaluate the reproductive performance traits. Data of reproduction traits were standardized and normalized.

The pregnancy rates of cows in each lactation were calculated as suggested by USDA (2003).

$DPR = 21 / (\text{service period} - \text{voluntary waiting period} + 11)$

The constant factors 11 centralize the measure of possible conception within each 21 days time period. The voluntary waiting period (VWP) varies in the range of 70-90 days. However, to have the precise estimates, standard voluntary waiting period of 63 days was considered to estimate the pregnancy rate. The data of total 41 years from 1972-2012 were collected and grouped in periods as:

(i) Period of birth : for FG genetic group P₁ (19742-1973), P₂ (1974-1975) and P₃ (1976-1977), for IFG genetic group P₁ (1980-85), P₂ (1986-91), P₃ (1992-97), P₄ (1998-2003) and P₅ (2004 and above), for FJG genetic group P₁ (1975-77) and P₂ (1978-80) and for IFJG genetic group P₁ (1977-82), P₂ (1983-88), P₃ (1989-94), P₄ (1995-2000), P₅ (2001-06) and P₆ (2007 and above).

(ii) Period of calving : for FG genetic group P₁ (1974-1979) and P₂ (1980-1985), for IFG genetic group P₁ (1982-87), P₂ (1988-93), P₃ (1994-99), P₄ (2000-2005) and P₅ (2006 and above), for FJG genetic group P₁ (1977-82) and P₂ (1983-88) and for IFJG genetic group P₁ (1979-84), P₂ (1985-90), P₃ (1991-96), P₄ (1997-2002), P₅ (2003-08) and P₆ (2008 and above).

Table-2 : Least squares means for AFC (days) in halfbred and three breed crosses of Gir.

Source of variation	Halfbred						Three breed crosses of Gir					
	FG			IFG			FJG			IFJG		
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
μ	167	793.62	6.22	332	1020.83	8.16	117	800.83	6.36	380	949.10	7.49
Period of birth												
1972-73	41	836.93 ^a	13.33	77	955.36 ^c	16.74	68	781.15b	7.07	90	930.28bc	12.80
1974-75	57	788.93 ^b	11.01	63	976.43 ^{bc}	18.84	49	828.16a	10.50	109	873.95c	12.13
1976-77	69	771.78 ^b	7.81	75	1068.28 ^a	17.87	-	-	-	108	972.02b	13.33
-	-	-	-	63	1090.57 ^a	18.74	-	-	-	44	1110.27a	17.23
-	-	-	-	54	1018.72 ^b	19.76	-	-	-	18	970.00b	38.16
-	-	-	-	-	-	-	-	-	-	11	943.82b	33.74
Season of birth												
Rainy	57	804.14	11.19	104	995.58	11.41	29	794.21	13.14	115	958.09	14.17
Winter	61	798.10	9.57	112	1017.95	11.49	44	799.16	14.48	142	949.47	12.13
Summer	49	775.84	11.61	116	1046.26	10.03	44	806.89	14.29	123	940.27	12.89

Means under each class in the same column with different superscripts differed significantly.

(iii) **Season of birth and Calving** : Each year was divided into three seasons namely Rainy (June-September), Winter (October-January) and Summer (February-May).

(iv) **Lactation order/Parity** : The parities were considered up to 6th lactation and coded as L₁, L₂, L₃, L₄, L₅ and L₆.

(v) **Age at First Calving Group** : Data on age at first calving group was classified by dividing AFC into six groups i.e. A₁ (<800 days), A₂ (801-850 days), A₃ (851-900 days), A₄ (901-950 days), A₅ (951-1000 days) and A₆ (>1000 days).

The collected data were analyzed by linear models of least-squares means (SAS, 2011). When the analysis of variance indicated the existence of significant within class, Duncan's Multiple Range Test (DMRT) was employed to test and locate means that are significantly differed from the rest.

Model-I : The model for estimation of effect of year and season of birth on age at first calving was described as under:

$$Y_{ijk} = \mu + P_i + S_j + e_{ijk}$$

Where,

Y_{ijk} = Observation on production traits of kth animal born in ith period and jth season

μ = Overall mean

P_i = Fixed effect of ith period of birth (i = 1, 2....6)

S_j = Fixed effect of jth season of birth (j = 1, 2 and 3)

e_{ijk} = Random error associated with NID (0, σ^2_e)

Model-II : Fixed model (Model-II) was used to estimate the influence of non-genetic factors on post partum reproduction as follows:

$$Y_{ijklm} = \mu + P_i + S_j + AG_k + Pa_l + e_{ijklm}$$

Where,

Y_{ijklm} = Observations on reproduction traits of the nth animal belonging to ith period of calving, jth season of calving, kth age group and lth parity

μ = Overall mean

P_i = Effect of ith period of calving (i = 1, 2....6)

S_j = Effect of jth season of calving (j = 1, 2 and 3)

AG_k = Effect of kth age at first calving group (k = 1, 2 and 3)

Pa_l = Effect of lth parity (l = 1, 2....6)

e_{ijklm} = Random error associated with NID (0, σ^2_e)

Results and Discussion

The results pertaining to the analysis of variance and

Table-3 : Least-squares means for waiting period (days) in halfbred and three breed crosses of Gir.

Source of variation	Halfbred				Three breed crosses of Gir											
	FG		IFG		FJG				IFJG							
	N	Mean	SE	μ	N	Mean	SE	μ	N	Mean	SE	μ	N	Mean	SE	μ
μ	469	74.51	1.18		680	74.56	1.19		231	80.77	2.05		750	91.34	1.55	
Period of calving																
1974-79	319	76.30 ^a	1.30	1982-87	95	69.80 ^b	2.92	1977-82	180	83.15		1979-84	79	94.80 ^{ab}		4.47
1980-85	150	70.70 ^b	2.43	1988-93	131	81.22 ^a	3.14	1983-88	51	72.39		1985-90	258	84.05 ^{ab}		2.51
	-	-	-	1994-99	174	75.46 ^{ab}			-	-		1991-96	193	99.32 ^a		3.29
	-	-	-	2000-05	136	73.96 ^{ab}			-	-		1997-02	129	96.75 ^{ab}		3.85
	-	-	-	>2006	144	71.11 ^b			-	-		2003-08	70	85.54 ^{ab}		4.44
	-	-	-		-	-			-	-		>2008	21	82.42 ^b		9.53
Season of calving																
Rainy	152	70.80	1.79	Rainy	212	74.09	2.23	Rainy	86	80.43	3.42	Rainy	236	92.78		2.79
Winter	157	75.77	2.15	Winter	229	73.59	1.97	Winter	76	79.84	3.71	Winter	290	91.73		2.58
Summer	160	76.80	2.14	Summer	239	75.90	2.04	Summer	69	82.24	3.55	Summer	224	89.32		2.70
Lactation order																
L ₁	145	77.94	2.11	L ₁	226	75.61	2.10	L ₁	86	88.84	3.48	L ₁	262	94.14		2.71
L ₂	111	75.08	2.15	L ₂	169	74.82	2.51	L ₂	53	78.56	3.88	L ₂	193	89.69		3.03
L ₃	95	70.48	2.16	L ₃	118	71.67	2.65	L ₃	38	77.57	4.20	L ₃	135	92.12		3.73
L ₄	55	70.69	3.62	L ₄	83	79.47	3.30	L ₄	26	71.53	5.31	L ₄	93	88.82		3.84
L ₅	37	77.81	5.06	L ₅	52	75.61	4.80	L ₅	17	67.00	7.65	L ₅	47	84.02		5.94
L ₆	26	71.07	7.57	L ₆	32	61.87	4.37	L ₆	11	82.54	14.35	L ₆	20	94.30		12.04
Age at first calving group																
< 800	217	74.23	1.70	< 800	46	86.26	5.10	< 800	146	82.45	2.53	< 800	148	88.10		3.30
801-850	142	73.34	2.13	801-850	42	71.54	4.41	801-850	35	83.74	4.99	801-850	87	97.55		5.11
851-900	44	79.43	4.21	851-900	47	68.83	4.37	851-900	23	78.30	7.59	851-900	93	85.69		4.42
901-950	30	75.86	4.05	901-950	84	76.83	3.85	901-950	17	65.18	5.59	901-950	144	89.41		3.56
951-1000	7	93.85	19.57	951-1000	90	77.85	3.50	951-1000	7	80.86	19.02	951-1000	55	102.49		5.86
>1000	29	68.82	3.55	>1000	371	72.86	1.53	>1000	3	72.33	3.18	>1000	223	91.93		2.76

Means under each class in the same column with different superscripts differed significantly.

least-squares means for Age at first calving, Waiting period, Service period and Pregnancy rate in halfbred and three breed crosses of Gir are presented in Table 1 to 5.

Age at first calving : The overall least-squares means of AFC in FG, IFG, FJG and IFJG group were estimated as 793.62 ± 6.22 , 1020.83 ± 8.16 , 800.83 ± 6.36 and 949.10 ± 7.49 days, respectively. These results were in close agreement with Mishra and Prasad (1998) reported in RS and Narula *et al.* (2005) in FH halfbreds.

Effect of period of birth : The analysis of variance revealed that the period of birth had significant ($P < 0.01$) effect on AFC in FG, IFG, FJG and IFJG groups. Similar results were reported by Bhoite (1996) and Dahiya *et al.* (2003) in Haryana crossbreds. In FG, DMRT indicated that the cows born during 1976-77 (771.78 ± 7.81 days) significantly lower AFC, which was at par with the cows born during 1974-75 (788.93 ± 11.01 days). In FJG, the AFC was significantly lower in 1975-77 (781.15 ± 7.07 days) than 1978-80 (828.16 ± 10.50 days).

In IFG, DMRT indicated that the cows born during 1980-85 had significantly shorter AFC (955.36 ± 16.74 days) than other periods. The DMRT confirmed in IFJG that the cows born during 1983-88 had significantly shorter AFC (873.95 ± 12.13 days) than other periods. The variations might be due to influence of environmental factors and also genetic inheritance of parents or origins.

Effect of season of birth : The variation due to season of birth in

Table 4 : Least squares means for service period (days) in halfbred and three breed crosses of Gir.

Source of variation	Halfbred				Three breed crosses of Gir							
	FG		IFG		FJG		IFJG		N	Mean	SE	N
	N	Mean	SE	N	Mean	SE	N	Mean				SE
μ	337	147.77	3.78	593	145.80	3.04	197	141.63	4.97	161.78	3.05	707
Period of calving												
1974-79	229	150.79	4.91	82	138.46	7.71	155	142.21	5.88	155.70	7.91	80
1980-85	108	141.38	5.58	122	148.78	6.70	42	139.55	10.41	156.72	5.30	235
	-	-	-	158	145.84	6.05	-	-	-	156.96	5.75	178
	-	-	-	116	158.81	7.10	-	-	-	166.38	7.23	131
	-	-	-	115	134.68	6.62	-	-	-	185.70	11.35	66
	-	-	-	-	-	-	-	-	-	188.18	24.61	17
Season of calving												
Rainy	101	136.41	5.92	182	137.08	4.68	74	139.65	7.81	155.75	4.91	225
Winter	115	150.76	7.23	204	151.44	5.13	65	150.12	9.54	166.28	5.20	275
Summer	121	154.42	6.23	207	147.90	5.77	58	134.67	8.55	162.38	5.70	207
Lactation order												
L ₁	95	156.00	7.58	205	149.41	5.20	78	148.27	7.92	159.94	5.19	249
L ₂	86	137.08	6.75	146	140.55	6.04	44	142.39	12.13	163.62	6.23	177
L ₃	60	146.15	9.62	105	134.70	6.71	35	134.97	11.02	164.53	6.76	133
L ₄	45	155.00	11.58	70	148.40	9.01	19	129.63	13.12	157.01	8.94	88
L ₅	32	152.91	9.74	44	157.16	11.34	12	138.42	22.39	172.83	12.46	42
L ₆	19	134.47	13.85	23	168.00	19.12	9	136.11	18.41	146.72	16.85	18
Age at first calving group												
< 800	156	142.96	5.32	40	139.80	8.19	126	138.79	6.24	155.31	7.43	133
801-850	105	154.22	7.61	34	141.44	11.64	29	148.86	13.54	160.84	7.51	85
851-900	33	154.18	11.46	44	154.95	13.09	18	153.94	16.98	164.09	8.02	95
901-950	20	140.00	13.61	71	153.18	9.35	15	140.73	18.72	155.83	6.74	132
951-1000	5	178.00	36.03	83	142.51	8.22	6	157.83	24.33	164.21	10.99	53
>1000	18	140.50	13.41	321	144.98	4.15	3	89.67	9.39	168.41	6.01	209

AFC was non-significant in all the genetic groups. These findings were in close agreement with Singh *et al.* (2011) and Hasan and Khan (2013).

Waiting Period : Waiting period or days required to first service after calving is one of the important reproduction trait in cows. The overall least squares means for waiting period in FG, IFG, FJG and IFJG group were estimated as 74.51 ± 1.18 , 74.56 ± 1.19 , 80.77 ± 2.05 and 91.34 ± 1.55 days, respectively. Similar results were obtained by Van Raden *et al.* (2004) in HF cows and Nawale (2010) in Murrah buffaloes.

Effect of period of calving : In the present study, waiting period was significantly influenced by period of calving in FG ($P < 0.05$) and IFG ($P < 0.05$) and in IFJG ($P < 0.01$) group. In FG cows calved during 1980-85 (70.70 ± 2.43 days) had significantly shorter waiting period than the cows calved during 1974-79 (76.30 ± 1.30 days).

In IFG group, the DMRT revealed that cows calved during 1982-1987 had significantly lower waiting period (69.80 ± 2.92 days) and cows calved during 1988-93 had significantly highest (81.22 ± 3.14 days) waiting period. The waiting period of cows calved during period 1982-87 was at par with 1994-99 and 2000-05 while waiting period of cows calved during 1988-1993 was at par with each other. In IFJG group, the DMRT revealed that cows calved during had significantly lower waiting period in >2008 (82.42 ± 9.53 days) than other periods. Similar results were obtained by Miller *et al.* (2007) in HF and Jersey cows and Valasalan (2012) in Murrah buffaloes.

Effect of season of calving, lactation order and age at first calving group : The variation due to season of calving, lactation order and age at first calving group in waiting period were non-significant in all the genetic groups under study. Similar, results were reported by Miller *et al.* (2007) in HF and Jersey cows and Valasalan (2012) in Murrah buffaloes.

Table-5 : Least squares means for PR (per cent) in halfbred and three breed crosses of Gir.

Source of variation	Halfbred				Three breed crosses of Gir							
	FG		IFG		FJG		IFJG					
	N	Mean	SE	N	Mean	SE	N	Mean	N	Mean	SE	SE
μ	337	0.35	0.01	518	0.31	0.009	172	0.32	636	0.28	0.008	0.008
Period of calving												
1974-79	229	0.35	0.02	72	0.32	0.02	138	0.33	73	0.28	0.02	0.02
1980-85	108	0.34	0.02	109	0.31	0.02	34	0.29	205	0.29	0.02	0.02
	-	-	-	136	0.32	0.02	-	-	160	0.28	0.02	0.02
	-	-	-	2000-05	0.28	0.02	-	-	121	0.27	0.02	0.02
	-	-	-	>2006	0.33	0.02	-	-	62	0.25	0.03	0.03
	-	-	-	-	-	-	-	-	15	0.21	0.04	0.04
Season of calving												
Rainy	101	0.38	0.02	163	0.33	0.02	67	0.34	204	0.28	0.01	0.01
Winter	115	0.35	0.02	177	0.28	0.02	59	0.31	250	0.27	0.01	0.01
Summer	121	0.32	0.02	178	0.32	0.02	46	0.30	182	0.27	0.02	0.02
Lactation order												
L ₁	95	0.34	0.02	185	0.31	0.02	74	0.32	225	0.28	0.01	0.01
L ₂	86	0.37	0.02	126	0.33	0.02	37	0.32	154	0.26	0.02	0.02
L ₃	60	0.36	0.03	88	0.33	0.02	29	0.35	125	0.27	0.02	0.02
L ₄	45	0.33	0.03	61	0.30	0.03	17	0.35	77	0.29	0.03	0.03
L ₅	32	0.29	0.04	39	0.26	0.03	8	0.24	39	0.25	0.03	0.03
L ₆	19	0.40	0.06	19	0.22	0.03	7	0.24	16	0.34	0.08	0.08
Age at first calving group												
< 800	156	0.36	0.02	37	0.28	0.03	109	0.33	116	0.31	0.02	0.02
801-850	105	0.35	0.02	31	0.34	0.04	27	0.35	80	0.28	0.03	0.03
851-900	33	0.30	0.03	40	0.34	0.04	17	0.29	82	0.25	0.02	0.02
901-950	20	0.35	0.05	60	0.27	0.02	12	0.31	120	0.29	0.02	0.02
951-1000	5	0.30	0.15	70	0.31	0.03	5	0.19	47	0.24	0.03	0.03
>1000	18	0.36	0.06	280	0.31	0.01	2	0.45	91	0.27	0.01	0.01

Service period : The service period is an important economic trait in dairy cows. As a component of calving interval, it influences reproductive efficiency and thus has a bearing on lifetime production of dairy animals.

The overall least-squares means for service period in FG, IFG, FJG and IFJG were 147.77 ± 3.78 , 145.80 ± 3.04 , 141.63 ± 4.97 and 161.78 ± 3.05 days, respectively. The present results resembled with Jadhav (2011) in *interse* of Phule Triveni (155.69 ± 8.67 days), Dahiya *et al.* (2003) in JH (135.46 ± 9.54 days) and Sandhu *et al.* (2011) in HF (129.95 ± 2.14 days).

The analysis of variance showed that period of calving, season of calving, lactation order and age at first calving group had non-significant effect on service period in all genetic groups under study. Similar results were reported by Narula *et al.* (2005) in Haryana crossbred, Jadhav (2009) in HF x Gir halfberds and Hammoud *et al.* (2010) in Friesian cows.

Pregnancy rate : Pregnancy rate is defined as the percentage of non-pregnant cows that become pregnant during each 21 days period, because each estrus cycle represents one chance for a cow to become pregnant. The overall least-squares means for pregnancy rate in FG, IFG, FJG and IFJG were 0.35 ± 0.01 , 0.31 ± 0.009 , 0.32 ± 0.01 and 0.28 ± 0.008 per cent, respectively. These results were in close agreement with Van Raden (2004) in various cattle breeds.

The influence of period of calving, season of calving, lactation order and age at first calving group on pregnancy rate was found to be non-significant in all the genetic groups under study. Similar result was reported by Miller *et al.* (2007) in HF cows, Srivastav *et al.* (2005), Alam and Sardar (2010) in dairy cows and El-Wishy (2013) in HF cows.

Conclusion

This study provides a preliminary indication of reproduction management

in Research Cum Development Project on cattle, MPKV, Rahuri. Most of the reproduction traits under study were affected by non-genetic factors indicated the importance of feeding and management for enhanced performance.

Acknowledgments

The authors acknowledge with thanks Dr. D.K. Deokar, Assistant Dairy Cattle Breeder and all staff members of Research Cum Development Project on Cattle (RCDP) for providing the required data of halfbred and three breed crosses of Gir cows from the record maintained at RCDP and their unreserved collaboration. Appreciation is also expressed to Dr. A.K. Chakravarty for his continuing guidance and valuable comment.

References

1. Alam, M.M. and Sardar M.J.U. 2010. Effects of nutrition on production and reproduction of dairy cows in Bangladesh. *The Bangladesh Veterinarian.*, 27 (1) : 8-17.
2. Bhoite, U.Y. 1996. Comparative performance of economic traits of halfbreds, triple crosses of Gir and their interbred cows. Ph.D. Thesis submitted to, M.P.K.V., Rahuri.
3. Cabrera V.E., 2011. The economic value of changes in 21-day pregnancy rate and what control this value. Department of Dairy Science, University of Wisconsin-Madison.
4. Dahiya, D.S., Singh, R.P. and Khanna, A.S. 2003. Genetic group differences and the effect of non-genetic factors in crossbred cattle for reproduction traits. *Indian J. Anim. Res.*, 37(1): 61-64.
5. De Vries. A. 2010. The economic value of changes in 21-day pregnancy rate and what control this value. Department of Animal sciences, University of Florida.
6. El-Wishy, A. B., 2013. Fertility of Holstein cattle in a subtropical climate of Egypt. *Iranian Journal of Applied Animal Science*, 3(1): 45-51.
7. Hammoud, M.H., El-Zarkouny, S.Z. And Oudah, M.Z. 2010. Effect of sire, age at first calving, season and year of calving and parity on reproductive performance of Friesian cows under semi-arid conditions in Egypt. *Archiva Zootachnica*, 13(1): 60-82.
8. Hassan F. and Khan M.S., 2013. Performance of crossbred dairy cattle at military dairy farms in Pakistan. *J. nim. Plant. Sci.*, 23(3) : 705-714.
9. Jadhav, V.A. 2009. Generationwise breeding efficiency of HF x Gir. *M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri.*
10. Jadhav, P.D. 2011. Generationwise comparative reproduction and production performance of HF x Gir and Phule Triveni synthetic cows. M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri.
11. Kadarmideen H.R., Thompson R. and Simm G. 2007. Linear and threshold model genetic parameters for disease, fertility and milk production in dairy cattle. *J. Anim. Sci.*, 71(4): 411-419.
12. Lucy, M.C. 2001. Reproductive loss in high-producing dairy cattle: Where will it end? *J. Dairy Sci.*, 84(6): 1277-1293.
13. Miller, R.H., Norman, H.D., Kuhn, M.T., Clay, J.S and Hutchison, J.L. 2007. Voluntary waiting period and adoption of synchronized breeding in dairy herd improvement. *J. Dairy Sci.*, 90(3): 1594-1606.
14. Mishra, A.K. and Prasad, R.B. 1998. Performance of purebred, halfbred and three breed crosses of Sahiwal with exotic dairy breeds. *Indian J. Anim. Prod. Mgmt.*, 14(4): 203-205.
15. Narula, H.K., Kanaujia, A.S., Malik, C.P. and Sikka, A.K. 2005. Genetic investigation on reproduction efficiency traits in Friesian x Haryana halfbreds ISAGB 111/31.
16. Nawale, V.S. 2010. Development of optimum model for prediction and assessment of breeding efficiency in Murrah buffaloes. M.V.Sc. Thesis submitted to, NDRI (Deemed University), Karnal, Haryana, India.
17. Pearson, R.E. 2006. Economic evaluation of breeding objectives in dairy cattle: Intensive specialized milk production in temperate zones. In: Proc. 3rd World Cong. Appl. Livest., Pp. 11-17.
18. Pryce J.E., Nielsen B.L., Veerkamp R.F. and Simm G., 1999. Genotype and feeding system effects and interactions for health and fertility traits in dairy cattle. *Livest. Prod. Sci.* 57(4): 193-201.
19. SAS (Statistical Analysis System) (2011). SAS Version 9.3, SAS Institute Inc., Cary, NC, USA. Sandhu, Z.S., Tariq, M.S., Balochand, M.H. and Qaimkhani, M.A. 2011. Performance analysis of HF cattle in intensive management of dairy farm Quetta, Balochistan, Pakistan. *Pak. J. life. soc. Sci.*, 9(2): 128-133.
20. Scottt McDougall, 2006. Relationship of fertility to milk yield in Swedish cattle. *J. Dairy Sci.*, 74(6): 264-268.
21. Singh, R.R., Dutt, T., Kumar, A., Tomar, A.K.S. and Singh, M., 2011. Evaluation of production and reproduction traits in Vrindavani cattle. *Indian J. Anim. Sci.*, 81(3): 296-298.
22. Srivastav, S.K., Sahni, K.L. and Tiwari, C.B., 2005. Effect of oestrus detection frequency on pregnancy in Holstein Friesian and crossbred cows. *Indian J. Anim. Sci.*, 75(9) : 1060-1062.
23. USDA. 2003. Estimated relative conception rate valuation. Animal Improvement Programs Laboratory Research Report. [www. aipl.arsusda.gov.com](http://aipl.arsusda.gov.com).
24. Valsalan, J. 2012. Impact of progeny testing programme on lifetime fertility and lifetime milk yield in Murrah buffaloes. M.V.Sc. Thesis, NDRI (Deemed University), Karnal, Haryana, India.
25. VanRaden P., 2001. Cow fertility and effect on longevity. <http://aipl.arsusda.gov/reference/nmcalc.htm>. Van Raden P.M., Saders A.H., Tooker M.E., Miller A.H., and Norman H.D., 2004. Daughters pregnancy rate evaluation of cow fertility. Animal Improvement Programs Laboratory, USDA-AIPL Research Report.



Studies of Adoption Technology of Trained and Untrained Farm Women's of Different Villages of District Chandauli

Satya Pal Singh, Abhay Deep Gautam, Ritesh Singh, S.K. Pandey, Krishna Murari, Manoj Mishra¹ and Y.K. Singh²

K.V.K. Chandauli, Acharya Narandra Dev University of Agricultural and Technology, Ayodhya, U.P.

¹*Directorate of Research, CSA University of Agriculture and Technology, Kanpur-208002*

²*CSAUAT-Agriculture Research Station, Kalai, Aligarh, U.P.*

Email : satyaapalsingh@gmail.com

Abstract

Studies of 280 farmers who had undergone six days training and untrained on the subjects namely Scientific Mushroom farming, Dairy farming, Goat farming and Fish farming was carried out in four villages of (Dulhipur, Baghahi, Karemua and Kodochak) Block Niyamtabad and Sahabganj of Chandauli -District. A total of 14 character were selected based on the examine performance and past research studies. It was found that among the various groups of character of the farm women; most of the farm women belonged to mid age group. Had primary level of education, opting equally to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding. This study was undertaken to assess the behavior of the farm women Chandauli- District which will help in giving appropriate policy implication based on the derived conclusions to uplift the behavior status of the farm women.

Key words : *Mushroom farming; dairy farming; goat farming; fish farming; extension agency; mass media exposure; economic motivation; scientific orientation; innovativeness; perceived effectiveness.*

Research Methodology

The studies were examined conducted in four clusters of villages namely Dulhipur, Baghahi, Karemua and Kodochak adopted by Krishi Vigyan Kendra Chandauli Uttar Pradesh. The respondents in this study comprising of 280 farmwomen both who had undergone six days training and untrained on the subject namely Mushroom farming, Dairy farming, Goat farming and Fish farming were selected. For this purpose, 14 variables were identified in consultation with the experts and perusal of the available literature. The mean, standard deviations and percentage were calculated for categorizing the farmers. Relevant data on the character were collected through well structured interview schedule, observation technique subsequently analyzed and tabulated.

Results and Discussion

Its oviparous from the data on behavioral character of the respondents in the study of four categories is discussed here under :

Age : It could be observed from the Table-I, that in the category of Mushroom farming exactly more than half (51.42%) of the farm women were of mid age followed by old (28.57%) and young (20%) in trained category, whereas in untrained category more than half of the farm

women were of middle age group (54.24%) followed by old (31.42%) and young (14.24%).

In scientific Dairy farming most of the trained farm women (45.71%) belonged to middle age group followed by old (28.57%) and young (25.71%), whereas more than half (54.28%) were of middle age group followed by young (23.28.00%) and old (11.42%) in untrained category of farm women.

In goat farming exactly half of the trained farm women (45.71%) were of mid age group followed by young (34.28%) and old (20.00%), whereas in untrained category a more than half (57.14%) belonged middle age group followed by old (25.71%) and young age (17.14%).

In fish farming a more than half of the farm women (51.42%) were of middle age group followed by young (25.71%) and old (22.85%) in trained category, whereas the untrained farm women were found to be sharing near to half percentage in middle (48.57%) and old age (37.14%) followed by young (14.28%). It is amounted to indicate that the farm women differ in their age group. The studies of, Kavita Angadi *et.al* (2020). Soumya P.S *et.al* (2016). S.K Zamir Ahmed *et.al.* and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Farm women near to half (48.57%) had high school level of education followed by primary and middle are

equal (20.00%) in Mushroom farming secondary (8.57) level of education followed by graduation level of education (2.85%), whereas middle less than one-fourth (22.85%) of untrained farm women were primary percentage (2.85%), high school more than half (51.42%) and secondary (14.28%), followed by graduate are (8.51%) percent educated level.

In the trained category of dairy farming, middle less than one-fourth (22.85%) of the farm women had high school level of education (37.14), secondary (20.00%) and primary (5.71%) and graduate (14.28%) level of education, whereas in untrained category illiterate (22.85%) and primary (20.00%) middle (28.57) followed by high school and secondary are equal (11.42%) and collegiate (5.71%) of education level.

In the goat farming, illiterate less than one-fourth (17.14%) of the trained farm women and middle (20.00) had level of education and less than half (42.85) of high school level of education followed by secondary (5.71%) and collegiate (14.24%) level of education, whereas in untrained category illiterate (14.24), primary (28.57) level of education followed by less than half (40.00) percentage of level education and high school (17.14%) level of education.

In fish farming a less than half of the farm women (34.28%) level of education were of illiterate 20.00% and primary level of education (20.00%), followed by collegiate (14.28%), high school 5.71% and secondary (8.51%) level of education trained, whereas the untrained farm women were found to be illiterate and collegiate are equal level of education percentage (28.57%) primary (20.00%) followed by middle (22.85%) level of education percentage.

A wide range of literacy among the farm women was due to the establishment of more number of educational institutions for the islanders in every nook and corner of the village which acted as an instinct for the villagers to send their ward to the school. This study support from the S.K Zamir Ahmed *et.al.* (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Occupational status : The Table 1, portrayed that with regard to occupational status in the category of mushroom farming, most of the trained farm women had agriculture as their main occupation (57.14%) followed by agriculture as a subsidiary (42.85%), whereas in the case of untrained farm women it was found to be reverse i.e., majority of the farm women had agriculture as their subsidiary occupation (57.14%) followed by (42.85%) percent having agriculture as their main occupation.

The trained farm women of dairy farming had agriculture as their subsidiary occupation (54.28%)

followed by agriculture as main (45.71%), whereas in untrained category more than half (51.42 %) of agriculture as their main occupation, followed by (48.57%) percent having agriculture as their subsidiary occupation.

In goat farming, more than half of the trained farm women (51.42%) had agriculture as their subsidiary occupation followed by agriculture as main (48.57%), whereas in untrained category most of the farm women (57.14%) had agriculture as their main followed by agriculture as their subsidiary occupation (42.85%).

In fish farming, (62.85%) percent of the trained farm women had agriculture as their main occupation followed by agriculture as their subsidiary occupation (37.14%), whereas in untrained category more than half (60.00%) had agriculture as their subsidiary occupation followed by agriculture as their main occupation (40.00%).

Due to under employment on one side and higher price of daily essentials on the other side have motivated the farm women equally towards the agriculture as the main occupation and as well as subsidiary occupation, in order to meet and supplement themselves with fresh and nutritious produce besides generating self employment avenue. This observation was consistent with earlier Kavita Angadi and Belli (2020).

Farm experience : About (37.14) percent of the trained farm women of mushroom farming had high level of farm experience followed by medium (42.85%) and low (20.00%), the same trend was reflected in the untrained category i.e., high farm experience (37.14%) followed by medium (45.71%) and low (17.14) percent.

Less than half of the trained farm women (45.71%) in dairy farming had medium level of farm experience followed by high (40.00%) and low (14.28%), whereas the untrained farm women (51.42%) had medium level of experience followed by high (25.71%) and low (22.85%).

In goat farming, more than half of the trained farm women (57.14%) had medium level of farm experience followed by high (28.57%) and low (14.28%), whereas in untrained category little less than half (45.71%) had medium level of farm experience followed by high (31.42%) and low (22.85%).

Equal percentage of trained farm women of fish farming had high (42.85%) and medium level of farm experience, followed by low (14.28%), whereas exactly more than half of the untrained farm women (51.42%) had medium level of farm experience followed by high (37.14%) and low (11.42%).

The fact, that majority of the farm women belonged to young and middle age groups with agriculture as both main and subsidiary occupation got reflected in having

Table-1 : Distribution of the respondent according to their agriculture farming characteristics (Trained (n=35), untrained. (n=35)

S. No.	Variables / Category	Agriculture farming categories																	
		Mushroom Farming						Dairy Farming						Goat farming					
		UT			T			T			UT			T			UT		
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
1		Age																	
	Young (up to 34 years)	7	20.00	5	14.28	09	25.71	12	23.28	12	34.28	6	17.14	9	25.71	5	14.28		
	Middle (35 to 45 years) Old	18	51.42	19	54.28	16	45.71	19	54.28	16	45.71	20	57.14	18	51.42	17	48.57		
	(above 45 years)	10	28.57	11	31.42	10	28.57	4	11.42	07	20.00	9	25.71	08	22.85	13	37.14		
2		Educational status																	
	Illiterate	-	-	-	-	-	-	8	22.85	6	17.14	5	14.28	7	20.00	10	28.57		
	Primary	7	20.00	1	2.85	2	5.71	7	20.00	7	20.00	10	28.57	6	17.14	7	20.00		
	Middle	7	20.00	8	22.85	8	22.85	10	28.57	15	42.85	14	40.00	12	34.28	8	22.85		
	High school	17	48.57	18	51.42	13	37.14	4	11.42	2	5.71	6	17.14	2	5.71	-	-		
	Secondary	3	8.75	5	14.28	7	20.00	4	11.42	5	14.24	-	-	3	8.51	10	28.57		
	Collegiate	1	2.85	3	8.51	5	14.28	2	5.71	-	-	-	-	5	14.28	-	-		
3		Occupational status																	
	Agriculture(Main)	20	57.14	15	42.85	16	45.71	17	48.57	17	48.57	20	57.14	22	62.85	14	40.00		
	Agriculture(Subsidiary)	15	42.85	20	57.14	19	54.28	18	51.42	18	51.42	15	42.85	13	37.14	21	60.00		
4		Farm Experience																	
	Low	7	20.00	6	17.14	5	14.28	8	22.85	5	14.28	8	22.85	5	14.28	4	11.42		
	Medium	15	42.85	16	45.71	16	45.71	18	51.42	20	57.14	16	45.71	15	42.85	18	51.42		
	High	13	37.14	13	37.14	14	40.00	9	25.71	10	28.57	11	31.42	15	42.85	13	37.14		
5		Farm size																	
	Marginal (up to 2.50 ac)	5	14.28	6	17.14	12	34.28	9	25.71	14	40.00	16	45.71	12	34.28	14	40.00		
	Small (2.50 to 5.0 as)	23	65.71	17	48.57	16	45.71	11	31.42	15	42.85	8	22.85	4	11.42	6	17.14		
	Medium (5.01 to 10.0ac)	7	20.00	5	14.28	7	20.00	5	14.28	3	8.51	4	11.42	7	20.00	-	-		
	Big (Above 10.00)	-	-	7	20.00	-	-	10	28.57	3	8.51	7	20.00	12	34.28	15	42.85		
6		Annual income																	
	Low (upto Rs. 5,000/-)	6	17.14	9	25.71	10	28.57	6	17.14	8	22.85	7	20.00	9	25.71	5	14.28		
	Medium (Rs. 5,001 -10,000/-)	17	48.57	20	57.14	18	51.42	21	60.00	22	62.85	22	62.85	19	54.28	24	68.57		
	High (Above 10,000/-)	12	34.28	6	17.14	7	20.00	8	22.85	5	14.28	6	17.14	7	20.00	6	17.14		
7		Contact with Extension agency																	
	Low	8	22.85	14	40.00	13	37.14	5	14.28	7	20.00	6	17.14	9	25.71	8	22.85		
	Medium	20	57.14	18	51.42	16	45.71	22	62.85	17	48.57	20	57.14	19	54.28	21	60.00		
	High	7	20.00	3	8.51	6	17.14	8	22.85	11	31.42	9	25.71	7	20.00	6	17.14		
8		Social Participation																	
	Low	6	17.14	7	20.00	10	28.57	9	25.71	8	22.85	17	48.57	5	14.28	10	28.57		
	Medium	17	48.57	19	54.28	18	51.42	16	45.71	21	60.00	15	42.85	10	28.57	16	45.71		
	High	12	34.28	9	25.71	7	20.00	7	20.00	6	17.14	3	8.51	20	57.14	9	25.71		

Table-1 : Contd.....

S. No.	Variables / Category	Agriculture farming categories															
		Mushroom Farming				Dairy Farming				Goat farming				Fish farming			
		UT		T		UT		T		UT		T		UT		T	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
9		Mass media Exposure															
	Low	12	34.28	13	37.14	11	31.42	12	34.28	15	42.85	9	25.71	10	28.57	12	34.28
	Medium	20	57.14	18	51.42	14	40.00	17	48.57	14	40.00	15	42.85	16	45.71	19	54.28
	High	3	8.51	4	11.42	10	28.57	6	17.14	6	17.14	11	31.42	9	25.71	4	11.42
10		Economic Motivation															
	Low	10	28.57	17	48.57	12	34.28	5	14.28	7	20.00	7	20.00	15	42.85	14	40.00
	Medium	9	25.71	14	40.00	14	40.00	22	62.85	16	45.71	14	40.00	15	42.85	13	37.14
	High	15	42.85	4	11.42	9	25.71	8	22.85	12	34.28	14	40.00	5	14.28	8	22.85
11		Risk orientation															
	Low	8	22.85	15	42.85	11	31.42	13	37.14	12	34.28	6	17.14	4	11.42	14	40.00
	Medium	17	48.57	8	22.85	17	48.57	20	57.14	18	51.42	17	48.57	20	57.14	16	45.71
	High	10	28.57	12	34.28	7	20.00	02	5.71	5	14.28	12	34.28	11	31.42	5	14.28
12		Scientific Orientation															
	Low	14	40.00	12	34.28	6	17.14	14	40.00	12	34.28	13	37.14	16	45.71	10	28.57
	Medium	13	37.14	18	51.42	15	42.85	18	51.42	20	57.14	18	51.42	15	42.85	20	57.14
	High	8	22.85	5	14.28	14	40.00	3	8.51	3	8.51	4	11.42	4	11.42	5	14.28
13.		Innovativeness															
	Low	7	20.00	17	48.57	11	31.42	13	37.14	7	20.00	12	34.28	8	22.85	12	34.28
	Medium	18	51.42	12	34.28	14	40.00	16	45.71	18	51.42	15	42.85	20	57.12	17	48.57
	High	10	28.57	6	17.14	10	28.57	6	17.14	10	28.57	8	22.85	7	20.00	6	17.14
14.		Perceived effectiveness of the training															
	Low	6	17.14	13	37.14	4	11.42	9	25.71	9	25.71	8	22.85	14	40.00	5	14.28
	Medium	21	60.00	18	51.42	11	31.42	19	54.28	20	57.14	21	60.00	17	48.57	20	57.14
	High	8	22.85	4	11.42	20	57.14	7	20.00	6	17.14	6	17.14	4	11.42	10	28.57

medium level of experience. This observation was consistent with earlier of Kavita Angadi and Belli (2020). S.K. Zamir Ahmed, RC Srivastava and Rolokrishnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Farm size: A glance at the Table 1, pointed out that in mushroom farming, more than half of the trained farm women (65.71%) had small land holdings followed by medium (20.00%) and marginal land holdings (14.28%), whereas in untrained category less than half of the farm women had small size holdings (48.57%), followed by big (20.00%), marginal (17.14%) and medium size land holdings (14.28%).

In Dairy farming, 45.71 percent of the trained farm women had small size land holdings followed by marginal (34.28%) and medium (20.00%), whereas in untrained category little more than one-third (31.42%) had small size holdings followed by of marginal (25.71%) and medium (14.28%). Remaining (28.57%) had big size land holdings.

The trained farm women in goat farming, had small size (42.85%) and marginal holdings (40.00%) followed by equal medium and big farm size holding (8.51%), whereas in untrained category less than half of the farm women (45.71%) had marginal size holdings followed by small (22.85%) and medium percentage of size of holding of the farm woman (11.42) followed by big size holdings (20.00%).

In fish farming, the trained farm women are equal size holding (34.28%) had big and marginal size holdings and, medium (20.00%) and small size holdings (11.42%), whereas in untrained category of farm women had marginal (40.00%) and followed by big (42.85%) followed by small size holdings (17.14%).

Due to manifold increase in the population and the trend of nuclear type of family living would have forced them to divide ancestral property from generation after generation resulting in fragmentation of holding into smaller sizes. This might be the reason for more number of farm women operating small sized farms. Similar studies was consistent with earlier Kavita Angadi and Belli (2020). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Annual income : The data in the Table-1, revealed that the annual income of (48.57%) of the trained respondents were medium followed by high (34.28%) and low (17.14%), whereas the untrained farm women (57.14%) had medium level of annual income followed by low (25.71%) and high (17.14%), in the mushroom farming.

In dairy farming, more than half of the trained farm women (51.42%) had medium level of annual income

followed by low (28.57%) and high (20.00%), whereas in untrained category more than half of the farm women (60.00%) had medium level of annual income followed by low (17.14%) and high (22.85%).

More than half of the trained farm women (62.85%) of goat farming had medium level of income followed by low (22.85%) and high (14.28%), whereas in untrained category more than half of the farm (62.85%) had medium level of income followed by low (20.00%) and high (17.14%).

In fish farming more than half (54.28%) of the trained farm women had medium level of income followed by low (25.72%) and low (20.00%), whereas in untrained category more than half (68.57%) had medium level of income followed by high (17.14%) and low (14.58%).

This might be due to the practice of undertaking more than one farming of agriculture and allied fields in an integrated manner, so as to increase the production and productivity per unit for sustainable revenue to the farm women. This study was consistent with earlier Kavita Angadi and Belli (2020).

Contact with extension agency: In mushroom farming as evident from the Table 1, that in the category of trained farm women medium level of contract with the extension agency was exhibited by more than half (57.14%) followed by the of medium (20.00%) and high (22.85%) and high (20.00), whereas in untrained category more than half of the farm women (51.42%) reported to have medium level of contract with extension agency followed by low (40.00%) and high (8.51%).

A less than half (45.71%) of the trained farm women showed medium level of contract with extension agency followed by low (37.14%) and high (17.14%), whereas in the untrained category more than half (62.85%) had medium level of contact with extension agency followed by high (22.85%) and low (14.28%) in the dairy farming.

In goat farming less than half of the trained farm women (48.57%) had medium level of contract with extension agency followed by high (31.42%) and low (20.00%), whereas in untrained category of farm women, a little more than half (57.14%) had medium level of contact with extension agency followed by high (25.71%) and low (17.14%).

In the fish farming, in the category of trained farm women more than half (54.28%) had medium level of contract with extension agency followed by low (25.71%) and high (20.00%), whereas in the category of untrained farm women (60.00%) showed medium level of contact with extension agency followed by low (22.85%) and high (17.14%).

The extension activities are extended by the scientists and specialists of KVK Chandauli among the farming community. This resulted in maintenance of medium level of contact with extension agency. These studies carried out by S.K.Zamir Ahmed, RC Srivastava and M.Balokrisnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Social participation: The Table-1, apparently reveals that in mushroom farming, little less than half of the trained farm women (48.57%) exhibited medium level of social participation followed by high (34.28%) and low (17.14%), whereas in untrained category more than half of the farm women (54.28%) showed medium level of social participation followed by high (25.71%) and low (20.00%).

In dairy farming, the trained farm women (51.42%) had medium level of social participation followed by low (28.57%) and high (20.00%), whereas exactly less than half of the untrained farm women (45.71%) reported to have maximum level of social participation followed by low (25.71%) and high (20.00%).

The trained farm women (60.60%) of goat farming could show medium level of social participation followed by low (22.85%) and high (17.14%), whereas (48.57%) of the untrained farm women showed low level of social participation followed by medium (42.85%) and low (8.51%).

In the fish farming, more than half of the trained farm women (57.14%) exhibited high level of social participation followed by medium (28.57%) and one-third low (14.57%), whereas in untrained category of farm women, medium level of social participation was exhibited by (45.71%) farm women followed by low (28.57%) and low (25.71%).

The reason for the above substantiated results would have been due to existence of social stratification among the bight, small farmers and other minor communities of the villages. In addition, more work in the farm coupled with lack of time and interest might be the other valid reasons for facilitating the result. The result is in line with the studies Kavita Angadi *et.al.* (2020).

Mass media exposure: By glancing at the Table 1, it can be inferred that in mushroom farming, more the half (57.14%) of the trained farm women had medium level of exposure to mass media followed by low (34.28%) and high (8.51%), whereas in untrained category exactly half (51.42%) of the farm women showed medium level of exposure to mass media followed by (37.14%) low and (11.42%) high.

In dairy farming, the trained farm women exhibited

medium (40.00%) and low (31.42%) levels of mass media exposure followed by high (28.57%), whereas in untrained category, little half (48.57%) showed medium level of mass media exposure followed by low (34.28%) and high (17.14%).

Less than half (42.85%) of the trained farm women showed low level of exposure to mass media followed by medium (40.00%) and high (17.14%), whereas in untrained category less than half (42.85%) of the farm women exhibited medium level of mass media exposure followed by high (31.42%) and low (25.71%) in the goat farming.

In fish farming, half (45.71%) of the trained farm women showed medium level of mass media exposure followed by low (28.57%) and high (25.71%), whereas (54.28%) of the untrained farm women showed medium level of mass media exposure followed by low (34.28%) and high (11.42%).

Economic motivation; It is noticed from the data of the Table 1, that in mushroom farming, the trained farm women (42.85%) showed high level of economic motivation followed by low (28.57%) and medium (25.71%), whereas in untrained category little than half (48.57%) of the farm women exhibited low level of economic motivation followed by medium (40.00%) and high (11.42%).

In goat farming, (40.00%) of trained farm women exhibited medium level of economic motivation followed by low (34.28%) and high (25.71), whereas in untrained category (62.85%) of the farm women showed medium level of economic motivation followed by high (22.85%) and low (14.28%).

Less than half (45.71%) of the trained farm women showed medium level of economic motivation followed by (34.28%) as high and (20.00%) low, whereas in untrained category same value of medium level and high (40.00%) followed by low (20.00%) in goat farming.

In fish farming are equal of little half (42.85%) of the trained farm women exhibited low level and medium of economic motivation followed by high (14.28%), whereas in untrained category (40.00%) of the farm women showed low level of economic motivation followed by medium (37.14%) and high (22.85%).

The assured regular and sustained income derived from main and subsidiary farming paved way to increase more income from their farms. Also the desire to compete with each other in terms of standard of living might be another possible reason. All these factors would have contributed for exhibiting medium level of economic motivation.

Risk orientation: Regarding risk orientation, it could be discerned from the Table 1, that in mushroom farming, less than half (48.57%) of the trained farm women exhibited medium level of risk orientation followed by high (28.57%) and low (22.85%), whereas low level of risk orientation was shown by the (42.85%) of untrained farm women followed by high (34.28%) and medium (22.85%).

In dairy farming, less than half (48.57%) in the trained farm women category showed medium level of risk orientation followed by low (31.42%) and high (20.00%), whereas in untrained category more than half (57.14%) showed medium level of risk orientation followed by low (37.14%) and high (5.71%).

In goat farming, (51.42%) of the trained farm women showed medium level of risk orientation followed by low (34.28%) and high (14.28%), whereas a little less than half (48.57%) of the untrained farm women exhibited medium level of risk orientation followed by low (34.28%) and low (17.14%).

More than half of the trained farm women (57.14%) exhibited medium level of risk orientation followed by high (31.42%) and low (11.42%), whereas in untrained category of the farm women exactly less than half (45.71%) showed medium level of risk orientation followed by low (40.00%) and high (14.28%) in the fish farming.

The reason might be due to the fact that the farmers who were found to be economically motivated had the sternness and determination to bear risk in taking up any other enterprises which would facilitate or generate additional income. These studies carried out of S.K.Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Scientific orientation: It is clear from the table 1, that in the mushroom, the trained farm women showed equal distribution (40.00%) in exhibiting both medium and low level of scientific orientation followed by high (20.00%), whereas in the category of the untrained farm women exactly more than half (51.28%) exhibited medium level of scientific orientation followed by low (34.28%) and high (14.24%).

In dairy farming showed equal distribution (40.00%) in exhibiting both medium and high level of the trained farm women of scientific orientation followed by low (14.28%), whereas in untrained category more than half of the farm women (51.42%) showed medium level of scientific orientation followed by low (40.00%) and high (8.51%).

In goat farming, more than half (57.14%) of the trained farm women exhibited medium level of scientific orientation followed by low (34.28%) and high (8.51%),

whereas in the untrained category (51.42%) of the farm women showed medium level of scientific orientation followed by low (37.14%) and high (11.42%).

In fish farming, less than half (45.71%) of the trained farm women reported for low level of scientific orientation followed by Medium (42.85%) and high (11.42%), whereas more than half (57.14%) of the untrained farm women expressed medium level of scientific orientation followed by low (28.57%) and high (14.28%).

The close association between the scientists of KVK- Chandauli and the enterprising farm women motivated them to venture into any innovative technology extended to them, so as to hasten their remuneration. This reason would have inclined them to have medium level of scientific orientation. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Innovativeness : The Table-I, revealed that in mushroom farming, more than half (51.42%) of the trained farm women was observed to have medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas less than half (48.57%) of the untrained farm women exhibited low level of innovativeness followed by medium (34.28%) and high (17.14%).

In dairy farming, (40.00%) of the trained farm women exhibited medium level of innovativeness followed by showed distribution (31.420%) in exhibiting low and high (28.57) level, whereas in untrained farm women category (45.71%) of them showed medium level of innovativeness followed by low (37.14%) and high (17.14%).

In goat farming, more than half (51.42%) of the trained farm women showed medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas in untrained farm women category (42.85%) showed medium level of innovativeness followed by low (34.28%) and high (22.85%).

In fish farming, in the trained farm women category (57.12%) expressed medium level of innovativeness followed by low (22.85%) and low (20.00%), whereas in untrained category less than half of the farm women (48.57%) showed medium level of innovativeness followed by low (34.28%) and high (17.14%).

Most of the farm women being energetic, enterprising, in theistic and venturesome having medium level of message exposure and annual income, paved way to grasp more of latest technologies from the experts of KVK Chandauli for early act on and thereby resulting in medium level of innovativeness. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010).

Perceived effectiveness of the training: It is vivid from the Table I, that in mushroom farming (60.00%) of the trained farm women had medium level of perceived effectiveness of the training followed by high (22.85%) and low (17.14%), whereas in untrained farm women category little half (51.42%) expressed medium level of perceived effectiveness of the training followed by low (37.14%) and high (11.42%).

The trained farm women (57.14%) of dairy farming, showed high level of perceived effectiveness towards training followed by medium (31.42%) and low (11.42%), whereas in the untrained category of farm women more than half (54.28%) expressed medium level of perceived effectiveness training followed by low (25.71%) and high levels (20.00%).

In goat farming, more than half (57.14%) of the trained farm women showed medium level of perceived effectiveness towards training followed by low (25.71%) and high (17.14%), whereas in the untrained category of farm women (60.00%) showed medium level of perceived effectiveness of the training followed by low (22.85%) and high (17.14%).

In the fish farming, the trained farm women less than half (48.57%) expressed medium level of perceived effectiveness towards training followed by low (40.00%) and high (11.42%), whereas in untrained farm women category (57.14%) training followed by high (28.57%) and low (14.28%).

The studies of the farm women and the delivery of the technology in the right form, place and time by the experts has given them a better understanding for capacity and confidence building. This may have routed to have a medium level of perceived effectiveness of training among the farm women. These studies carried out of S. K. Zamir Ahmed, RC Srivastava and M. Balokrishnam (2010)

Conclusion

It can be concluded that, among the various categories of characteristics of the farm women (both trained and untrained) most of the farm women belonged to middle

age group, had primary level of education, opting equally to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding.

The study brought out the actual happenings on personal, economic, situational, communication and psychological characteristics of both trained and untrained category adopting four different farming to the forefront. On this basis, certain implication could be brought out which might be useful in formulating strategies and organizing quality and effective training programmers for bridging the knowledge deficit, change in attitude and finally adoption of the technological interventions by farm women to a desirable extent and thus in turn would result in improving socio-economic status of the farm women leading to overall development of the family and the nation as the whole.

References

1. Kavita Angadi and Belli (2020). Study the relationship between adoption level and Scio-economic profile of trained and untrained farmers of northen Karnataka India: *International Journal of Chemical Studies*. 8(2): 1671-1674.
2. Pandey H. (2001). Understanding farmwomen, NRCWA, ICAR, Bhubaneshwar, pp: 5-12.
3. Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet (2021). Comprehensive Studies of Adoption Technology of Trained and Untrained Farm Women's of Different Villages of District –Barabanki. *Agriways* 9(1): 57-64
4. Zamir, S.K. Ahmed, RC Srivastava and M. Balokrishnam (2010). A Micro-level study of the trained and untrained farm women of Andaman: *Indian Res. J. Ext. Edu.*, 10(1): 117-125.
5. Soumya P.S. and Bind Podikkunju (2016). Effect of training on knowledge and adoption of value addition Technology: *J. Krishi, Vigyan.*, 4(2) : 1-4



Pattern of Calf Mortality in Gangatiri Cattle at Araziline Organized Dairy Farm of District, Varanasi

Shiv Bachan¹, K.B. Anand¹, R.K. Pal² and Aditya Kumar³

¹U.P. College, Varanasi, Uttar Pradesh ²T.D. College, Jaunpur, Uttar Pradesh ³Janta College Etawah, Uttar Pradesh

Abstract

Pattern of calf mortality to study of the objectives in Gangatiri breed of cattle. The information were collected from the record of Gangatiri herd, maintained at Government cattle farm Arajiline block of district Varanasi. The data was recorded for a period of 12 years (from 2008-2020). The period wise distribution of calf mortality presented that highest mortality rate (16.50%) was recorded in the period P4 (2012-2018) and the lowest mortality rate (7.50%) was showed in P2 (2010-2015), Disease-wise distribution of calf mortality presented that it was maximum (8.53%) in gastrointestinal troubles in both sex and the minimum calf mortality rate was found in tympany 2.46 percent, which might be due to better management practices given to this age group. The mortality rate from season to season from winter to rainy was also calculated. Season-wise distribution of calf mortality presented that the high mortality of calf 5.45% was determined in those calf born in winter season, many managerial practices are also not apply for calf to proper growth and this reason increased mortality of calf.

Key words : Mortality, calf, disease, managerial practices.

Introduction

The mortality of calf is a most important character for breeding and economic point of view in dairy farming. More survival rate in dairy herds help increase the selection criteria, which is one of main factor regulating genetic gain and more economic benefits. Mortality was higher in male than female calf as well as was lower in winter and higher in summer season. The objectives of present study was determinate the Gangatiri cattle in respect survival of young stock and suckling practices of different sex up to 15 days of their life for obtaining about improvement in overall efficiency. Gangatiri cattle is one of the well known dual purpose breed, especially found in eastern zone of Uttar Pradesh and adjoining areas of Bihar.

Materials and Methods

The information of present study were collected from the obtained of Gangatiri herd, maintained at Government cattle farm, Shahanshah pur, Arajiline Block District, Varanasi. Uttar Pradesh maintaining data to a period of 12 years from 2008 to 2020.

The total period of the calf mortality was divided in to three groups (p1: 2008-2012, p2: 2013-2016, p3:2017-2020). The years was divided in to three reason, Winter-October to January, Summer-February to May and Rainy season- June to September.

Results and Discussion

Mortality rate on the basis of different period of the year :

The mortality rate showed that the maximum (16.13%) was recorded in p1(2008-2012), which included 35.00% and 22.64% in male and female calves respectively, whereas the lowest (9.24%) was indicates that in the p2 (2013-2016) which included that 8 and 3 percent male and female calves respectively (Table-1). Second phase of calf mortality was lowest indicates that out of total 103 male calves, 33 female calves(14.89%) died, whereas out of 203 female calves a total of 23 calves (18.58%) were reported to be died. The reason of higher percentage of death in male calves than female calves. Better care and management practices would have been adopted for rearing of female calves, whereas male calves sometimes ignored. In the present study, the overall average mortality in Gangatiri calves were obtained to be 16.13%, however Mishra et. al. (2015) a higher mortality rate (18.50%) in buffaloes.

Mortality rates of calves according seasons :

The overall mortality was found to maximum in winter season (5.45%) probably due to excessive low temperature below 3 and un productive managerial practices. Ghosh et. al. (1996) in different breeds of cattle and their cross reported resembling lethal factor effect of the winter season on calve mortality rate in the present study. Higher mortality in male (6.82%) than the female (3.96) percent was recorded.

Mortality rates of calves according to cause of disease :

The highest mortality rate in Gangatiri calves were found due to gastrointestinal troubles (8.53%), which was due to bacterial or viral infections or due to feeding of

Table-1 : Mortality of calf according to period of the year.

Periods	Male			Female			Over Mortality		
	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %
P ₁	72	12	22.64	80	14	35	155	26	16.13
P ₂	56	8	16.32	63	3	4.76	119	11	9.24
P ₃	47	7	14.89	60	6	16	107	13	12.45

Table-2 : Mortality rate of calf according to season of death.

Seasons	Male			Female			Overall Mortality		
	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %
Winter	220	15	6.82	202	8	3.96	422	23	5.45
Summer	190	11	5.79	195	6	3.07	385	17	4.47
Rainy	180	8	4.44	185	6	3.24	365	14	3.83

Table-3 : Mortality of calf according to cause of diseases.

Diseases	Male			Female			Overall Mortality		
	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %	No. of birth	No. of death	Mortality %
Gastroenteritis	220	20	9.10	190	15	7.89	410	35	8.53
Pneumonia	195	10	5.13	185	4	2.60	380	14	3.66
Tympany	186	5	2.69	180	4	2.26	366	9	2.46
Others	210	7	3.33	182	5	2.75	392	12	3.06

colostrum should be late. Balvir et.al. (2009) observed gastrointestinal infections (7.30%) as a main cause of mortality followed by pneumonia an other animal disease in this study. Pneumonia was found to be the second one cause of mortality with (3.66%). Insufficient or delayed colostrum feeding, cause of handling, over and under feeding, weaning is not adopted, worm infestation, snake bite etc, were found to be third one reason of calf mortality, which results in 3.06 percent. Verma et.al. (1996) also observed that timely and essential required amount of colostrum feeding to neonatal calves found in to lower incidence of death. The percentage of mortality due to tympany, hepatitis and septicemia were low cause of mortality.

Conclusion

The influence of period, season of birth, cause of disease on mortality rate of Gangatiri calves has been investigated. The sex and season of death do not have significantly effect on the calf mortality rate, however the age and disease has highly significantly effect on the mortality rate in Eastern Haryana calves.

References

1. A.K. Mishra, Rawat N.S., Nanawati. S, Gaur, A.K.(2015) Study on the calf mortality pattern in Gir breed. *International J.L. Prod.* 6(4): 47-51
2. Balvir. S, Brijesh S., Ghosh A.K. (2009). Cause of mortality among Red Shindhi cattle at organized herd. *Indian J. Anim. Prod. Manage* 24(3-4): 20-22
3. Ghosh S.K., Roy S.K, Samanth A.R. (1996). Effect of metrological factors on calf mortality in subtropical zone of West Bengal. *Indian J. Anim. Prod. Manage.* 10(4): 156-58.
4. Islam S. (2005). Cause and consequences of calf mortality in a dairy farm of Bangladesh. *J. Anim. And Vet. Advances*, 4 (2): 260-264.
5. Kamboj M.L, Joshi B.K, Shiv P. (2006). A study on calf mortality in Nili-Ravi. Buffalo calves. *Indian J. Dairy Science*, 95 (3): 181-185.
6. Kunal C.R. (2006). Calf mortality pattern to age. Sex in organized livestock farm in Andhra Pradesh. *Indian J. Anim. Science*, 72(10): 921-923.
7. Pal R.K, Anand K.B., Shiv Bachan (2021). Studies on nutritional status and its relationship to milk production of lactating murrah buffaloes of rural areas of Kushinagar District (U.P.) *Progressive Research—An International Journal Volume* 16(1): 14-16.



Adoption of Dairy Technology by Indian Dairy Farmers

Thorat Dinesh D.¹, Sonwane Rajkumar S.^{2*} and Naik Arvind P.¹

¹Department of Dairy Science, Toshniwal Arts, Commerce and Science College, Sengaon, M.S.

²Department of Dairy Science, Yeshwant Mahavidyalaya, Nanded, M.S.

*Corresponding Author Email : rajkumarsonwane2013@gmail.com

Abstract

Milk is a necessary and essential commodity for human life. Milk is not the perfect alternative. Milk is the main raw material for dairy products like ghee, curd, cheese, butter, cottage cheese etc. These are all processed types of milk. India is not only the largest milk producer in the world but also consuming almost the entire milk production. It is important to adopt modern technology in agriculture to improve the productivity and welfare of poor farmers in developing countries. Not much is known about how (not) the value chain affects technology transfer and /or household food chain adoption in developing countries. This paper reveals about the dairy technology adopted by the Indian dairy farmers.

Key words : Dairy technology, milk, adoption, dairy farmers.

Introduction

Improving the productivity and welfare of poor farmers in developing countries like India requires the adoption of modern technology in dairying as well as in agriculture and is an important factor in achieving poverty reduction and rural development. However, the adoption of modern technology is disappointing, especially in the poorest agricultural sector in the world.

Milk is a necessary commodity for human life. Milk is not the perfect alternative. Milk is the main raw material for dairy products like ghee, curd, cheese, butter, cottage cheese, etc. These are all processed types of milk. India possesses large livestock wealth which contributes substantial income to the national economy (35.5% of GDP, Rs 93,361 crore) by generating employment to the vast population of small and marginal farmers possessing meagre resources. Though the country is leading in total milk production in the world (195 mIntonnes), the productivity per unit is very less and India's per capita availability is 394 grams/day. (Source–NDDB 2019). According to the Food and Agriculture Organization of the United Nations Dairy Market Survey Report, world milk production in 2018 reached 900 million tonnes, which is 2.5% more than the milk production in 2017.

In the year 2011-18, the country has produced 210.5 million tonnes, which is 21% of the global milk production with a per capita availability of 385 grams. This made India the largest milk producer, followed by the United States of America. But the level of milk production has slowed down compared to the increase in demand.

In 2006, India became the largest producer and consumer of milk, gaining the popularity of the White

Revolution. Dairy in India has claimed the lives of billions of dairy farmers as dairy farming is considered to be the second most important business after agriculture. There are currently 22 state milk-marketing federations in the country, and AMUL is a federation's most popular milk team member.

With the proliferation of the internet, the government has created a web portal called Dairy Knowledge Portal. The National Dairy Development Board (NDDB) has published a booklet reiterating its commitment to take care of and adhere to dairy farmers in India.

Milk; as dairy products are essential commodities and basic raw materials, the main focus is to distribute the value of the dairy according to quality and quantity. Dairy farms are the primary stage of milk procurement and overall agricultural productivity is a major concern, which is currently not up to expectations. Farm-level productivity depends on the production of each dairy product on the farm. In the case of India, the average production of a milking unit is 10.2 kg less than that of the USS where it is 28.6 kg.

Milk Cooperation System in India : A co-operative is a voluntary organization of people that contributes their resources and energy to some common cause. The Gujarat-based cooperative system in the Indian dairy sector has an important role to play in the supply chain. According to a 1995 survey of 28 countries conducted by the International Dairy Federation (IDF) in 1995, producer co-operatives sold 86% of the total farm milk sales out of 55% of the world's milk supply. At present, there are more than 19,000 milk co-operative societies in the state of Gujarat and more than 2,00,000 organizations across the country have been inspired by 25 milk federations.

Table-1 : State wise Milk Production in India from 2014-15 to 2018-19 (000 tonnes).

State	2014-15	2015-16	2016-17	2017-18	2018-19
All India	146,314	155,491	165,404	176,347	187,749
Andhra Pradesh	9,656	10,817	12,178	13,725	15,044
Arunachal Pradesh	46	50	53	54	55
Assam	829	843	861	872	882
Bihar	7,775	8,288	8,711	9,242	9,818
Chhattisgarh	1,232	1,277	1,374	1,469	1,567
Goa	67	54	51	55	57
Gujarat	11,691	12,262	12,784	13,569	14,493
Haryana	7,901	8,381	8,975	9,809	10,726
Himachal Pradesh	1,172	1,283	1,329	1,392	1,460
J & K	1,951	2,273	2,376	2,460	2,540
Jharkhand	1,734	1,812	1,894	2,016	2,183
Karnataka	6,121	6,344	6,562	7,137	7,901
Kerala	2,711	2,650	2,520	2,576	2,548
Madhya Pradesh	10,779	12,148	13,445	14,713	15,911
Maharashtra	9,542	10,153	10,402	11,102	11,655
Manipur	82	79	79	82	86
Meghalaya	83	84	84	85	87
Mizoram	20	22	24	25	26
Nagaland	76	77	79	74	73
Orissa	1,903	1,930	2,003	2,088	2,311
Punjab	10,351	10,774	11,282	11,855	12,599
Rajasthan	16,934	18,500	20,850	22,427	23,668

Source : National Dairy Development Board, Government of India.

The concept of Dairy Co-operative Society has made a significant contribution to the social as well as the economic life of the dairy farmers. The White Revolution aims to raise funds for social welfare, community development, and self-employment opportunities in the village. Dairy co-operatives and federations have developed a modern system of veterinary health care through veterinary trained surgeons equipped with van services and provided the necessary medicines to help veterinarians with the help of artificial insemination technology.

AMUL has extended the use of information and communication technology on the rural milk supply chain to other players in the country. GCMMF has proven that if information and communication technology is properly designed and implemented, it can benefit people in rural areas and the dairy industry as a whole. This has facilitated digital payments to the herdsman, keeping the farmers' DBMS-based records with milk supply details, as well as keeping a GPS track of milk transport to avoid wastage. Dairy co-operatives in the dairy sector have a market share and they have been able to sustain it even in the face of competition from the private sector. The model of cooperatives in the dairy sector has inspired other sectors of the economy and has expanded to other manufacturing and marketing sectors as well.

The role of technology in the business world has grown tremendously. Traditional business functions,

models, and concepts have been revolutionized as a result of the establishment of technology because technology has provided an innovative and good approach to doing business. It provides a convenient, smoother, and more efficient way to do business. Many companies, regardless of their product or service orientation, have realized that the adoption of technology from the procurement process to delivery has led to drastic positive changes in the business process and reduced profits. The business revolution caused by the Internet and other technologies makes it clear that technology interventions are essential to the success of today's Internet-based business ventures. Therefore, as managers, entrepreneurs, and business professionals of tomorrow, how to use and manage a wide variety of information technologies to revive the challenges of the dairy business process and gain a competitive advantage with improved managerial decision-making.

Implementation of technology reflects this value in terms of cost optimization, quality control, waste reduction, achieving economies of scale, efficient dairy utilization, improved yield/productivity, standardized processes, enhanced decision support systems, and overall management.

Implementation of Technology-Present Scenario of Indian Dairy Farms : Various technologies have been introduced in the Indian technology sector. Cattle and health-related problems are the main problems in Indian

Dairy. This is due to an inefficient health research system that can be fixed through ICT-based monitoring or artificial insemination. Over the last few years, India has seen negative growth in the bovine population which could affect supply shortages in line with demand. ICT-enabled monitoring helps in the early detection of animal health and facilitates database management by keeping daily records of the animals such as heat detection, movement, and proper timing for milking, timely veterinary assistance. Etc. Although under NDP I (NDDDB), the initiative to set up Micro Training Centers (MTCs) to reach out to farmer training and promote new technologies on improved fodder production and culture has been successful. Farmer to farmer education/technology transfer has become faster than other traditional methods. This in turn takes away the productivity and longevity of the inanimate 'property' of the dairy cattle. The emerging trend is that of dairy farms that are crucial to meet upcoming demands. Therefore, the adoption of technology spread in such fields is essential for beneficial outcomes through effective management.

Complexity of the Problem : Dairy milk procurement has a high potential to meet the growing demand and hence this side of the opportunity but at the same time, small, marginal and medium-sized farmers face various challenges. There are many established dairies across the country. Some are performing while struggling. The main reason for non-performance is the inefficient management of dairy departments in terms of their health and productivity which affects the overall productivity of agriculture.

Previous research has suggested that technology intervention is one way to maximize the efficiency of dairy farming as technology is one of the major factors in increasing the efficiency of the dairy sector. Also, there are competent factors that act as barriers to achieving the value of the potential implementation and maintenance related challenges of some implementations in the adoption of technology. Costs, infrastructure, awareness, technical and management support, skills, etc. These are some of the biggest challenges. Global examples support the success story of technology implementation and its drastic impact on dairy productivity. Thus it can be noticed that some competing companies are pushing for the adoption of technology while some challenges are limiting this adoption, where the overall aim is to produce specific types of values like quality management, productivity enhancement, cost optimization, conformity, waste management, etc. in the presence of some controlled or unregulated elements controlling the adoption of technology. Being in the same system, each component acts as a subsystem and these subsystems affect all

other subsystems as well as other systems and other subsystems.

System Approach to Problem Solving : Systems approaches have been developed in response to the increasing complexity of socio-technical and managerial systems. Many techniques and approaches have been developed based on system philosophy that helps to analyze different problem situations in multiple ways. Ludwig von Bertalanfi reports extensive developments in the field of general systems theory and discusses trends in systems science, mathematical systems theory, systems technology, and systems philosophy. The approach to systems is broadly divided into 'hard' systems and 'soft systems'. The evolution of the idea of ??applied system ideas has overcome the disadvantages of hard systems. As businesses grew with increasing competition, many issues arose in terms of marketing, profitability, quality concerns, cost reduction approaches, corporate social responsibility, diversity, and so on. Hence it was noticed that the approach of linear or hard system is not correct. Solve problems and create optimal strategies when making complex and plural decisions. For this reason, the approach to soft systems emerged as a better way of thinking in response to increasing non-linear complexity in business and the environment.

Conclusions

Adoption of modern technology in dairying and agriculture can be important to improve the productivity and welfare of poor farmers in developing countries like India. The value chain can play an important role in adopting new technologies, disseminating information, and supporting the modernization of the procurement system. This process has been analyzed in high-value supply chains in developing countries and, but not much is known about how value chains (not) affect technology transfer and / or adoption in domestic food chains in developing countries.

References

1. Burkitbayeva, Saule; Janssen, Emma; Swinnen, Johan F.M. *Technology adoption and value chains in developing countries : Panel evidence from dairy in Punjab*, Waaistraat, KULEUVEN, Faculty of Economics and Business, LICOS Centre for Institutions and Economic Performance.
2. Chopde, S.S., Deshmukh, M.A., Kalyankar, S.D. and Kele, V.D. (2015). Computer Applications in Dairy Industry, *Oriental journal of computer science & technology*, Vol. 8, Issue: 1, pp.24-34.
3. Donde, P. (2017), Automatic quality information management system of dairy business, *International Journal of engineering science and computing*, Vol. 7, Issue: 4, pp. 6277-6280.
4. Deshmukh, M.S. (2014). Growth and performance of dairy

- sector in India, *Voice of Research*, Vol. 3, Issue: 2, pp. 39-44.
5. Government of India (2018-19). National Dairy Development Report (NDDDB), Annual Report.
 6. Higgins, V. (2007). Performing Users : The Case of a Computer-Based Dairy Decision Support System, *Science Technology & Human Values*, Vol. 32, No. 3, pp. 263-286.
 7. Kumar, A., D. Roy, P.K. Joshi, G. Tripathi, and R.P. Adhikari. (2016). Impact of Contract Farming on Profits and Yield of Smallholder Farms in Nepal: Evidence from Lentil Cultivation. *Annual Meeting, July 31-August 2, 2016, Boston, Massachusetts. Agricultural and Applied Economics Association*.
 8. Kumar, A., S.J. Staal, and D.K. Singh. (2011). Smallholder Dairy Farmers' Access to Modern Milk Marketing Chains in India. *Agricultural Economics Research Review*, 24, 243-253.
 9. Squicciarini, M., and A. Vandeplas. (2010). *The Dairy Sector of Andhra Pradesh: Findings from a Company Survey*. No. TAPSIM deliverable D5.3, LICOS, KU Leuven, Belgium.



Correlation and Path Analysis in Indian Mustard [(*Brassica juncea* L. (Czern and Coss))]

Jyotsana Rathore*, Hemlata Sharma, Natwar Singh Dodiya, Abhay Dashora and Nitu Yadav

Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur 313001

*Email : jyotsanarathore55@gmail.com

Abstract

An experiment was undertaken to study the correlation and path analysis of fourteen characters in forty seven Indian mustard (*Brassica juncea* L.) germplasm lines including three checks. The experiment material was evaluated in augmented design with four blocks. The mean sum of squares due to genotypes were significant for all the characters, suggesting the existence of high genetic variability among different genotypes for all the traits studied. The analyses of variance for different characters showed significant differences for number of primary branches, number of seed per siliqua, length of siliqua, seed yield per plant and harvest index studied at 1 per cent level of significance while plant height, number of secondary branches, number of siliquae per plant, days to maturity and biological yield per plant at 5 per cent level of significance. The results showed that the genotypic correlation coefficient was greater than phenotypic correlation coefficient for all the traits indicating strong inherent association between among these traits. The less difference between GCV and PCV revealed that there was very low influence of environment on the expression of various characters. Highest GCV and PCV estimates were revealed for number of secondary branches per plant, number of siliquae per plant. High heritability (>60%) coupled with high genetic gain (>30%) was depicted by for number of secondary branches and number of siliquae per plant. Data for correlation analysis showed that the genotypic correlation coefficient was greater than phenotypic correlation coefficient for all the traits indication strong inherent association between among these traits. Data for correlation analysis at genotypic level depicted that highest positive significant association was found between seed yield per plant and harvest index and data for correlation analysis at phenotypic level depicted that highest positive significant association was found between seed yield per plant and harvest index. Days to 50% flowering, plant height and number of secondary branches had showed positive direct effect on grain yield per plant at genotypic level, while number of secondary branches per plant and days to 50% flowering had showed positive direct effect on grain yield per plant.

Key words : Genetic variability, correlation and path analysis, mustard.

Introduction

Indian mustard scientifically known as *Brassica juncea* L. is globally used as vegetable, oilseed and condiments (Saleem *et al.*, 2017). Mustard belongs to family Brassicaceae and genus *Brassica*. Three diploid species viz., *Brassica nigra* (L.), *Brassica oleracea* (L.) and *Brassica campestris* (L.) are included in *Brassica* genus and they have developed three amphidiploid species, viz., *Brassica carinata* (L.), *Brassica juncea* (L.) Czern and Coss and *Brassica napus* (L.) Most of the species of *Brassica* are used as oilseed crop and some as forage. Indian mustard [*B. juncea* (L.) Czern and Coss] which is popularly known as rai, raya or laha is one of the major oil seed crops of the country occupying considerably large acreage among the Brassica group of oil seed crops. Indian mustard is natural amphidiploid ($2n=36$) of *Brassica campestris* ($2n=20$) and *Brassica nigra* ($2n=16$) (Nagaharu, U, 1935). Mustard is a Rabi season crop which is grown in temperate region having cool and dry weather. After groundnut it is second major edible oilseed crop of the India. Mustard is extensively availed as oilseed crop as its oil is considered one of the healthiest one to

consume. India occupies first position both in acreage and production of rapeseed and mustard in Asia. In India, it covers an area of about 6.23 M ha having 9.34 M tones production. (Directorate of economics and statistics, 2018-19). The foremost mustard cultivating states of India are Rajasthan, Uttar Pradesh, Gujarat, Madhya Pradesh, Assam, Bihar, Odisha, Haryana, Punjab and West Bengal. Rajasthan is the bulkiest producer of rapeseed- mustard followed by MP, UP, Haryana, West Bengal, Gujarat and Assam. In Rajasthan, it is mostly grown in districts of Alwar, Bharatpur, Sri Ganganagar, Kota and Jaipur. It covers 2.37 M ha area in Rajasthan with 4.08 M tones production. (Directorate of Economics and Statistics, 2018-19).

Yield is an important quantitative trait for any crop improvement programme. Thus the study of correlation between yield and its component is of primary importance in formulating the selection criteria under crop improvement. Genetic improvement for quantitative traits relies upon the nature and amount of variability present in the genetic stock and the extent of heritability of desirable traits. In order to increase production of Indian mustard,

Table-1 : Variability parameters for various characters in Indian mustard.

S. No.	Characters	Vg	Vp	GCV	PCV	h^2 (bs) %	GA	GG
1.	Days to 50% flowering	2.99	8.36	5.11	6.79	56.51	5.35	7.91
2.	Days to maturity	4.72	12.18	3.37	3.68	83.84	8.2	6.36
3.	Plant height	68.58	116.25	8.38	9.07	85.19	31.49	15.92
4.	Number of primary branches	0.10	0.14	12.43	13.01	91.27	1.22	24.46
5.	Number of secondary branches	0.59	0.73	24.55	26.6	85.2	2.92	46.68
6.	Length of main branch	28.11	80.17	7.51	9.08	68.35	18.06	12.78
7.	Number of siliquae per plant	886.57	1629.18	19.71	21.67	82.69	111.55	36.92
8.	Length of siliqua	0.06	0.09	9.3	9.86	88.99	0.97	18.08
9.	Number of seeds per siliqua	0.69	1.00	11.54	11.62	98.74	3.41	23.63
10.	Seed yield per plant	0.43	0.66	8.78	9.35	88.22	2.54	16.99
11.	1000-Seed weight	0.01	0.03	0.01	0.02	20.49	0.03	0.07
12.	Biological yield per plant	1.40	2.42	4.26	4.77	79.85	4.35	7.84
13.	Harvest index	1.90	2.81	10.22	10.56	93.61	5.49	20.37
14.	Oil content	0.02	0.08	0.61	0.88	47.51	0.34	0.87

Vg - Genotypic variance, Vp - Phenotypic variance, GCV - Genotypic coefficient of variation, PCV - Phenotypic coefficient of variation, h^2 (bs) - Heritability (broad sense), GA - Genetic advance, GG - Genetic gain

there is requisite to develop high yielding varieties which in turn demand for a systematic breeding approach to be carried out. To develop superior cultivars or hybrids, genetic variability present in the breeding material plays vital role in planning breeding programme. The appraisal of parameters comprising phenotypic and genotypic coefficients of variation, heritability in broad sense, and genetic advance as per cent of mean is a pre-requisite for making effective selection (Manjunath *et al.*, 2017). Good understanding about genetic factors responsible for the inheritance of yield contributing characters, is necessary for any applied breeding programme. The comprehension of genetic correlation, which occurs between characters, can help the breeder to improve the efficiency of selection by using favourable combinations of traits and to minimize the retarding effect of negative correlations. Correlation and path analysis helps in assessing yield contributing characters for selection.

Materials and Methods

The present study was carried out at experimental farm, Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *Rabi* 2020-21 to estimate genetic variability, heritability, genetic advance, correlation, direct and indirect effect of yield components on yield through path analysis. Seeds of each genotype was sown in 3 rows of 3 m length and crop geometry of 30 cm row to row and 10 cm plant to plant spacing was maintained. All the recommended package of practices for Zone IVA of Rajasthan were followed to raise a healthy crop.

The data were recorded for 14 traits on five randomly selected competitive plants per plot in each replication except for days to 50% flowering and days to maturity where observations will be recorded on whole plot basis. The experimental material consisted 47 brassica genotypes including 3 checks and genotypes were planted in Augmented design in 4 blocks. These traits were computed on basis of mean data after computing for each character was subjected to standard method of analysis of variance following Fisher (1925). The phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri *et al.* (1958) while path analysis was carried out using the genotypic correlation coefficient to know direct and indirect effects of the components on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1957).

Results and Discussion

The analysis of variance revealed significant differences among the 47 genotypes for all the fourteen characters presented in Table-1. The perusals of data revealed that phenotypic variance were higher than the corresponding genotypic variance for all the traits studies. Which indicated the influences of environmental factor on these characters. Data presented in Table- 1 showed highest GCV estimates were revealed for number of secondary branches per plant (24.55), followed by number of siliquae per plant (19.17) and lowest magnitude of GCV for 1000-seed weight (0.01) followed by oil content (0.61) and highest PCV estimates were revealed for number of secondary branches per plant (26.60), followed by number of siliquae per plant (21.67) whereas lowest PCV

Table-2 : Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient matrix for different characters.

	Days to 50% flowering	Days to maturity	Plant height	No of primary branches	No of secondary branches	Length of main branch	No of siliquae per plant	Length of siliqua	No of seeds per siliqua	Seed yield per plant	1000-Seed weight	Biological yield per plant	Harvest index	Oil content
Days to 50% flowering		-0.87**	0.07	0.30	0.15	0.62**	0.10	0.08	0.10	0.54**	0.82	0.28	0.34*	0.37*
Days to maturity	-0.44**		0.16	-0.16	0.08	0.11	0.31*	-0.20	-0.23	0.05	0.71	0.19	-0.05	-0.79**
Plant height	0.16	0.18		0.34*	0.29	0.74**	0.34*	-0.18	-0.19	0.39**	0.82	0.21	0.23	0.23
No of primary branches	0.63**	-0.12	0.37*		0.31*	0.33*	0.08	-0.01	0.12	0.25	0.71	-0.09	0.25	0.36*
No of secondary branches	0.41**	0.17	0.25	0.33*		0.29	-0.04	-0.17	-0.16	0.30*	0.50	-0.02	0.23	-0.04
Length of main branch	0.22	0.02	0.56**	0.32*	0.42**		0.03	0.05	-0.14	-0.27	0.81	0.44**	-0.44**	-0.09
No of siliquae per plant	0.17	0.43**	0.34*	0.10	0.07	-0.06		-0.12	-0.01	0.24	0.49	-0.06	0.21	0.10
Length of siliqua	0.08	-0.16	-0.20	-0.04	-0.17	-0.04	-0.07		0.78**	-0.37*	-0.19	-0.15	-0.24	0.15
No of seeds per siliqua	0.07	-0.20	-0.19	0.11	-0.14	-0.21	-0.03	0.86**		-0.39**	0.73	-0.29	-0.19	0.08
Seed yield per plant	0.32*	-0.02	0.29	0.21	0.34*	-0.08	0.25	-0.43**	-0.35*		0.01	-0.04	0.90**	0.02
1000-Seed weight	-0.06	0.10	0.02	-0.06	-0.07	-0.04	-0.23	0.78	-0.22	0.81		0.92	0.77	0.95
Biological yield per plant	0.23	0.15	0.08	-0.14	-0.04	0.29	-0.04	-0.31*	-0.26	-0.17	0.16		-0.56**	-0.17
Harvest index	0.18	-0.09	0.19	0.25	0.29	-0.22	0.21	-0.21	-0.17	0.89**	-0.06	-0.49**		0.05
Oil content	0.14	-0.32*	0.10	0.23	0.02	0.06	-0.03	0.18	0.08	0.01	-0.31*	-0.10	0.09	

Table-3 : Genotypic and phenotypic correlation coefficients between seed yield per plant and other characters in Indian mustard.

Characters	Genotypic Correlation Coefficient (rg)	Phenotypic Correlation Coefficient (rp)
Days to 50% Flowering	0.54**	0.32*
Days to maturity	0.05	-0.02
Plant height (cm)	0.39**	0.29
Primary branches per plant	0.25	0.21
Secondary branches per plant	0.30*	0.34*
Length of main branch	-0.27	-0.08
Number of siliquae per plant	0.24	0.25
Length of siliqua	-0.37*	-0.43**
Number of seeds per siliqua	-0.39**	-0.35*
1000-Seed weight	9.00	0.01
Biological yield per plant	-0.17	-0.04
Harvest index	0.89**	0.90**
Oil content	0.01	0.02

obtained for 1000-seed weight (0.03), followed by oil content (0.88). These traits suggested the possibility of yield improvement through selection. High heritability was observed for number of seeds per siliqua (98.74), followed by harvest index (93.61) and number of primary branches per plant (91.27). Highest genetic gain was observed for number of secondary branches per plant (46.68), followed by number of siliquae per plant (36.92%) and number of primary branches per plant (24.46).

The genotypic and phenotypic coefficient of different traits with their relationship among themselves are presented in table-2. Data for correlation analysis showed that the genotypic correlation coefficient was greater than phenotypic correlation coefficient for all the traits. Data for correlation analysis at genotypic level depicted that highest positive significant association was found between seed yield per plant and harvest index (0.90**) and the lowest positive significant association at genotypic level was found between number of secondary branches and seed yield per plant (0.30*). While it showed highest negative significant genotypic association between days to 50% flowering and days to maturity (-0.87**). Similarly, data for correlation analysis at phenotypic level depicted that highest positive significant association was found between seed yield per plant and harvest index (0.89**) and the lowest positive significant association at genotypic level was found between days to maturity and number of siliquae per plant (0.31*). While it showed highest negative significant genotypic association between harvest index and biological yield per plant

Table-4 : Estimation of path coefficient at genotypic level for seed yield per plant.

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No of primary branches	No of secondary branches	Length of main branch (cm)	No of siliquae per plant	Length of siliqua (cm)	No of seeds per siliqua	1000-Seed weight (g)	Biological yield per plant (%)	Oil content	Correlation with seed yield (r)
Days to 50% flowering	-0.5883	0.0804	-0.1422	-0.0840	0.2307	0.8369	0.1076	-0.1409	0.1296	-0.1141	-0.0680	0.2942	0.5417**
Days to maturity	0.5142	-0.0920	-0.1611	0.0163	0.0973	0.1493	0.2713	0.3310	-0.2947	-0.1141	-0.0450	-0.6254	0.0471
Plant height	-0.0924	-0.0164	-0.9057	-0.0446	0.1647	0.9992	0.2114	0.3101	-0.2503	-0.1141	-0.0499	0.1826	0.3947**
No of primary branches	-0.3709	0.0112	-0.3035	-0.1332	0.1779	0.4515	0.0475	0.0233	0.1578	-0.1141	0.0207	0.2853	0.2536
No of secondary branches	-0.2388	-0.0157	-0.2625	-0.0417	0.5685	0.3877	-0.0226	0.2792	-0.2147	-0.1141	0.0040	-0.0286	0.3006*
Length of main branch	-0.3632	-0.0101	-0.6676	-0.0444	0.1626	1.3556	-0.0398	-0.0882	-0.2787	-0.1141	-0.1051	-0.0739	-0.2670
No of siliquae per plant	-0.1011	-0.0399	-0.3060	-0.0101	-0.0206	-0.0861	0.6258	0.2053	-0.0085	-0.1141	0.0149	0.0780	0.2376
Length of siliqua	-0.0491	0.0180	0.1663	0.0018	-0.0940	0.0708	-0.0761	-1.6884	1.1192	-0.1141	0.0729	0.1437	-0.4288**
No of seeds per siliqua	-0.0583	0.0207	0.1734	-0.0161	-0.0934	-0.2891	-0.0041	-1.4459	1.3069	-0.1141	0.0690	0.0598	-0.3911**
1000-Seed weight	-5.2948	-0.8280	-8.1511	-1.1992	5.1162	12.2001	5.6326	-15.1952	11.7620	-0.0127	-2.1503	7.1204	0.819
Biological yield per plant	-0.1675	-0.0173	-0.1891	0.0116	-0.0096	0.5963	-0.0390	0.5150	-0.3774	-0.1141	-0.2389	-0.1350	-0.1651
Oil content	-0.2187	0.0727	-0.2090	-0.0481	-0.0206	-0.1267	0.0617	-0.3067	0.0988	-0.1141	0.0408	0.7912	0.0212

Residual is -0.60

(-0.89**). A perusal table 3 revealed that seed yield per plant exhibited significant positive correlation with number of secondary branches per plant at both genotypic and phenotypic level ($r_g = 0.30^*$, $r_p = 0.34^*$), days to 50 per cent flowering at both genotypic and phenotypic level ($r_g = 0.54^{**}$, $r_p = 0.32^*$), harvest index at both genotypic and phenotypic level at both genotypic and phenotypic level ($r_g = 0.89^{**}$, $r_p = 0.90^{**}$), plant height at genotypic level ($r_g = 0.39^{**}$, $r_p = 0.29$). While it exhibited significant negative correlation with number of seeds per siliqua at both genotypic and phenotypic level (-0.39^{**} , $r_p = 0.35^*$) and length of siliqua at both genotypic and phenotypic level (-0.37^* , 0.43^{**}). These findings are in accordance with the findings of Devi (2018), Yadav and Panday (2018), Kumar *et al.* (2018), Prasad and Patil (2018), Rout *et al.* (2019) and Lakra *et al.* (2020).

The results of the path coefficient analysis at genotypic level are presented in table 4. Data for path analysis revealed that days to 50% flowering (0.5417**) followed by plant height (0.3947**) and number of secondary branches (0.3006*) had showed positive direct effect on grain yield per plant at genotypic level. While, length of siliqua (-0.4288**) and number of seed per siliqua (-0.3911**) had showed negative direct effect on grain yield per plant at genotypic level. Data for path analysis at phenotypic level revealed that number of secondary branches per plant (0.3392*) and days to 50% flowering (0.3192*) had showed positive direct effect on grain yield per plant. While, length of siliqua (-0.3716*) and number of seeds per siliqua (-0.4375*) had showed negative direct effect on grain yield per plant. Similar findings were reported by Roy *et al.* (2017) Gupta (2018), Rout *et al.* (2019) and Lakra *et al.* (2020).

References

1. Al-Jibouri, H.A, Miller, P.A., Robinson, H.F. (1958). Genotype and environmental variances and co-variance in upland cotton cross of interspecific origin. *Agron. Journal*, 50: 633-637.
2. Burton G.W. (1952). Quantitative Inheritance in Grasses in: *Proc. 6th Int. Grassland Congress*. 7: 273-283.
3. Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of wheat grass seed production. *Agronomy Journal*, 51: 515-518.
4. Directorate of Economics and Statistics. (2018-19). Production of food grains and commercial crops, Department of Agriculture, Cooperation and Farmers Welfare.
5. Fisher, R.A. (1954). Statistical Methods for Research Workers. *Biological Monograph and Manuals*, 5: 130-131.
6. Gupta, A., Pant, N., Dwivedi, U., Tiwari, S., Pandey, C., Dhaudiyal R., Maurya, K. and Verma, O.P. (2018). Studies on correlation and path coefficient analysis for yield and yield related traits in Indian mustard (*Brassica juncea* L.

- Czern & Coss) under timely and late sown conditions. *Journal of Pharmacognosy and Phytochemistry*, 7: 2545-2551.
7. Manjunath, H., Phogat, D.S., Kumari, P. and Singh, D. (2017). Genetic analysis of seed yield and yield attributes in Indian mustard (*Brassica juncea* (L.) Czern and Coss). *Electronic Journal of Plant Breeding*, 8(1): 182-186.
 8. Lakra, A., Tantuway, G., Tirkey, A.E. and Srivastava, K. (2020). Genetic variability and Trait association studies in Indian mustard (*Brassica juncea* L. Czern & Coss). *International Journal of Current Microbiology and Applied Sciences*, 9(1): 2556-2563.
 9. Nagaharu, U. (1935). Genome analysis in Brassica with special reference to the experimental formation of B. napus and peculiar mode of fertilization. *Japan Journal of Botany*, 7: 389-452.
 10. Rout, S., Kerkhi, S.A. and Gupta, A. (2019). Estimation of genetic variability, heritability and genetic advance in relation to seed yield and its attributing traits in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Journal of Pharmacognosy and Phytochemistry*, 8(3): 4119-4123.
 11. Roy, R.K., Kumar, A., Kumar, S. and Kumar, A. (2017). Correlation and path analysis in Indian mustard (*Brassica juncea* L. Czern and Coss) under late sown condition. *The Biosean*, 11(4): 3117-3124.
 12. Wright, S. (1921). Correlation and Causation. *Journal of Agriculture Research*, 20: 2528.



Extent of Knowledge, Adoption and Existing Gap Regarding Recommended Pigeonpea Production Practices among the Farmers of Raipur District in Chhattisgarh

Pooja Yadav, P.K. Pandey, M.A. Khan and M.L. Sharma

Department of Agricultural Extension, IGKV, Raipur (CG)

Email : py864469@gmail.com

Abstract

Present study was carried out during 2019-20 in the Raipur district of Chhattisgarh state. This study was conducted in purposively selected 12 Villages of Arang and Dharsiwa blocks with sample comprised of 120 respondents. The findings of the study showed most of the respondents belonged to middle age group (36-50) years, had primary level of school education, belonged to Other Backward Class, residing with joint type of family with medium size family of 6 to 8 members, more than 20 years of farming experience. Among selected package of practices, maximum level of knowledge (91.10%) was found regarding improved variety followed by land preparation (70.55%). Maximum knowledge gap (46.12%) was reported regarding weed management, insect management (45.84%) and diseases management (45.0%). In case of adoption level maximum level of adoption (90.27%) was shown towards improved variety followed by land preparation practices (65.55%). In case of adoption gap it was observed that maximum adoption gap (48.62%) was found regarding adoption of nutrient management practices in pigeonpea cultivation followed by weed management, disease management and insect management practices which were 47.23, 46.95 and 46.67 percent respectively. Very less adoption gap (9.73%) was found regarding adoption of improved varieties recommended by the agencies. Variables like education, occupation, cosmopolitaness and knowledge level was positively and significantly correlated with adoption level of recommended pigeon pea production technology at 1 percent level of significance. Moreover, with the increase in knowledge level, adoption of recommended technology by the respondents also increases.

Key words : Knowledge, adoption, extent, gap, pigeonpea

Introduction

A legume food such as pigeonpea (*cajanus cajan* (L.) Millsp.), red gram (*Tur*), or yellow lentil could play an important role in ensuring food and nutritional security. Population growth and rapid industrialization are reducing available land for food grain cultivation. As a result, the only way forward is to increase production per unit area through intensive efforts made at various research centers on high yielding pigeonpea varieties, good agronomical practices, and effective control measures against insects and pests. It could be due to the lack of adoption of pigeonpea production technology keeping in view the above points, the present investigation has been designed to study the socio-economic profile characteristics of the respondents, extent of knowledge and major constraints faced by respondents towards recommended pigeonpea production technology.

Materials and Methods

The study was conducted in two selected blocks namely Arang and Dharsiwa block of the Raipur District in 2019-20. 12 villages were chosen randomly and data was collected purposively from 120 (10x12) pigeonpea growing respondents via personal interview. To find out the adoption and knowledge index and gap the adoption

and knowledge quotient were worked out. Data were analysed by using appropriate statistical methods like, mean, percentage, and correlation.

Results and Discussion

Attributes of the respondents : The majority (45.00%) of the respondents were found in middle age group (36 to 50 years). The maximum number of the respondents were found to be educated up to primary school 41.60 per cent followed by 33.33 percent of the respondents who were educated upto middle school whereas 11.60 per cent respondents were illiterate. 13.30 per cent of the respondents were educated up to high school.

Other backward class were dominated in the population with 68.33 percent among the caste groups. Regarding the type of family, the maximum numbers of respondents about 73.40 per cent belong to joint family type. Among family size category the maximum (62.50%) of respondents had medium size of family (6 to 8 members). About 53.30 per cent of respondents were (above 20 years) in Farming experience. The findings are similar to Barodia (2005) and Tiwari *et al* (2019).

Extent of knowledge and existing knowledge gap : Table-2 shows the extent of knowledge and existing knowledge gap regarding recommended practices of

Table-1 : Distribution of respondents according to their socio-personal profile.

S.N.	Categories	Frequency	Percentage
1.	Age		
	Young (upto 35 years)	30	25.00
	Middle (36-50 years)	54	45.00
	Old (above 50 years)	36	30.00
2.	Education		
	Illiterate	14	11.60
	Primary school (1 to 5th)	50	41.60
	Middle school (6th to 8th)	40	33.33
	High school and above	16	13.30
3.	Caste		
	Scheduled Tribe	18	15.00
	Scheduled Caste	10	8.33
	Other Backward class	82	68.33
	General	10	8.33
4.	Family type		
	Nuclear	32	26.6
	Joint	88	73.4
5.	Family size		
	Small(3 to 5 members)	25	20.83
	Medium (6 to 8 members)	75	62.50
	Big (above 8 members)	20	16.6
6.	Farming experience		
	Up to 10 years	16	13.4
	11 to 20 years	40	33.3
	Above 20 years	64	53.3

pigeonpea production among the respondents. The overall knowledge index was 64.83 per cent wherein majority (39.84%) of the respondents had medium level of knowledge level followed by 32.83 per cent of the respondents with low knowledge level and 27.33 per cent of the respondents with complete knowledge level. The overall knowledge gap was 35.17 percent which signifies that there was low knowledge gap among the respondents.

The results regarding extent of knowledge towards different practices of pigeonpea production technology reveals that, maximum knowledge extent (91.10%) was recorded for improved variety of pigeonpea followed by land preparation, seed rate, sowing methods, seed treatment which were 70.55, 70.27, 69.72, 64.44 and 61.11 percent respectively. While, least extent of knowledge was recorded towards knowledge of weed management practices among the respondents. In case of knowledge gap regarding recommended pigeonpea production practices, the result reveals that the maximum knowledge gap (46.12%) was found regarding weed management practices followed by insect management, disease management and post harvest management practices which were 45.84, 45.00 and 41.95 per cent respectively. Very least knowledge gap (8.90%) was

observed regarding knowledge of improved varieties of pigeonpea among the respondents. Pandey (2000) also revealed the similar findings in his study.

Extent of adoption and existing adoption gap : The data presented in Table-3 reveals the extent of adoption and existing gap in adoption of recommended pigeonpea production technology among the respondents of study area. It was found that majority of the respondents (80.00%) were had higher level of adoption of improved varieties of pigeonpea followed by 51.66 per cent respondents had medium level of adoption of recommended seed rate of pigeonpea. Very low level adoption was observed regarding nutrient management practices among the 53.33 per cent respondents followed by 50.83 per cent respondents had low adoption level regarding weed management practices. High adoption index (90.27%) was recorded regarding adoption of improved varieties followed by land preparation (65.55%), seed rate (60.55%), sowing methods (60.00%) and seed treatment practices with score of 57.77 per cent adoption index. The adoption index regarding practices of post harvest management, insect management, disease management, weed management and nutrient management were recorded 56.94, 53.33, 53.05 and 51.38 per cent respectively.

In case of adoption gap, maximum adoption gap (48.62%) was found regarding nutrient management practices followed by weed management (46.95%), disease and insect management which was 46.95 and 46.67 per cent respectively. Very less adoption gap (9.73%) was observed towards the adoption of recommended improved varieties of pigeonpea among the respondents. Findings are similar as reported by Khuspe and Kadam (2012) in their investigation.

Relationship between independent variables and adoption of recommended pigeonpea production technology : The outcomes of statistical analysis presented in Table-3 reveals that education, occupation, cosmopolitaness and knowledge level were found highly positively and significantly correlated with adoption level of recommended pigeon pea production technology at 0.01 level of probability whereas, the variables like, age, caste, land holding, family type, farming experience, irrigation, annual income and method of cultivation had shown non-significant relationship with dependent variable. The similar results were also reported by Dewangan (2016) in his study.

The results reveal that with increase in educational qualification, adoption level also increases. Similarly, with increase in number of occupation, their adoption level also increases due to increase in their annual income. In the same manner, with increase in their cosmopolitaness,

Table-2 : Distribution of respondents according to their extent of knowledge.

S.N.	Practices	Knowledge level			K. I. (%)	K.G. (%)
		Low	Medium	High		
1.	Improved variety	10 (8.33)	12 (10.00)	98 (81.66)	91.10	8.90
2.	Land preparation	21 (17.5)	64 (53.3)	35 (29.16)	70.55	29.45
3.	Seed rate	35 (29.1)	37 (30.83)	48 (40)	70.27	29.73
4.	Sowing method	25 (20.83)	59 (49.16)	36 (30.00)	69.72	30.28
5.	Seed treatment	38 (40)	52 (42.5)	30 (17.5)	64.44	35.56
6.	Nutrient management	42 (35.00)	56 (46.66)	22 (18.33)	61.11	38.89
7.	Weed management	59 (49.16)	48 (40.00)	13 (10.83)	53.88	46.12
8.	Diseases management	58 (48.33)	46 (38.33)	16 (13.33)	55.00	45.00
9.	Insect management	57 (47.50)	51 (42.50)	12 (10.00)	54.16	45.84
10.	Post-harvest management	49 (40.83)	53 (44.16)	18 (15.00)	58.05	41.95
Overall knowledge		394 (32.83)	478 (39.84)	328 (27.33)	64.83	35.17

Note : Figure in parentheses are in percentage. K.I = Knowledge index

Table-3 : Extent of adoption and existing gap among the respondents regarding recommended practices of pigeonpea production.

S.N.	Practices	Low	Medium	High	A.I. (%)	A.G. (%)
1.	Improved variety	11 (9.16)	13 (0.83)	96 (80.00)	90.27	9.73
2.	Land preparation	36 (30)	52 (43.33)	32 (26.66)	65.55	34.45
3.	Seed rate	40 (33.33)	62 (51.66)	18 (15.00)	60.55	39.45
4.	Sowing method	46 (38.33)	52 (43.33)	22 (18.33)	60.00	40.00
5.	Seed treatment	52 (43.33)	48 (40.00)	20 (16.66)	57.77	42.23
6.	Nutrient management	64 (53.33)	47 (39.16)	9 (7.50)	51.38	48.62
7.	Weed management	61 (50.83)	48 (40.00)	11 (9.16)	52.77	47.23
8.	Diseases management	59 (49.16)	42 (35.00)	16 (13.33)	53.05	46.95
9.	Insect management	59 (49.16)	50 (41.66)	11 (9.16)	53.33	46.67
10.	Post-harvest management	53 (44.16)	49 (40.83)	18 (15.00)	56.94	43.06
Overall adoption		481 (40.08)	463 (38.58)	253 (21.08)	54.10	45.90

Note : Figures in parentheses are in percentage. A.I. = Adoption index, A.G. = Adoption gap

Table-4 : Coefficient of correlation between independent variable and adoption level of pigeonpea production technology.

S.N.	Independent variables	'r' Value
1.	Age	0.004
2.	Education	0.290**
3.	Caste	0.081
4.	Land holding	0.034
5.	Family type	-0.009
6.	Farming experience	-0.061
7.	Irrigation	0.103
8.	Annual income	0.037
9.	Occupation	0.267**
10.	Method of cultivation	-0.062
11.	Cosmopolitaness	0.300**
12.	Knowledge	0.497**

**Significant at 0.01 level of probability.

their adoption level also increases. Moreover, with the increase in knowledge level, adoption of recommended technology by the respondents also increases.

Conclusions

On the basis of above findings it may be concluded that the majority of the respondents had very high level of

knowledge and adoption regarding improved varieties, land preparation, seed rate, sowing methods and seed treatment. Remarkable finding has been observed regarding knowledge and adoption of improved varieties of pigeonpea. It seems like that the main reason behind such higher extent of adoption and knowledge is the supply of improved seeds by line department to the farmers, which indicates that the subsidies and inputs distribution by different extension agencies are major stimulants for adoption of recommended production technologies. The findings also raise the question that what will the extent of adoption if the subsidies and inputs supply would withdrawn by the Govt. agencies? The provision of inputs and subsidies cuts the cost of cultivation incurred by the farmers which is not the permanent solution towards the profitable farming. There is need to rethink about cost cutting technology from 'minimum input to maximum output' which may make able to the farmers to adopt the technology without any support by agencies which may be resulted in self reliance of the farmers.

References

1. Barodia, A.R. 2005. A study on adoption behaviour of vegetable growers in relation to improved technology in Phanda block of Bhopal district (M.P.). *M.Sc. (Ag.) Thesis*, JNKVV, Jabalpur
2. Deshmukh, M.P. 2006. Knowledge and adoption of pigeon pea variety BSMR 736 by the farmers in Jalna district. *M.Sc. (Ag.) Thesis*, MAU. Parbhani (M.S.).
3. Dewangan Mayank, 2016., An economic analysis of productivity and marketing of major pulses in Gariyaband district of (C.G.). *M.Sc. (Ag.) Thesis*. IGKV, Raipur (C.G.).
4. Gurjar J. 2014. A study on technological gap in adoption of chickpea production technology among farmers of Tikamgarh District of Madhya Pradesh. *M.Sc. (Ag.) Thesis*, JNKVV, Jabalpur (M.P.).
5. Khuspe S.B. and Kadam R.P. 2012. Adoption gap in recommended production practices of chickpea. *Agric. Update*, 7(3&4) Aug. & Nov., 2012 : 301-303.
6. Pandey P.K. 2000. Constraints analysis in adoption of rice production technology in the Kota tribal block of Bilaspur district in Madhya Pradesh. *M.Sc. (Ag.) Thesis*, IGKV, Raipur (C.G.).
7. Tiwari Abha, Markam Neha and Dubey, M.K. 2019. Factors Responsible for Adoption of Improved Pea Production Technology among the Pea Growers. *Int. J. Curr. Microbiol. App. Sci.* 8(03): 933-938.



Population Dynamics of the Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Rabi Maize

Rohit Kumar*, S. Ramesh Babu, N.L. Dangi, M.K. Mahla and Beerendra Singh

Department of Entomology, Rajasthan College of Agriculture, Udaipur-313001 Rajasthan (India)

*Email : a9636800219@gmail.com

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated worldwide which the most versatile crop is showing a wider range of adaptability under different agroclimatic conditions. Among the cereal crops, due to its highest genetic yield potential maize is called as “queen of cereals” (Singh *et al.*, 2012). Globally, maize crop is cultivated in an area of about 190 m ha in 165 countries which contribute to a global grain production of 39%. Indian ranks 4th in area and 7th in production among the maize growing countries. As a predominant *kharif* crop in India, it covers around 83% of the total maize area while 17% area is covered by *rabi* maize. In India, about 9.2 million ha area is covered by the maize crop (DACNET, 2020) with a production of 27.8 million MT in 2018-19 and average productivity of 2965 kg/ha. Around 16.98 lakh hectares were covered by *rabi* maize in the country (Maize Outlook, 2020). In Rajasthan, about 0.86 million ha area was covered by the maize crop with the production of 1.96 million tonnes and productivity of 2285 kg/ha (Anonymous, 2018-19).

In India, FAW was first time reported on maize during May 2018 (Sharanabasappa *et al.*, 2018) from the state of Karnataka. In India, FAW has been found to attack maize, sorghum, sugarcane, and millets (Nayyar *et al.*, 2021). It has been reported to capable of feeding on around 353 host plants belonging to seventy-six families, mainly consists of Poaceae, Asteraceae, and Fabaceae from Brazil (Montezano *et al.*, 2018). In Rajasthan, FAW was detected for the first time in early 2019 from the Southern region of the state on *rabi* maize which was confirmed by the morphological and molecular method (Ramesh Babu *et al.*, 2019). The rapid dispersal of *S. frugiperda* and the absence of proper management tactics pose a major threat to the food security (De Groote *et al.*, 2020) and economy and it has the potential to cause yield losses of 8.3 to 20.6 million metric tons of maize per year in Africa's maize producing countries (CABI, 2016).

Materials and Methods

An experiment was conducted to study the population

dynamics of fall armyworm in maize and the trial was laid out in uniformly sized plots measuring 3 x 2.5 m replicated four times. The seeds of maize varieties/hybrids viz., Sugar-75 (Sygenta; sweet corn), AHC 2595 (HYVEG) and local variety were sown in the well-prepared field at Agronomy Farm, RCA during *Rabi*, 2020-21 with the spacing of 60 x 25 cm. All the recommended agronomic practices were followed as per the package of practices of Zone Iva and the trial was maintained without the insecticidal sprays throughout the study period.

Observations :

(a) Larval Population of *S. frugiperda* was recorded at different stages of the maize crop (Belfield and Brown, 2008). During morning/evening hours, the larvae were observed during the vegetative growth stage 1 (V1: week 2–4 after sowing); vegetative growth stage 2 (V2: weeks 5–7 after sowing); tasselling/silking; cob formation; milk stage; dough and senescence from 10 randomly selected plants in each plot as per the procedure suggested by Gabriella *et al.*, 2006.

(b) The larvae collected from the field were brought to the laboratory and maintained in a plastic container on maize leaves until the emergence of adult of *S. frugiperda* or any parasitoid. The per cent parasitism (%) was calculated by the following equation :

$$\text{Parasitism per cent} = \frac{\text{No. of parasitized individuals}}{\text{No. of total individuals observed}} \times 100$$

(c) The pheromone traps were installed in two locations of approximately 40-50 m distances at the field site with the help of a wooden stick. Traps were placed 2 meters height from the ground inside the maize crop at 15 days after sowing. Each trap was re-baited regularly at 25 days intervals to attract and lure male moths of *S. frugiperda* into the pheromone trap. The adult male population of *S. frugiperda* was monitored and counted at weekly intervals till the harvest of the maize crop. The adult male population of *Mythimna separata* was also monitored and counted at weekly intervals with the help of installed pheromone traps till the harvest of the maize crop.

Statistical Analysis : The weather parameters for the period 2020-21 were recorded from the metrological unit

located at the Rajasthan College of Agriculture, Udaipur. The weekly data on maximum temperature (°C), minimum temperature (°C), morning and evening relative humidity (%), Wind speed (km/hr) and sunshine (hrs) was recorded during the experimental period. Population data of *S. frugiperda* thus obtained were subjected to statistical analysis to find out the co-efficient of correlation with the abiotic factors using the following formula :

$$r_{xy} = \frac{\frac{\sum xy}{n}}{\sqrt{\left(\frac{\sum x^2}{n}\right) \left(\frac{\sum y^2}{n}\right)}}$$

Where, r_{xy} = Simple correlation coefficient

x = Variable i.e. abiotic component

y = Variable i.e. Mean number of insects

n = Number of observations

The data were analyzed by using simple correlation and regression tools with the help of Minitab 19 Statistical Software (trial version) and WASP -Web-Based Agricultural Statistics Software Package of Central Coastal Agricultural Research Institute, ICAR, Goa.

Spatial distribution of *S. frugiperda* in maize : During different growth stages of maize, a total of seven samples on the larval population of fall armyworm and other stem borer were taken from 10 randomly selected plants per plot to study the spatial distribution of fall armyworm, *Spodoptera frugiperda* during *Rabi*, 2020-21. A total of 70 plant samples were taken at each growth stage of the maize crop for this study. The data from original counts were arranged in frequency tables for fitting the different statistical parameters. Variance to mean ratio (Southwood, 1978), exponent-K (Lloyd, 1967), patchiness index (Lloyd, 1967), clumping index (David and Moore, 1954), mean colony size (Tanigoshi *et al.*, 1975), mean clump size (Arbous and Kerrich, 1951), Iwao's patchiness regression (Iwao's, 1968) and Taylor's power law (Taylor, 1961) were analyzed to test the dispersion behavior of *S. frugiperda* during *rabi* season. $\hat{a}$ and $\hat{b}$ were obtained from the regression of the mean crowding against mean density refer to the basic component of dispersion and the pattern of distribution, respectively (Iwao, 1968). The regression constants 'a' and 'b' of Taylor's power law also indicated the sampling parameter and the aggregation index, respectively (Taylor, 1961).

Results and Discussion

The fall armyworm infestation was initiated in the first week of November (44th Standard Meteorological Week, SMW). A maximum mean population of 8.33 FAW

larvae/5 plants was observed during the first vegetative stage and the population of FAW decreased gradually and recorded a minimum (2.33 FAW larvae/5 plants) at the senescence stage. Similarly, the larval population per five plants of 6.89, 4.22, 3.67 and 2.78 was observed during the different growth stages of the maize crop viz., vegetative II stage, tasselling/silking, cob formation, milky and hard dough, respectively (Figure-1).

The data presented in figure-2 shows that the adult male moth population of Oriental armyworm, *Mythimna separata* was observed 11 days after germination of the maize crop and it was more abundant from November to March during the year of observations in *rabi* maize. The larval population of *M. separata* was negligible when compared with the new invasive pest and the data on the larval was not presented in the present study. Whereas the new invasive pest, FAW, *Spodoptera frugiperda* was recorded from the first week of November onwards and the adult male moth population was increased with the growing season and decreased towards the end of the growing season (table-1 and figure-2). The population increased gradually and reached its peak population in the 3rd week of February (8th SMW) with a mean adult moth population of 10/trap. At the peak, the maximum temperature (29.6°C), minimum temperature (8.9°C), morning relative humidity (65.4%), evening relative humidity (18.3%), wind speed (2.4 Km/hr) and Sunshine (9.3 hrs) were recorded. Further, the population decreased up to crop maturity and the last incidence was observed during the 12th SMW with a mean population of 4.5 adult male moths/trap (table-1).

The literature available on the incidence of *M. separata* and *S. frugiperda* during *rabi* maize is very limited. Due to this, another stem borer incidence was taken for comparison during this present study. Sharma *et al.*, (2017) revealed that the larval population of *S. inferens* on maize was observed from 45th SMW to 7th SMW (last week of October to the first week of March) whereas, the highest larval population of *S. inferens* observed during the last week of February and 2nd week of March recorded the peak activity of adult moths in maize (Deole *et al.*, 2016).

The present findings are in concurrence with the previous work of Anandhi *et al.* (2020) who revealed that the population was maximum during the first fortnight of November and gradually decreased and recorded the minimum during the second fortnight of January in different locations during *rabi* season. The first appearance of fall armyworm in 27 to 34 days old crop in *rabi* maize as reported by Dhar *et al.*, (2019) whereas, Bhavani *et al.*, 2019 noticed the incidence of fall armyworm in 20-60 days old sugarcane crop. The present

Table-1 : Influence of Weather Factors on Adult Male Moth Population of *S. frugiperda* in Maize (Rabi, 2020-21).

SMW	Maxi. Temp. (°C)	Mini. Temp. (°C)	Mor. RH (%)	Eve. RH (%)	Wind speed (Km/hr)	Sunshine (hrs)	Mean Adult Male Population/trap
44	30.1	10.3	67	21.4	2.6	8.6	5.5 (2.45)
45	30.2	9.6	68.9	24.4	2.2	8.7	7.5 (2.83)
46	28.9	11.6	79.7	42.9	2.3	6.8	9 .0 (3.08)
47	26.2	9.4	73.1	34.3	2.4	7.1	6.0 (2.55)
48	27.1	9.7	83	34	2.9	8	7.5 (2.83)
49	30.4	10.2	76.1	27.3	1.8	8.8	4.0 (2.12)
50	24.5	12.1	85.4	52.1	2.9	4.1	7.5 (2.83)
51	23.3	4.3	80.9	26.7	2	7.9	9.5 (3.16)
52	22.5	3.8	81.9	27.8	2.4	8.3	8.0 (2.92)
1	24.0	8.7	85.7	46.7	2.3	3.4	7.0 (2.74)
2	22.8	9.7	90.6	51.4	2.4	4.3	8.5 (3.00)
3	27.3	7.5	87.9	32.9	1.8	8.3	9.0 (3.08)
4	24.5	4.1	83.1	28.1	2.3	8.8	8.0 (2.92)
5	26.1	4.4	76.1	23.1	2.2	8.6	4.0(2.12)
6	26.6	5.9	75.6	22.3	2.6	8.7	5.0 (2.35)
7	29.0	8.0	74.4	23.1	2.6	8.3	5.5 (2.45)
8	29.6	8.9	65.4	18.3	2.4	9.3	10.0 (3.24)
9	32.3	11.4	64.9	23.1	3.2	9.6	6.5 (2.65)
10	33.1	13.1	54.4	26.5	4.4	9.5	5.0 (2.35)
11	33.3	14.7	57.4	27.1	2.7	8.5	4.0 (2.12)
12	33.2	15.3	61.7	20.7	3.5	7.3	4.5 (2.24)

Table-2 : Correlation Co-efficient between Pheromone Trap Catches of *Spodoptera frugiperda* and Weather Parameters on Rabi Maize (2020-21).

Insect pest	Maxi. Temp. (°C)	Mini. Temp. (°C)	Mor. RH (%)	Eve. RH (%)	Wind speed (Km/hr)	Sunshine (hrs)
<i>Spodoptera frugiperda</i> (n=21)	-0.512*	-0.330	0.530*	0.360	-0.324	-0.239
<i>Mythimna Separata</i> (n=21)	-0.065	0.079	0.080	0.080	-0.155	-0.167

**Significant at 1% *Significant at 5%

Table-3 : Regression Analysis between Pheromone trap catches of *Spodoptera frugiperda* and Weather Parameters on Rabi Maize (2020-21).

Insect pest	Regression equation	R ²
<i>Spodoptera frugiperda</i>	$Y = 2.844 + (-0.096) X_1 + (0.067) X_2 + (0.009) X_3 + (0.008) X_4 + (-0.064) X_5 + (0.144) X_6 + 0.347 (SE)$	0.36*

**Significant at 1% *Significant at 5%

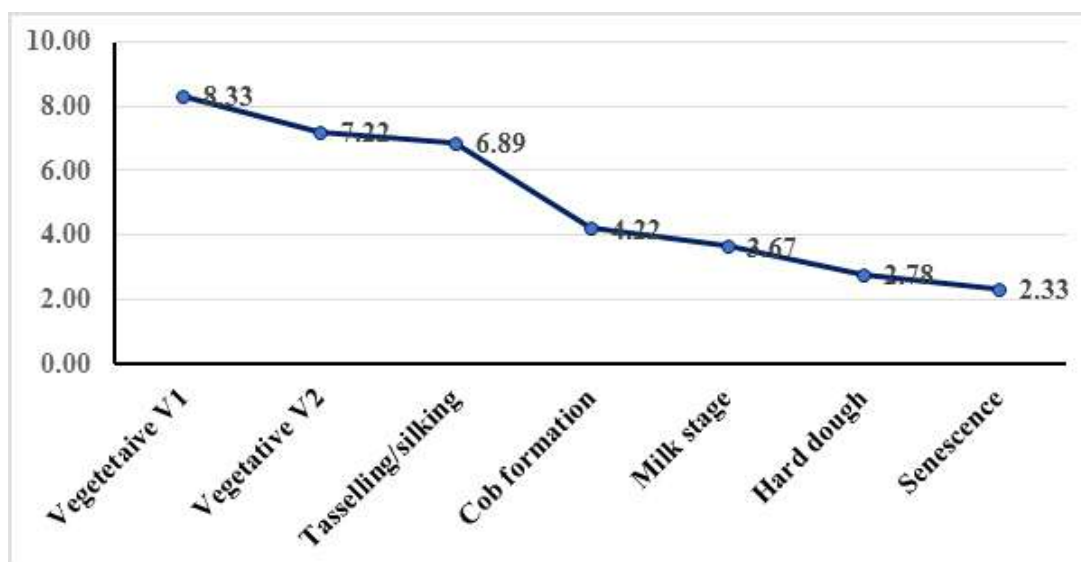
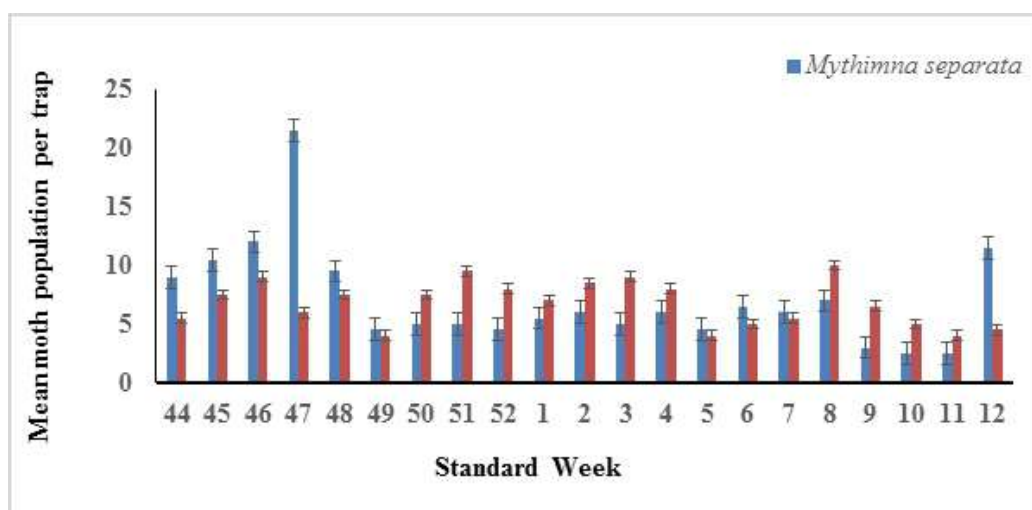
X₁ = Maximum temperature (°C); X₂ = Minimum temperature (°C); X₃ = Morning relative humidity (%) X₄ = Evening relative humidity (%); X₅ = Wind speed (km/hr); X₆ = Sunshine (hrs)

results are contradictory with the results of Venkateswarlu *et al.* (2018) who observed the initial incidence in the first week of October (40th SMW) and reached its maximum in the last week of October. Similarly, during rabi, the incidence was maximum during the first fortnight of November while the minimum was recorded at the second fortnight of November. Meena *et al.* (2019) revealed that during the last week of October and the first fortnight of November, the larval infestation of 12-15/25 plants was recorded.

Correlation and Regression Analysis on the Incidence of fall armyworm (FAW) and *Mythimna separata* with the Weather Parameters during Rabi, 2020-21 : The data presented in Tables 2 and 3 revealed that the adult male moth population of fall armyworm indicated a significant negative correlation with the maximum temperature ($r = -0.512^*$) whereas, significant positively correlated with the morning relative humidity ($r = 0.530^*$). All other weather factors showed negatively correlated with the adult moth population of FAW except evening relative humidity and were non-significant. The regression

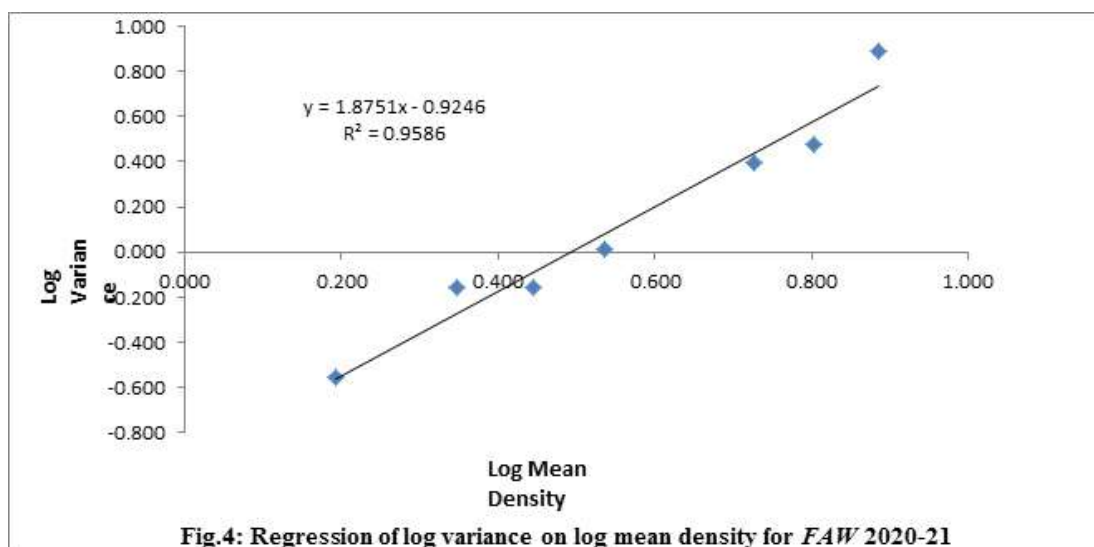
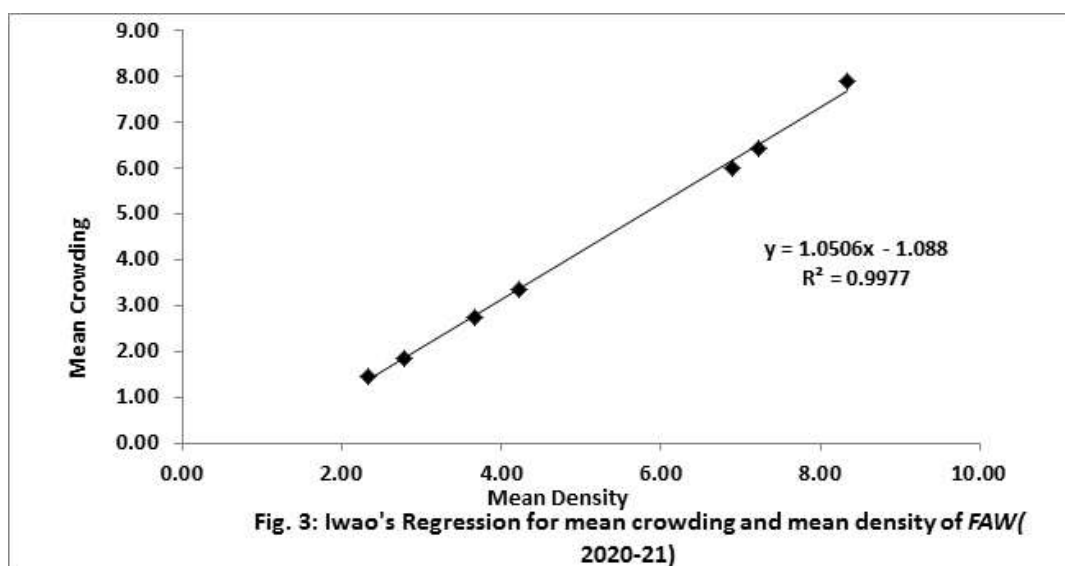
Table-4 : Indices of Spatial Distribution of *S. frugiperda* on Maize (Rabi 2020-21).

Stages of Observation	Mean density ($\bar{x}$)	Variance (s^2)	Disp. Index (VMR)	Disp. pattern (K)	Clumping Index (IDM)	Mean Crowding Index (X^*)	Llyod's Patchiness Index	Co-efficient of variation (CV)	Pattern of distribution
Vegetative V1	8.33	4.50	0.54	-18.12	-0.46	7.87	0.94	0.25	C
Vegetative V2	7.22	1.44	0.20	-9.03	-0.80	6.42	0.89	0.17	U
Reproductive R1	6.89	0.61	0.09	-7.56	-0.91	5.98	0.87	0.11	U
Reproductive R2	4.22	0.44	0.11	-4.72	-0.89	3.33	0.79	0.16	U
Reproductive R3	3.67	0.25	0.07	-3.93	-0.93	2.73	0.75	0.14	U
Reproductive R4	2.78	0.19	0.07	-2.99	-0.93	1.85	0.67	0.16	U
Reproductive R5	2.33	0.25	0.11	-2.61	-0.89	1.44	0.62	0.21	U

Figure-1: Distribution of FAW, *Spodoptera frugiperda* in Rabi maize (2020-21).Figure-2 : Weekly male moth catches in pheromone trap of major insect-pests (*Mythimna separata* and *Spodoptera frugiperda*) (SE) observed in Rabi maize (2020-21).

equation presented in table 2 exhibited that all the weather parameters (maximum temperature, minimum temperature, morning and evening relative humidity, wind speed and sunshine) had a significant influence of 36 per

cent ($R^2 = 0.36$) on the adult male moth population of fall armyworm. The individual weather factors did not significantly influence the adult male moth population of *S. frugiperda*. The regression equation further indicated that



the sunshine had a non-significant positive impact on the population *i.e.* 1 unit increase in sunshine led to 0.144 unit increase in fall armyworm population (table-3).

The population of adult moths of *Mythimna separata* showed the least correlation with weather parameters during *rabi* 2020-21. The population of *Mythimna separata* also shows a non-significant positive correlation with minimum temperature ($r = 0.079$), morning relative humidity ($r = 0.080$) and evening relative humidity ($r = 0.080$), while non-significant negative correlation with maximum temperature ($r = -0.065$), wind speed ($r = -0.155$) and sunshine hrs ($r = -0.167$). Due to the non-significant results of correlation studies and least per cent influence on the population of *Mythimna separate* and data are not presented for multiple linear regression analysis.

These results are in agreement with the work of Deepika (2020) who observed that the fall armyworm

population depicted a negative non-significant correlation with mean atmospheric temperature and there was a positive but non-significant correlation with the mean relative humidity. However, the fall armyworm population has shown a significant and positive correlation with minimum temperature and relative humidity and a negative correlation with maximum temperature. However, non-significant positive correlation with rainfall as reported by Fonseca-Medrano *et al.* (2019). Similarly, Nboyine *et al.* (2020) reported a positive correlation between fall armyworm population and relative humidity. Kumar *et al.* (2020) revealed that the fall armyworm population has shown a positive correlation with maximum temperature whereas a negative correlation was observed with the minimum temperature and relative humidity. These differences have deviated from the present studies may be due to differences in places /regions, stages of the insects and also due to differences in seasons.

In the present study, the early larval parasitoid, *Campoletis chloridae* Uchida on fall armyworm in rabi maize was recorded. The percentage of natural parasitization was below 5% during rabi season. Deepika (2020) recorded six hymenopteran larval parasitoids viz., *Chelonus* sp., *Cotesia* sp., *Microplitis* sp., *Campoletis chloridae* Uchida and others were unidentified species belongs to *Ichneumonidae* and *Braconidae*. The maximum parasitization of 14.15% was reported by different workers which are contradictory to the present findings. Similarly, Magali *et al.*, (2015) also reported *Chelonus* sp.; Shylesha *et al.*, (2018) whereas, Chormule *et al.*, (2019) and Sharanabassapa *et al.*, (2020) also observed *Campoletis* sp., Ramesh babu *et al.*, (2020) reported the parasitization percentage of 7.33% by the early instar larval parasitoid, *Campoletis chloridae* on the fall armyworm during rabi season at Banswara, Rajasthan. Similarly, Navik *et al.*, (2021) reported the most abundant incidence of larval parasitoid, *C. chloridae* on the larvae of *S. frugiperda* with the parasitism percentage of 1.86–6.63% in maize at Karnataka. But their season and time of observations and regions were different from the present study.

Spatial distribution of fall armyworm on maize during Rabi, 2020-21 : The results on the spatial dispersion pattern of *S. frugiperda* on maize are presented in Table 4. The values of the Dispersion Index (VMR) were less than one in all the sampling occasions indicating a regular type of distribution. Further, the values of Dispersion pattern (K), which measure the degree of aggregation, were negative in all cases, suggesting a low degree of aggregation. The values of other parameters viz., Clumping Index (IDM) values were all negative; Mean Crowding Index (X^*) values were lesser than Mean Density and Lloyd's Patchiness Index values were less than one, which confirmed the regular nature of dispersion of *S. frugiperda*. The mean colony size (C^*) also decreased with the decreased in the number of larvae.

In order to find out the type of aggregation involved, i.e. whether it was an aggregation of insects in colonies or an aggregation of colonies, Iwao's patchiness regression was fitted over a range of different densities and was computed as $X^* = -1.088 + 1.050x^{-1}$ ($R^2 = 0.997$) (figure.3). The value of $\hat{a}$ (-1.088) which was less than zero represents the negative association between the individuals and the value of $\hat{a}$ (1.050), which is approximately equal to unity, indicates the random distribution of individuals. The Taylor's Power Law equation was computed as $\log s^2 = -0.924 + 1.875 \log x^{-1}$ ($R^2 = 0.958$) (figure. 4). The value of the index of aggregation, b (1.875), was more than unity, which shows the aggregate nature of the distribution.

The results of the Farias *et al.* (2001b), Serra and Trumper (2004), Melo *et al.* (2006) and Hernandez-Mendoza *et al.* (2008) were concurrence with the present study results due to the random nature of distribution was observed in their studies. Meena *et al.* (2019) also observed the uniform or close to random, rather than aggregated larval distribution of fall armyworm population. Whereas the results of the present study contradictory by outcome of Deepika (2020) who reported that the *S. frugiperda* followed clumped dispersion and Hernandez-Mendoza *et al.*, 2008 observed the random distribution of the fall armyworm larvae and their infestations were highly associated with the different stages of the maize crop. The findings of Farias *et al.* (2001), Fernandes *et al.* (2002), Farias *et al.* (2008) and Rios *et al.* (2014) revealed that the distribution pattern of fall armyworm was clumped which contradictory the results of the present study.

References

1. Anandhi, S., Saminathan, V.R., Yasodha, P., Roseleen, S.S.J., Sharavanan, P. T. and Rajanbabu, V. 2020. Correlation of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) with Weather Parameters in Maize Ecosystem. *International Journal of Current Microbiology and Applied Science*, 9(8): 1213-1218.
2. Babu S.R., Kalyan R.K., Joshi, S., Balai, C.M., Mahla, M.K. and Rokadia, P. 2019. Report of an exotic invasive pest the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize in Southern Rajasthan. *Journal of entomology and zoology studies*, 7: 1296-1300.
3. Bhavani, B., Chandra Sekhar, V., Kishore Varma, P., Bharatha Lakshmi, M., Jamuna, P. and Swapna, B. 2019. Morphological and molecular identification of an invasive insect pest, fall army worm, *Spodoptera frugiperda* occurring on sugarcane in Andhra Pradesh, India. *Journal of Entomology and Zoology Studies*, 7(4): 12-18.
4. CABI, 2016. Datasheet, *Spodoptera frugiperda* (fall armyworm) Invasive Species Compendium.
5. Chormule, A., Shejawal, N., Sharanabasappa, C.M., Asokan, R., Swamy, H.M. and Studies, Z. 2019. First report of the fall Armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera, Noctuidae) on sugarcane and other crops from Maharashtra, India. *J. Entomol. Zool. Stud.*, 7(1): 114-117.
6. David, F.N. and Moore, P.G. 1954. Notes on contagious distributions in plant populations. *Annals of Botany*, 18(1): pp.47-53.
7. Dhar, T., Bhattacharya, S., Chatterjee, H., Senapati, S.K., Bhattacharya, P.M., Poddar, P., Ashika, T.R. and Venkatesan, T. 2019. Occurrence of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera : Noctuidae) on maize in West Bengal, India and its field life table studies. *Journal of Entomology and Zoology Studies*, 7(4): 869-875.
8. Fonseca-Medrano, M., Specht, A., Silva, F.A.M., Otanásio, P.N. and Malaquias, J.V. 2020. The population dynamics of three polyphagous owl moths (Lepidoptera:

- Noctuidae) and the influence of meteorological factors and ENSO on them. *Revista Brasileira de Entomologia*, 63: 308-315.
9. Groote, H.D., Kimenju, S.C., Munyua, B., Palmas, S., Kassie, M. and Bruce, A. 2020. Spread and impact of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) in maize production areas of Kenya. *Agriculture, Ecosystems & Environment*, 292.
 10. Iwao, S.I. 1968. A new regression method for analyzing the aggregation pattern of animal populations. *Population Ecology*, 10(1), pp.1-20.
 11. Kumar, N.V., Yasodha, P. and Justin, C.G.L. (2020). Seasonal incidence of maize fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Noctuidae; Lepidoptera) in Perambalur district of Tamil Nadu, India. *Journal of Entomology and Zoology Studies*, 8(3): 01-04.
 12. Lloyd, M. 1967. Mean crowding'. *The Journal of Animal Ecology*, pp.1-30.
 13. Maize Outlook. 2020. *Agricultural Market Intelligence, PJTSAU*.
 14. Meena, A.K., Chhangani, G., Kumar, A. and Swaminathan, R. 2019. Incidence of the fall armyworm *Spodoptera frugiperda* (JE Smith) at Udaipur in Maize. *Indian Journal of Entomology*, 81(2): 251-254.
 15. Montezano, D.G., Specht, A., Sosa-Gómez, D.R., Roque-Specht, V.F., Sousa-Silva, J.C., Paula-Moraes, S.V., Peterson, J.A. and Hunt, T.E. 2018. Host plants of *Spodoptera frugiperda* (Lepidoptera : Noctuidae) in the Americas. *African Entomology*, 26: 286-300.
 16. Navik, O., Shylesha, A.N., Patil, J., Venkatesan, T., Lalitha, Y. and Ashika, T.R. 2021. Damage, distribution and natural enemies of invasive fall armyworm *Spodoptera frugiperda* (JE smith) under rainfed maize in Karnataka, India. *Crop Protection*, 143: 105-136.
 17. Nayyar, N., Gracy, R.G., Ashika, T.R., Mohan, G., Swathi, R.S., Mohan, M., Chaudhary, M., Bakthavatsalam, N. and Venkatesan, T., 2021. Population structure and genetic diversity of invasive Fall Armyworm after 2 years of introduction in India. *Scientific reports*, 11(1): pp.1-12.
 18. Nboyine J.A., Kusi F., Abudulai M., Badii B.K., Zakaria M., Adu G.B., Haruna A., Seidu A., Osei V., Alhassan S. and Yahaya A. 2020. A new pest, *Spodoptera frugiperda* (J.E. Smith), in tropical Africa: Its seasonal dynamics and damage in maize fields in northern Ghana. *Crop Protection*, 127: 104960.
 19. Ordóñez-García, M., Rios-Velasco, C., Berlanga-Reyes, D.I., Acosta-Muñiz, C.H., Salas-Marina, M.Á. and Cambero-Campos, O.J. 2015. Occurrence of natural enemies of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in Chihuahua, Mexico. *Florida Entomologist*, pp.843-847.
 20. Sharanabasappa., Kalleshwaraswamy, C.M., Maruthi, M.S. and Pavithra, H.B. 2018. Biology of invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize. *Indian Journal of Entomology*, 80: 540-543.
 21. Sharma, H., Jaglan, M.S. and Yadav, S.S. 2017. Population dynamics of pink stem borer, *Sesamia inferens* (Walker) on maize as influenced by weather conditions. *Journal of Applied and Natural Science*, 9(4) :1975-1980.
 22. Shylesha, A.N., Jalali, S.K., Gupta, A., Varshney, R., Venkatesan, T., Shetty, P., Ojha, R., Ganiger, P.C., Navik, O., Subaharan, K. and Bakthavatsalam, N. 2018. Studies on new invasive pest *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) and its natural enemies. *Journal of Biological Control*, 32(3): 145-151.
 23. Singh, P.K., Singh, A.K., Shahi, J.P. and Ranjan, R. 2012. Combining ability and heterosis in quality protein maize. *The bioscan*, 7(2): 337-340.
 24. Southwood, T.R.E. 1978. Ecological method with particular reference to the study of insect population. 1st edn., The English language Book Society and Chapman and Hall, London. 524 pp.
 25. Taylor, L.R. 1961. Aggregation, variance and the mean. *Nature*, 189: 732-735.
 26. Venkateswarlu, U., Johnson, M., Narasimhulu, R. and Muralikrishna, T. 2018. Occurrence of the fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera, Noctuidae), a new pest on bajra and sorghum in the fields of agricultural research station, Ananthapuramu, Andhra Pradesh, India. *Journal of Entomology and Zoology Studies*, 6(6): 811-813.



Genetic Variability and Correlation Studies of Bread Wheat Genotypes under Late Sown Irrigated Conditions

V. Gupta*, M. Kumar, V. Singh and L. Chaudhary

Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana

*Email : vijetagupta1994@gmail.com

Abstract

Development of crop cultivars with superior performance has always been the prime objective of plant breeding programs. 100 wheat genotypes were characterized on the basis of 14 morpho-physiological characters. The genetic variability studies of 100 wheat genotypes under late sown irrigated conditions indicated high mean and wide range for all the traits under evaluation. PCV for all the traits was found higher than GCV. High GCV and moderate PCV were recorded for NDVI and grain yield per plot, number of tillers per meter, SPAD, spike length, biomass per plot, days to heading, NDVI, canopy temperature and plant height exhibited high heritability. GA as 5% mean was highest for NDVI, grain yield per plot, spike length, number of tillers per meter, biomass per plot and SPAD. Grain yield displayed significant correlations with biological yield per plant, spike length, 1000 grain weight, harvest index, number of grains per spike, number of tillers per meter, chlorophyll fluorescence, NDVI and SPAD but days to heading and plant height were non significantly correlated with grain yield per plot. This suggested better scope for selecting superior genotypes under heat stress.

Key words : Genetic variability, correlation, genotypes, gcv, pcv, wheat

Introduction

Wheat (*Triticum aestivum* L. em Thell), a cereal grass of the family *Graminae* (*Poaceae*) and genus *Triticum*, is the world's largest and most widely cultivated cereal crop. In India, wheat crop occupied about 29.32 million hectares during year 2020-21 with a record production of 103.6 million tones and 3.5 t/ha average productivity (FAOSTAT, 2020). Wheat is generally grown in India during *Rabi* season (mid-November to mid-April) after the harvesting of *Kharif* crops. Generally, wheat requires cool, moist weather during the major portion of growing period, followed by dry, warm weather for grain ripening. The risk of temperature is variable with stage of plant such as optimum range of temperature for growth during sowing is 16°C-22°C, for ideal germination is 20–25°C, for anthesis and grain filling is 12°C-22°C while during the period of ripening is 21°C-25°C (Bishwas *et al.*, 2021).

In North-western India, the remunerative rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) cropping system has forced wheat to be sown late. As a result, the late sown wheat crop at reproductive stages (anthesis to maturity) is generally exposed to very high temperature stress during the month of March and April. During this period the crop is at reproductive stage, which is the most sensitive one (Wollenweber *et al.*, 2003). Thus exposure of wheat to sub-optimal temperatures at vegetative stages

and supra-optimal temperature at post-anthesis stage (reproductive stages) results in reduced spikelets/spike, spikelet fertility, grain number *per* spike, photosynthates translocation within kernels and eventually poor grain filling due to reduced period and rate of grain filling.

Wheat improvement programmes lay major emphasis on breeding high yielding cultivars with better stability which require the proper evaluation of genotypes for yield and its components traits. For development of stable varieties there must be a presence of large genetic diversity in genotypes under study. From such genotypes, one can identify those genotypes showing wide stability under different environmental conditions. The development of elite genotypes depends upon the magnitude of genetic variability and the extent to which desirable characters are heritable. Genetic variability for yield and yield components is essential in the base population for successful crop improvement (Allard, 1960). The heritability of a character describes the extent to which it is transmitted from one generation to the next generation (Prasad *et al.*, 2021). The genetic advance is the further estimation of expected gain resulting from selection pressure in breeding material (Kumar and Kumar, 2021). High heritability associated with high genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection. Degree and direction of relationship between two or more variables lead to estimation of correlation. Correlation studies provide better understanding of yield components

which helps the plant breeder during selection (Baranwal *et al.*, 2012). Hence, the present investigation was conducted to study the extent of the genetic variability, heritability, genetic advance, correlation for grain yield and yield contributing traits of 100 wheat genotypes under late sown irrigated conditions.

Materials and Methods

The present investigation was conducted to assess the genetic variability for yield and yield attributing traits of 100 wheat genotypes under late sown irrigated conditions. Crop was grown in research area of Wheat Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, during the Rabi season of 2019-20 with 3 rows of 2-meter length each, along with two replications. Row to row distance of 20 cm was maintained in the present study.

The 100 wheat genotypes were evaluated for fourteen morpho-physiological traits as days to heading, days to maturity, plant height, number of tillers per meter, spike length, number of grains per spike, 1000 grain weight, grain yield per plot, biomass per plot, harvest index, chlorophyll fluorescence, canopy temperature, NDVI and SPAD. The data obtained was subjected to statistical analysis using OPSTAT software available online on www.hau.ernet.in. Genotypic and phenotypic coefficients of variation were estimated using formula suggested by Burton (1952) for each character. The broad sense heritability (h^2) was estimated as the ratio of genotypic variance to the total or phenotypic variance as suggested by Burton and Devane (1953). Genetic advance for each character was estimated by using the method suggested by Johnson *et al.* (1955). Genetic advance as 5% of mean was also estimated.

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sigma_g^2}{\text{Mean}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sigma_p^2}{\text{Mean}} \times 100$$

$$GA = h^2 \sigma_p K$$

Where,

σ_g^2 = Genotypic variance

σ_p^2 = Phenotypic variance

GA = Genetic advance

h^2 = Heritability estimate in broad sense

σ_p = Phenotypic standard deviation of the trait

K = Standard selection differential which is 2.06 at 5 per cent selection intensity.

The nature and extent of association between

different traits were studied by computing correlation coefficient (r) between pairs of traits. The calculation was based on mean values of traits and the correlation coefficients were calculated as given below :

$$r_g(xy) = \frac{\text{Cov}_g(xy)}{\sigma_g^2(x) \cdot \sigma_g^2(y)}$$

Where,

r_{xy} = Correlation coefficient between traits x and y

Cov(xy) = Covariance between x and y

$\sigma_g^2(x)$ = Variance of x

$\sigma_p^2(y)$ = Variance of y

Results and Discussion

Genetic Parameters : Pooling information about the genetic variability, relationships and mechanisms of inheritance of different traits is the key task in genetic improvement of any crop plant. Data on various yield, yield components and physiological traits of hundred genotypes were subjected to analysis of variance (ANOVA) as suggested by . The analysis of variance as presented in Table-1 revealed highly significant differences among the genotypes for all the characters studied *viz.* grain yield *per* plot, number of tillers *per* meter length, 1000-grain weight, spike length, number of grains *per* spike, plant height, biomass *per* plot, harvest index, days to heading, days to maturity, canopy temperature, chlorophyll fluorescence, NDVI and SPAD under late sown irrigated environment during Rabi season 2019-20. The ample amount of variability was found for all traits in 100 wheat genotypes under study. These traits can be used for selection in further generations. Phenotypic coefficient of variation (PCV) for all the traits was higher than genotypic coefficient of variation (GCV) which reveal the influence of environment on the expression of traits. These findings are in corroboration with those reported by earlier reports by Bayisa *et al.* (2020), Hossain *et al.* (2021) and Dutamo *et al.* (2015). It is likely to occur because phenotypic variations contain both genotypic and environmental components (Prasad *et al.*, 2021). Under late sown irrigated conditions the highest value of phenotypic coefficient of variation and genotypic coefficient of variation was observed for NDVI (24.57, 22.99) followed by grain yield *per* plot (24.20, 21.51), spike length (17.92, 17.46), biomass *per* plot (17.15, 16.42), number of tillers *per* meter (16.98, 16.75), chlorophyll fluorescence (15.58, 10.36), SPAD (15.36, 15.12) and harvest index (14.22, 12.23) (Table 2). Prasad *et al.* (2021) reported high GCV for grain yield *per* plant, grain weight *per* spike, biological yield *per* plant, number of grains *per* spike and number of effective tillers *per* plant whereas high PCV was observed for grain weight *per*

Table-1 : Mean sum of squares for various traits under late sown irrigated condition during 2019-20.

Source of variation (SV)	Degree of freedom (df)	Mean sum of squares						
		Days to heading	Days to maturity	Plant height (cm)	No. of tillers per meter	Spike length (cm)	Biomass per plot (g)	Grain yield per plot (g)
Replication	1	0.04	6.48	2.62	73.21	0.99	109699.28	47802.32
Genotypes	99	15.80**	8.09*	161.30**	552.24**	3.99**	155051.73**	19541.57**
Error	99	0.98	1.58	12.46	7.53	0.11	6704.86	2294.43

Table-1 : Contd.....

Source of variation (SV)	Degree of freedom (df)	Mean sum of squares						
		Harvest index (%)	1000 grain weight (g)	Number of grains per spike	Chlorophyll fluorescence	Canopy temperature	NDVI	SPAD
Replication	1	56.50	12.55	0.18	0.01	2.52	0.020	4.43
Genotypes	99	23.70**	17.13**	57.99*	0.07**	10.41**	0.023**	75.46**
Error	99	3.54	2.10	9.73	0.003	0.70	0.001	1.19

** Significant at (P< 0.01) percent and * significant at (P<0.05) percent level of probability, respectively

Table-2 : Estimates of genotypic and phenotypic coefficient of variance, heritability and genetic advance for grain yield and component characters of 100 wheat genotypes under late sown irrigated conditions.

Sr. No.	Characters	Mean $\pm$ SE	Range	Co-efficient of variation (%)		Heritability (h^2) (%)	Genetic advance (as % of mean)
				PCV	GCV		
1.	Days to heading	83.84 $\pm$ 0.99	77.00 - 97.00	3.46	3.25	88.32	6.29
2.	Days to maturity	115.55 $\pm$ 1.26	110.00 - 125.00	1.90	1.56	67.29	2.64
3	Plant height (cm)	89.47 $\pm$ 3.53	68.40 - 124.00	10.42	9.64	85.66	18.38
4	Number of tillers per meter	98.53 $\pm$ 2.74	61.00 - 146.00	16.98	16.75	97.31	34.04
5	Spike length (cm)	7.98 $\pm$ 0.32	4.87 - 14.51	17.92	17.46	94.87	35.02
6	Biomass per plot (g)	1658.23 $\pm$ 81.88	990.00 - 2550.00	17.15	16.42	91.71	32.40
7	Grain yield per plot (g)	431.72 $\pm$ 47.90	225.00 - 900.00	24.20	21.51	78.99	39.38
8	Harvest index (%)	25.95 $\pm$ 1.88	19.41 - 38.30	14.22	12.23	74.01	21.68
9	1000 grain weight (g)	30.93 $\pm$ 1.45	23.23 - 42.30	10.03	8.86	78.12	16.14
10.	Number of grains per spike	49.45 $\pm$ 3.12	33.00 - 68.00	11.77	9.93	71.27	17.28
11	Chlorophyll fluorescence	0.46 $\pm$ 0.05	0.29 - 0.64	15.58	10.36	44.24	14.20
12	Canopy temperature	23.94 $\pm$ 0.84	17.56 - 28.99	9.85	9.21	87.42	17.73
13	NDVI	0.45 $\pm$ 0.04	0.14 - 0.76	24.57	22.99	87.57	44.32
14.	SPAD	40.31 $\pm$ 1.09	23.39 - 54.40	15.36	15.12	96.90	30.66

spike followed by grain weight per plant, biological yield per plant, number of grains per spike, number of effective tillers per plant and length of main spike. Basavaraj *et al.* (2016) reported high PCV and GCV for number of tillers per plant and grain yield per plant whereas moderate PCV and GCV was observed for characters like plant height, number of spikelets per spike and spike length. Narrower difference between the values of GCV and PCV was observed as in the present study indicated that the environmental effect was small for the expression of these characters and these characters are governed by additive gene action.

Heritability and Genetic Advance : Among all the traits plant height, number of tillers per meter, SPAD, spike length, biomass per plot, days to heading, NDVI, canopy

temperature and plant height had high heritability (>80%). Rest all the traits exhibited moderate to low heritability as shown in Table 2. The high estimate of heritability suggested that heritability is due to additive gene action, thus it will respond to direct selection. These findings were further confirmed by Banyai *et al.* (2020) and Prasad *et al.* (2021). Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. GA as 5% means was highest for NDVI, grain yield per plot, spike length, number of tillers per meter, biomass per plot, SPAD, harvest index, plant height, canopy temperature, number of grains per spike and 1000 grain weight. Chlorophyll fluorescence, days to heading and days to maturity had very low genetic advance (Table 2). Similar

Table-3 : Genotypic correlation coefficients among various traits of 100 wheat genotypes under late sown irrigated conditions.

	DH	DM	PH	TPM	SL	BPP	GYP	HI	TGW	NGS	CF	CT	NDVI	SPAD
DH	1													
DM	0.878**	1												
PH	0.073	0.066	1											
TPM	0.100	-0.025	0.142*	1										
SL	0.053	0.020	0.210**	0.204**	1									
BPP	0.088	0.105	0.065	0.172*	0.228**	1								
GYP	0.102	0.057	0.127	0.314**	0.332**	0.802**	1							
HI	0.118	0.008	0.159*	0.289**	0.240**	0.063	0.635**	1						
TGW	0.024	-0.113	0.248**	0.114	0.254**	0.136	0.322**	0.328**	1					
NGS	0.058	0.016	-0.062	0.027	0.233**	0.163*	0.232**	0.150*	0.045	1				
CF	-0.093	0.109	0.089	0.432**	0.408**	0.194**	0.463**	0.497**	0.371**	0.158*	1			
CT	0.049	0.089	-0.085	-0.095	-0.158*	-0.073	-0.212**	-0.235**	-0.198**	-0.133	-0.224**	1		
NDVI	0.128	-0.040	0.044	0.079	0.260**	0.068	0.228**	0.283**	0.154*	0.071	0.255**	-0.598**	1	
SPAD	-0.015	0.045	0.046	0.112	0.124	-0.015	0.195**	0.302**	0.167*	0.088	0.166*	-0.390**	0.419**	1

results were confirmed by Hossain *et al.* (2021) who reported SPAD, number of grains per spike, 1000 grain weight and yield showed moderate to high genetic advance (GA) and the rest traits days to heading, maturity days, CT_{vg}, CT_{gf}, biomass, PH and harvest index (HI) exposed smaller genetic advance (% mean) under irrigated late sowing conditions.

Correlation Studies : The extent of correlation between grain yield and its components helps breeder for making selection more effective and efficient as direct selection for yield may not be effective due to contribution from different components and thus correlation increase the efficiency of breeding programs through determining the appropriate selection criteria. Biomass per plot had highest degree of association with grain yield per plot. Other traits viz. spike length, tillers per meter length, number of grains per spike, 1000 grain weight, harvest index, chlorophyll fluorescence, NDVI and SPAD all showed positive and significant correlation with grain yield per plot but days to heading, days to maturity and plant height were non significantly correlated with grain yield per plot. 1000 grain weight was positively and significantly correlated with spike length, grain yield per plot, harvest index, SPAD, NDVI and chlorophyll fluorescence but was non significantly correlated with number of grains per spike (Table-3). Spike length was having positive and significant correlation with biomass per plot, number of tillers per meter length, harvest index, NDVI and chlorophyll fluorescence. Canopy temperature was found significantly and negatively correlated with spike length, grain yield per plot, harvest index, 1000 grain weight, chlorophyll fluorescence, SPAD and NDVI, indicating that cell functioning viz., transpiration and photosynthesis is proper when canopy temperature is low during the grain filling period (Islam *et al.*, 2017).

Similar findings were obtained by found that the character grain yield *per* plant exhibited highly significant and positive genotypic as well as phenotypic correlation with harvest index, biological yield *per* plant and number of grains *per* main spike. Sohail *et al.* (2018) confirmed positive and non-significant correlation with days to heading and plant height as in the present study. Therefore, selection for these traits will ultimately aid into increase in overall productivity of the genotypes.

Acknowledgments

The author would like to express her sincere thanks to CCSHAU, Hisar, Haryana for providing the facilities to accomplish this research work.

References

- Allard, R.W. (1960) *Principles of Plant Breeding*. John, Wiley and Sons, Inc. New York.
- Bányai, J., Kiss, T., Gizaw, S.A., Mayer, M., Spitkó, T., Tóth, V., Kuti, C., Mészáros, K., Láng, L., Karsai, I. and Vida, G. (2020) Identification of superior spring durum wheat genotypes under irrigated and rain-fed conditions. *Cereal Research Communications*, 48(3): 355-364.
- Baranwal, D.K., Mishra, V.K., Vishwakarma, M.K., Yadav, P.S. and Arun, B. (2012) Studies on genetic variability, correlation and path analysis for yield and yield contributing traits in wheat (*T. aestivum* L. em Thell.). *Plant Archives*, 12(1): 99-104.
- Basavaraja, S., Naik, V.R., Biradar, S.S., Desai, S.A. and Veerasha, B.A. (2016) Genetic variability parameters for yield and rust resistance in F₅ populations of bread wheat. *Environment & Ecology*, 34(4C): 1958-1961.
- Bayisa, T., Abera, M., Letta, T. and Mulugeta, B. (2020). Stability analysis of bread wheat genotypes using the AMMI stability model. In *Regional Review Workshop on Completed Research Activities*: 61.
- Bishwas, K.C., Poudel, M.R. and Regmi, D. (2021). AMMI

and GGE biplot analysis of yield of different elite wheat lines under terminal heat stress and irrigated environment. *bioRxiv*.

7. Burton, G.W. (1952). Quantitative inheritance in grasses. *Proceedings of the Sixth International Congress*: 277-283.
8. Burton, G.W. and Devane, E.H. (1953). Estimating heritability in tall Fescue (*Festuca arundinacea*) from replicated clonal material. *Journal of Agronomy*, 45: 478-481.
9. Dutamo, D., Alamerew, S., Eticha, F. and Assefa, E. (2015). Genetic variability in bread wheat (*Triticum aestivum* L.) germplasm for yield and yield component traits. *Journal of Biology, Agriculture and Healthcare*, 5(13): 39-46.
10. Food and Agriculture Organization of the United Nations: FAOSTAT. Website <http://www.fao.org/faostat/en/> (2020).
11. Hossain, M.M., Azad, M.A.K., Alam, M.S. and Eaton, T.E.J. (2021). Estimation of variability, heritability and genetic advance for phenological, physiological and yield contributing attributes in wheat genotypes under heat stress condition. *American Journal of Plant Sciences*, 12(4): 586.
12. Islam, A.U., Chhabra, A.K., Dhanda, S.S. and Peerzada, O.H. (2017) Genetic Diversity, Heritability and Correlation Studies for Yield and its Components in Bread Wheat under Heat Stress Conditions. *IOSR Journal of Agriculture and Veterinary Science*, 10(5): 71-77.
13. Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybean. *Agronomy Journal*, 47: 314-318.
14. Kumar, M. and Kumar, S. (2021). Estimation of heritability and genetic advance in 24 genotypes of bread wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, 10(1): 1110-1113.
15. Prasad, J., Dasora, A., Chauhan, D., Rizzardi, D.A., Bangarwa, S.K. and Nesara, K. (2021). Genetic variability, heritability and genetic advance in bread wheat (*Triticum aestivum* L.) genotypes.
16. Ramanuj, B.D., Delvadiya, I.R., Patel, N.B., Ginoya, A. V (2018) Evaluation of bread wheat (*Triticum aestivum* L.) genotypes for heat tolerance under timely and late sown conditions. *International Journal of Pure & Applied Bioscience*. 6(1): 225–233.
17. Sohail, A., Rahman, H., Ullah, F., Shah, S.M., Burni, T. and Ali, S. (2018) Evaluation of F₄ bread wheat (*Triticum aestivum* L.) genotypes for genetic variability, heritability, genetic advance and correlation studies. *Journal of Plant Breeding and Genetics*, 6(1).
18. Wollenweber, B., Porter, J. R. and Schellberg, J. (2003). Lack of interaction between extreme high temperature events at vegetative and reproductive growth stages in wheat. *Journal of Agronomy and Crop Science*, 189(3): 142-150.



Heritability and Genetic Advance Studies in Single Cross Hybrids of Maize (*Zea Mays* L.)

N. Chamundeswari, K. Phani Kumar and K. Mohana Rao

Maize Research Centre, Vijayarai, West Godavari, Andhra Pradesh

Abstract

Ten single cross maize hybrids developed in Acharya N.G.Ranga Agricultural University were evaluated in Randomized Block Design with two check varieties at Maize Research Centre, Vijayarai, West Godavari Dist., Andhra Pradesh to know the selection efficiency of twelve agronomical, yield and yield contributing traits. Analysis of variance revealed significant differences for all traits except number of cob girth (cm). The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) recorded for all traits. Kernel yield showed the highest PCV (14.36%) and GCV (11.15%) whereas the lowest PCV (0.953%) and GCV (1.753%) were recorded for test weight. Heritability (broad sense) ranged from 20.445 (kernel girth in cm) to 73.832 (ear placement height in cm). Kernel yield (Kg/ha) had shown 60.316 broad sense heritability with 17.842 genetic advance as percent of mean. Days to maturity, Plant Height (cm), Ear placement height (cm), number of kernel rows per cob and Kernel yield (Kg/ha) had shown high heritability of >50% with high GCV and PCV. Hence these traits can be used further in crop improvement program.

Key words : Maize, genetic variability, heritability, genetic advance

Introduction

Maize (*Zea mays* L.) is one of the most valuable crops due to its multiple uses in food industry, animal husbandry and industry. The most important aspect concerning both researchers and farmers is the yielding capacity. The improvement of the yielding capacity begins with the selection of the inbred lines (1). Andhra Pradesh is the number one state in Maize productivity with 6604 kg/ha which is 4,025 kg higher than the national average of 2,498 kg per hectare. Predominant Maize growing districts in Andhra Pradesh are West Godavari, Vizianagaram, Kurnool and Guntur which accounted for 65.97% of the total area under the crop in the state. West Godavari District alone accounted for 23.29 % of the State Area and it has the potential area that covers up to 70% of seed production.

The estimates of genetic parameters as variances, coefficients of variation, heritability, genetic advance etc allows the plant breeders to know the magnitude of the genetic variability of a population, and the selection gains. A critical analysis of genetic variability present in the germplasm of a crop and its estimation is a pre-requisite for initiating any crop improvement programme as well as adopting appropriate selection techniques. Keeping the importance of the genetic parameters the present investigation on heritability (broad sense), variability and genetic advance studies were taken up at Maize Research Centre, Vijayarai, West Godavari Dist., Andhra Pradesh.

Materials and Methods

The material consists of ten Maize single cross hybrids developed in Acharya N.G. Ranga Agricultural University

along with two hybrid checks viz., DHM 117 and P 3396. All twelve single cross maize hybrids were evaluated in Randomised Block Design during *Kharif* 2020 at Maize Research Centre, Vijayarai, West Godavari Dist., Andhra Pradesh. Observations were recorded on 12 agronomical, yield and yield contributing traits viz., days to 50% pollen shed, days to 50% silking, days to maturity, plant height (cm), ear placement height (cm), cob length (cm), cob girth (cm), number of kernels per row, number of kernels per cob, test weight (g), shelling percentage and kernel yield (kg/ha). Genetic parameters viz., environmental variance (σ^2_e), genotypic variance (σ^2_g), phenotypic variance (σ^2_p), environment coefficient of variation(%), genotypic coefficient of variation (%), coefficient of variation (%), h^2 (Broad Sense), genetic advancement 5% and genetic advance as % of mean 5% was estimated using WINDOSTAT statistical software.

Results and Discussion

Analysis of Variance revealed significant differences for all traits except cob girth (cm). The ANOVA summary is given in Table-1. The mean performance of 12 single cross hybrids is presented in Table-2. The results obtained are presented in Table-3.

All the hybrids matured between 107 to 112 days. Among 12 hybrids, PDMH 171213 matured in 107 days while the hybrids viz., DHM 117, PDMH 1810, PDMH 1817, PDMH 153227 and PDMH 1222 took 112 days where as remaining hybrids matured in 110 days. For 12 hybrids, the average days to 50% pollen shed is 49.19 days while 50% silking is 53.92 days indicating that the tassels flowered earlier than respective silks. Plant height (cm) ranged from 138.3 cm (PDMH 1810) to 189.67 cm (PDMH 171213). Lowest ear placement height of 95cm is

Table-1 : Summary of Analysis of variance for twelve characters.

Sl. No.	Source Degrees of freedom	Replication 2	Treatment 11	Error 22
1.	Days to 50% pollen shed	1.4440	3.664**	1.02
2.	Days to 50% silking	1.7390	1.765*	0.58
3.	Days to maturity	0.7780	7.717**	1.02
4.	Plant Height (cm)	254.0830	950.485**	182.023
5.	Ear placement height (cm)	147.1750	465.604**	49.195
6.	Cob length (cm)	0.1640	0.147*	0.055
7.	Cob girth (cm)	0.3410	3.9290	2.219
8.	Number of kernels per row	1.4130	1.164*	0.472
9.	Number of kernels per cob	146.9950	1845.168**	299.389
10.	Shelling percentage	4.4160	3.33*	1.474
11.	Test weight (g)	4.7730	3.633*	1.591
12.	Kernel yield (kg/ha)	192742.9950	1300513.166**	233916.543

also observed in the hybrid PDMH 1810. Cob length ranged from 16.47 cm to 17.23cm with average of 16.69cm. Highest number of kernels per cob is observed in PDMH 1222 (543) followed by PDMH 19053 (533.71) and PDMH 1449 (532.05). The range of shelling percentage is 80.95 (P 3396) to 84.62 (PDMH 1829). (Table-2). All hybrids have >25g test weight with highest value in PDMH 153227 (29.63 grams). Kernel yield (Kg/ha) ranged from 4429 (PDMH 153227) to 6544 (DHM 117) with mean value of 5347 Kg/ha. DHM 117 recorded highest kernel yield of 6544 Kg/ha followed by PDMH 19053 and P 3396 (6005 and 5974 Kg/ha respectively).

Genetic variability is the pre requisite for any crop improvement program. Genetic variability, which is a heritable difference among cultivars, is required at an appreciable level within a population to facilitate and sustain an effective long term plant breeding program. Progress from selection has been reported to be directly related to the magnitude of genetic variance in the population (2). From the present study, it is found that the phenotypic coefficient of variation (PCV) values are higher than genotypic coefficient of variation (GCV) for all traits studied, indicating that the characters were less influenced by the environment. Therefore, response to direct selection may be effective in improving these traits. Similar results were also obtained by (3). Highest GCV of 11.152% is reported for Kernel yield (Kg/ha^{-1}), followed by ear placement height (cm) with 10.845% and plant height (cm) with 9.415%. Cob girth (cm) had recorded highest ECV of 9.938% indicating more influence of environment on this trait (4) reported high PCV and GCV values for grain yield per plant and ear height in maize. Moderate PCV values of ear girth, ear length, 100 grain weight and number of grain rows per cob. The estimates of genotypic coefficient of variation (GCV) reflect the total amount of genotypic variability which is transmitted from parents to the progeny is reflected by heritability. The success of any crop improvement program is not only depend on the amount of genetic variability present in the population but

also on the extent to which it is heritable, which sets the limit of progress that can be achieved through selection (5).

The Study of variability and genetic advance in the germplasm will help to ascertain the real potential of the genotype (6). Accordingly, study of genetic parameters like genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance as per cent of mean provides a clear cut idea about the extent of variability present in a plant population and a relative measure of efficiency of selection of genotypes based on phenotype in a highly variable population (2).

Heritability is a parameter which is widely used in the establishment of breeding programs and formation of selection indexes (7). Broad-sense heritability plays a predictive role in breeding, expressing the reliability of phenotype as a guide to its breeding value. In broad sense heritability, high value indicate that, the character is least influenced by environmental effects (2). Heritability (broad sense) is highest for ear placement height (cm) followed by number of kernels per cob and kernel yield (kg/ha) with 73.83%, 63.25% and 60.316% respectively (Table-3). The high heritability obtained for these traits suggests that the traits can easily improved by selection. Traits that had high heritability estimate indicate the preponderance of additive gene action. However, it has been accentuated that heritability alone has no practical importance without genetic advance. High genetic advance coupled with high heritability estimates offers the most effective condition for selection (6). The utility of heritability therefore increases when it is used to calculate genetic advance, which indicates the degree of gain in a character obtained under a particular selection pressure.

Genetic advances measure the expected genetic progress that would result from the best performing genotypes for the trait being evaluated (8). The ultimate goal of the plant breeder is to have higher genetic advance for the material selected since it is an indicator for the genetic improvement made in a population under

Table-2 : Mean performance of 12 single cross hybrids for 12 characters during Kharif 2020.

S. No.	Hybrid	Days to 50% pollen shed	Days to 50% silking	Days to maturity	Plant Height (cm)	Ear placement height (cm)	Cob length (cm)	Number of kernel rows per cob	Number of kernels per row	Number of kernels per cob	Shelling percentage	Test weight (g)	Kernel yield (kg ha-1)
M1	PDMH 171213	51.67	53.00	106.67	189.67	114.33	16.55	15.67	15.53	506.73	83.07	27.97	4687.5
M2	PDMH 1540	50.00	55.00	110.00	183.33	110.00	16.59	16.40	16.13	504.76	81.77	27.43	5145.4
M3	PDMH 16921	49.00	54.00	110.00	180.33	113.00	16.62	15.67	16.73	508.46	83.38	27.73	5204.0
M4	PDMH 1449	48.00	53.33	110.00	185.00	116.33	16.77	15.33	15.73	532.05	81.62	25.63	5862.6
M5	P 3396	50.00	54.33	110.67	181.00	129.00	16.52	15.00	16.13	516.45	80.95	26.93	5973.6
M6	PDMH 19053	48.00	52.67	110.00	188.00	123.00	16.51	16.00	16.20	533.71	82.24	28.13	6005.4
M7	PDMH 1829	48.00	53.67	109.33	165.33	81.67	16.65	14.80	15.40	459.37	84.62	28.27	5122.2
M8	DHM 117 (C)	50.00	55.00	112.00	164.67	105.67	16.99	13.93	16.27	497.44	81.53	27.40	6543.6
M9	PDMH 1810	49.33	54.33	112.00	138.33	95.00	16.65	13.13	14.47	469.96	81.99	26.03	4849.8
M10	PDMH 1817	48.33	53.67	112.00	147.33	108.33	16.74	16.53	16.67	521.20	83.22	26.80	5690.6
M11	PDMH 153227	49.33	53.33	112.00	171.00	104.67	16.47	13.53	15.53	500.73	83.51	29.63	4429.0
M12	PDMH 1222	48.67	54.67	112.00	146.00	102.67	17.23	13.87	16.13	543.94	82.21	28.53	4646.8
Mean		49.19	53.92	110.56	170.00	108.64	16.69	14.99	15.91	507.90	82.51	27.54	5346.7
CV		2.05	1.41	0.91	7.94	6.46	1.40	9.94	4.32	3.41	1.47	4.58	9.05
SEm		0.58	0.44	0.58	7.79	4.05	0.14	0.86	0.40	9.99	0.70	0.73	279.23
CD at 5%		1.71	1.29	1.71	22.85	11.88	0.40	2.52	1.16	29.30	2.06	2.14	818.97
CD at 1%		2.32	1.75	2.32	31.05	16.14	0.54	3.43	1.58	39.82	2.79	2.90	1113.1
Minimum		48.00	52.67	106.67	138.33	81.67	16.47	13.13	14.47	459.37	80.95	25.63	4429.0
Maximum		51.67	55.00	112.00	189.67	129.00	17.23	16.53	16.73	543.94	84.62	29.63	6543.5
Replication		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Treatment		S	S	S	S	S	NS	S	S	S	S	S	S

Table-3 : Genetic parameters of variation for twelve agronomical, yield and yield contributing traits.

Sl. No.	Character	Var Environ mental (² e)	ECV (%)	Var Genotypical (² g)	GCV (%)	Var Phenotypical (² p)	PCV (%)	h ² (Broad Sense)	Genetic Advance-ment 5%	Genetic Advance-ment as % of Mean 5%
1.	Days to 50% pollen shed	1.02	2.053	0.881	1.908	1.902	2.803	46.348	1.317	2.676
2.	Days to 50% silking	0.58	1.413	0.395	1.166	0.975	1.832	40.499	0.824	1.528
3.	Days to maturity	1.02	0.914	2.232	1.351	3.253	1.631	68.634	2.55	2.306
4.	Plant Height (cm)	182.023	7.936	256.154	9.415	438.177	12.313	58.459	25.208	14.828
5.	Ear placement height (cm)	49.195	6.456	138.803	10.845	187.998	12.621	73.832	20.854	19.196
6.	Cob length (cm)	0.055	1.401	0.031	1.049	0.085	1.75	35.913	0.216	1.295
7.	Cob girth (cm)	2.219	9.938	0.57	5.038	2.789	11.142	20.445	0.703	4.693
8.	Number of kernels per row	0.472	4.319	0.231	3.019	0.703	5.269	32.829	0.567	3.564
9.	Number of kernels per cob	299.389	3.407	515.26	4.469	814.649	5.62	63.249	37.188	7.322
10.	Shelling percentage	1.474	1.471	0.619	0.953	2.092	1.753	29.579	0.881	1.068
11.	Test weight (g)	1.591	4.58	0.68	2.995	2.272	5.473	29.954	0.93	3.377
12.	Kernel yield (kg/ha)	233916.543	9.046	355532.208	11.152	589448.751	14.359	60.316	953.945	17.842

selection. The genetic gain can be expected for a particular trait through selection. The genetic gain that can be expected for a particular trait through selection is the product of heritability, phenotypic standard deviation and selection differential (9). In the present study genetic advancement ranged from 0.216 (cob length in cm) to 953.945 (kernel yield Kg ha⁻¹). The traits plant height (cm), ear placement height (cm), number of kernels per cob and kernel yield Kg ha⁻¹ reported high genetic advance values of 25.21, 20.85, 37.19, 953.95 respectively. Genetic advance as percent of mean is also calculated as it is more accurate indicator for selection of a particular trait. Genetic advance as percent of mean is highest for the traits viz., traits number of kernels per cob, plant height (cm), ear placement height (cm), and kernel yield Kg ha⁻¹ (7.322, 14.828, 19.196, and 17.842 respectively) (Table 3).

From the present investigation, it is concluded that, the traits viz., plant Height (cm), ear placement height (cm), number of kernel rows per cob and Kernel yield (Kg/ha) had shown high heritability of >50% with high GCV and genetic advance which offers the most suitable condition for selection. It also indicates the presence of additive genes in the trait and further suggests reliable crop improvement through selection of such traits.

References

- Ambhure, R.G., Patil, K.H. and Mahajan, R.C. (2020). Combining ability analysis for yield and yield components in single cross hybrids of Maize (*Zea mays*). *Frontiers in Crop Improvement*, 8(1): 45-48.
- Mamud Aman (2021). Genetic variability, heritability and association of quantitative traits in maize (*Zea mays* L.) genotypes : Review Paper. *E.A.S. J.Biotechnol Genet.*, 3(2): 38-46.
- Bartaula S., Panthi U., Timilsena K., Acharya S. and Shrestha J. (2019). Variability, heritability and genetic advance of maize (*Zea mays* L.) genotypes. *Research in Agriculture Livestock and Fisheries*, 6(2): 163-169.
- Singh P.K., Jha P.B. and P. Kumar.(2003). Path coefficient for green fodder yield and grain yield in maize (*Zea mays* L.). *J. Appl. Biol.*, 13(1/2): 29-32.
- Sumathi P., Nirmala Kumari A. and Mohan Raj K. (2005). Genetic variability and traits interrelationship studies in industrially utilized oilrich CIMM YT lines of maize (*Zea mays* L.). *Madras Agric. J.* 92(10-12): 612-617.
- Larik A.S., Malik S.I., Kakar A.A., Naz M.A. (2000). Assessment of heritability and genetic advance for yield and yield components in *Gossypium hirsutum* L. *Scientific Khyber*, 13: 39-44.
- Falconer D.S. and Mackay T.F.C. (1996). Introduction to quantitative genetics. 4th ed. *Benjamin Cummings*, England, pp. 245-247
- Allard R.W. (1999). Principle of plant breeding. *John Wiley and Sons*. New York.
- Kassaye Negash (2006). Studies on genetic divergence in common Bean (*Phaseolus vulgaris* L.). Introductions of Ethiopia. *An MSc thesis presented to the school of graduate studies of Addis Ababa University*. 110p



Heterosis Studies for Yield and its Components in Sorghum

H.L. Barupal, N.S. Dodiya, Sandeep Kumar Bangarwa and Ravi Kumawat

Deptt. of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur Rajasthan

Email : heeralalbarupal74@gmail.com

Abstract

The 11 lines and 3 tester using L x T mating design consisted of 50 entries including 11 lines, 3 testers, 33 hybrids and three checks viz., CSV 23, CSV 17 and PC-1080. These were evaluated in RBD with three replications during *kharif* 2019 and 2020 in three environments. The experiment was carried out to estimate the amount of heterosis and heterobeltiosis, the general and specific combining ability for selection of potential parents, crosses and to study important quantitative characters associated with yields and its contributing traits.

Key words : Heterosis, line x tester, quantitative traits, RBD and yield.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is an annual diploid often cross-pollinating crop ($2n=2x=20$) known as jowar (Camel crop) crop it belongs to family Poaceae, sub-family Panicoideae, tribe Andropoganae and subtribe Sorghastrae (1). The crop is characterized by a C4 photosynthetic with higher photosynthetic efficiency, extensive root system, waxy bloom on the leaves that reduce evapotranspiration and recovery growth after water stress. As a result, ability to grow and produce grains under a wide range of agro-climatic conditions viz., arid and semi-arid regions which almost have much less water and high temperature. In wetter regions, its production is lower than that of more lucrative crops such as *Oryza sativa* (rice) and *Zea mays* (maize). It is one important source of food, feed, fiber and fuel in all continents Asia, Africa, Australia and America. Sorghum green and dry fodder is one of the inexpensive sources of feed for milch, meat and draft animals. Sorghum is grown all over the world (2). It covers an area of 40.98 million hectares with 61.62 MMT production and 1500 kg/ha productivity (3). The major growing nations are Sudan, Nigeria and India. In view of production and productivity USA hold first position. In India, it is grown in area of 4.20 million hectares with production and productivity of 3.85 million tonnes and 920 kg/ha, respectively (3).

Materials and Methods

The material consisted of eleven genetic divers' lines and three testers, which were collected from sorghum germplasm. The lines, testers, crosses and checks were grown in randomized block design with three replications during *kharif*-2019 and 2020. Each plot in the replicated trial consisted of two rows 2 m long with 45 x 15 cm spacing. All recommended package of practices was

followed to raise the crop along with timely plant protection measures.

Data was collected on ten randomly selected plants in each replication for days to, plant height, panicle length, number of primaries per plant, grain yield per plant and dry fodder yield per plant. The heterotic effects were computed as percentage increase or decrease in mean values over mid parental value (heterosis) better parent (heterobeltiosis) (3). For the estimation of combining ability of various characters the line x tester model suggested by (5) was used. To test the significance of heterosis, the following formula suggested by (6) was utilized.

Results and Discussion

Variance due to genotype, parents and crosses were highly significant for all the traits studied. However, parents' vs crosses were significant for all the traits except days to maturity and number of seeds per primaries in E1, days to 50 % flowering and protein content in grain in E2 and E3. These findings indicating good amount of genetic differences among the genetic material. Values in pooled table indicating MSS due to genotype, environment and parents were significant for all the traits. While, parents' vs crosses were also significant for all the traits except protein content in grain. The mean sum of square due to environment x parent vs crosses observed significant for days to 50 % flowering, plant height, grain yield per plant, dry fodder yield per plant and protein content in fodder (Table-1).

The highest positive significant heterosis for plant height were observed in 9.69 (SU-1080 x SU-1601), 14.28 (SU-1572 x SU-1601), 13.29 (SU-1572 x SU-1561) and 9.69 (SU-1539 x SU-1561) in E1, E2, E3 and over the environment respectively. Four Crosses namely,

Table-1 : Analysis of Variance of line x testers analysis in sorghum.

Source of variation	d.f.	Mean Sum of Square											
		Days to 50 % flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Number of primaries/ panicle	Number of Seeds/ primaries	Seed index (g)	Grain yield/ plant	DFY/ plant	Harvest Index	Protein content grain	Protein content fodder
Replication	2	10.83	10.34	92.88*	17.12**	28.35	5.99	0.023	19.79	60.1686	4.94	1.17*	0.16
Rep. x Env.	4	5.2	3.78	13.31	3.36	6.01	13.25	0.002	2.52	44.08	3.38	0.12	0.12
Env.	2	38.39**	174.92**	557.18**	103.03**	122.74**	541.93**	1.35**	1216.93**	1400.27**	125.58**	5.32**	3.2**
Treatments	46	82.93**	110.76**	761.3**	86.48**	683.99**	128.08**	0.4**	1462.09**	1870.09**	167.88**	5.74**	3.84**
Parents	13	116.49**	139.37**	715.19**	35.23**	352.37**	126.76**	0.45**	728.83**	1745.2**	64.99**	4.29**	1.75**
Line	10	68.48**	126.52**	869.73**	43.62**	353.43**	123.96**	0.42**	690.22**	1417.51**	83.49**	5.24**	2.07**
Testers	2	131.81**	53.48**	248.53**	10.36*	495.22**	20.82	0.02	14.3	51.002593	0.21	1.62**	0.86**
L vs T	1	565.93**	439.61**	103.05*	1.09	56.15*	366.7**	1.59**	2544.03**	8410.51**	9.58	0.04	0.27
Parents vs Crosses	1	120.27**	96.56**	14796.11**	454.86**	4055.77**	203.75**	1.41**	7491.64**	5978.79**	243.89**	0.44	44.95**
Treat x Env.	92	21.15**	28.75**	318.86**	13.38**	102.18**	66.73**	0.09**	140.46**	206.35**	25.48**	2.96**	1.92**
Env.x Parents	26	12.15**	32.99**	376.38**	16.64**	90.35**	48.14**	0.08**	89.06**	241.58**	18.4**	2.25**	1.32**
Env.x crosses	64	24.77**	27.57**	302.66**	12.45**	109.95**	75.83**	0.09**	163.3**	194.33**	29.04**	3.32**	2.15**
Env.x Line effect	20	39.82*	16.05	320.19	17.01	101.73	87.22	0.18**	182.12	192.82	39.76	4.06	2.99
Env.x Tester effect	4	28.19	31.65	210.53	0.78	225.14	65.3	0.04	114.92	792.25**	4.68	4.69	0.68
Env.x L x T effect	40	16.9**	32.93**	303.11**	11.33**	102.54**	71.19**	0.06**	158.73**	135.3**	26.12**	2.81**	1.88**
Env.x P. vs C.	2	22.21**	11.37	89.71*	1	7.61	17.24	0.01	77.79*	132.83*	3.44	0.64	2.47**
Error	276	4.72	3.84	25.24	3.34	12.52	7.07	0.01	16.95	28.5025	3.87	0.32	0.15
S.Em		0.72	0.65	1.67	0.60	1.17	0.88	0.03	1.37	1.78	0.65	0.18	0.12
CD (5%)		2.01	1.81	4.66	1.69	3.28	2.46	0.09	3.82	4.95	1.82	0.52	0.35
CV		3.37	1.948	1.736	6.75	6.52	6.43	3.41	6.89	4.70	5.72	5.88	5.77
GM		64.388	100.594	289.32	27.07	54.19	41.29	2.92	59.73	113.41	34.36	9.60	6.71

***, Significant at 1 and 5% level respectively

SU-1572 × SU-1561, SU-1581 × SU-1561, SU-1080 × SU-1561, SU-1539 × SU-1601 exhibited significant heterobeltiosis in all the environment including pool. All the crosses showed positive significant economic heterosis and hybrids SU-1539 × SU-1561 was observed highest significant standard heterosis for plant height. For the panicle length, out of 33 crosses 15 crosses in E1 and E3, 17, 18 crosses in E2 and pool respectively. Better parent heterosis was depicted by 10 crosses in E1, 13 crosses in E2, 11 crosses in E3 and 16 crosses in pooled environments. Standard heterosis was not significant in any of cross combinations for panicle length. The hybrid SU-1080 × SU-1561 showed highest value of heterosis and heterobeltiosis for no. of primaries per panicle in E2, E3 and over the environment. The F_1 hybrids SU-1080 × SU-1561 (3.89) and SU-1596 × SU-1601 (1.21) showed positive economic heterosis with respect to no. of primaries per plant. Study for the number of seeds per primary, 29.31 (SPV-2165 × SU-1601) in E1, 32.69 (SU-1581 × SU-1601) in E3, 46.37 and 30.45, (SU-1594 × SU-1561) in E2 and pool observed maximum relative heterosis and highest heterobeltiosis was observed in 29.31 (SU-1596 × SU-1561), 46.37 (SU-1594 × SU-1561), 27.19 (SU-1594 × SU-1561) and 21.42 (SPV-2165 × SU-1601) in E1, E2, E3 and pooled respectively whereas, cross combination, SPV-2165 × SU-1601 exhibited positive value for standard heterosis for no. of seeds per primary. For grain yield per plant, out of 33 crosses 24 and 20 crosses were found positive and significant heterosis and heterobeltiosis. The cross combination SU-1596 × SU-1601 observed had highest significant and positive value for mid-parent and better parent in E1 and over the environment for grain yield. However, SPV-2165 × SU-1601 were highest significant and positive value for mid-parent and better parent in E3. The standard heterosis was significant for only two crosses viz., SU-1596 × SU-1601 (22.56) and SU-1080 × SU-1606 (20.49) while as one cross SU-1600 × SU-1561 (0.02) showed positive heterosis with reference to grain yield per plant. Analysis of dry fodder yield per plant, out of 33 hybrids evaluated, in which 25 hybrids in E1, 12 hybrids in E2, 20 hybrids in E3 and 24 hybrids in pooled showed positive significant heterosis. Hence, these crosses were considered to be desirable for this trait. Positive and significant heterobeltiosis observed by 12 crosses in E2 and E3 and 17 crosses in E1 and over the environment. Out of 33 crosses ten crosses namely, SU-1572 × SU-1561 (18.43), SU-1581 × SU-1561 (17.18), SU-1080 × SU-1561 (10.84), SU-1572 × SU-1601 (21.00), SU-1596 × SU-1601 (8.67), SPV-946 × SU-1601 (16.74), SU-1080 × SU-1601 (21.10), SU-1581 × SU-1606 (18.79), SU-2185 × SU-1606 (35.03) and SU-1080 × SU-1606 (16.34)

showed positive significant heterosis over the standard checks for dry fodder yield per plant.

For days to 50 per cent flowering 8 crosses showed negative significant economic heterosis. Hence, out of these 8 crosses, SU-1539 × SU-1606 (9.67) was possesses minimum negative significant standard heterosis. The 24 crosses were found to be negatively significant for days to maturity. The hybrids SU-1539 × SU-1561 was observed highest significant standard heterosis for plant height. None of the cross combination was observed positive significant for panicle length, number of primaries per panicle and no. of seeds per primaries. In case of seed index 6 crosses found to be positively significant. Only one cross SU-1596 × SU-1601 (22.56) exhibited positive significant economic heterosis. For dry fodder yield per plant, maximum and positively significant standard heterosis was shown by the sorghum hybrid SPV-2185 × SU-1606 (35.40 %). The sorghum hybrid SU-1596 × SU-1601 had positive and significant for harvest index (7.1) and protein content in grain (16.37). only one cross, SPV-946 × SU-1606 (12.85) was showed positive and significant standard heterosis. Relative heterosis or average (mid parent) and heterobeltiosis (better parent) provide an idea about the nature of gene actions involved in the genetic control of the concerned traits. Relative heterosis, besides epistasis effects also indicates the presence of dominance effects (intra-allelic) while heterobeltiosis is indicative of over dominance (allelic). The negative and significant values of heterosis over mid-parent and better parent, recorded for days to 50% flowering were 8 and 18 crosses in over the environment. Estimates for relative heterosis and heterobeltiosis were found negative significant for 9 and 16 in pooled environment, respectively. For plant height cross combination SU-1539 × SU-1561 had highest positive significant value for relative heterosis (10.27) and heterobeltiosis (9.69). Under the study of panicle length SPV-2185 × SU-1606 (32.54) were observed maximum mid-parent heterosis. While, the F_1 hybrid SPV-946 × SU-1601 (28.57) had maximum positive significant value. The cross combination SU-1080 × SU-1561 was found to be highest positive and significant value for no. of primaries per panicle for relative heterosis (57.80) and heterobeltiosis (56.39). The hybrid SU-1594 × SU-1561 (30.45%) manifested maximum significant relative heterosis over the three environments. While hybrid SPV-2165 × SU-1601 (21.42%) evinced highest heterosis for no. of seeds per primary over all basis in significantly positive direction. Hybrid SU-1600 × SU-1561 (24.17 and 21.74%) revealed maximum heterosis and heterobeltiosis for seed index. Out of 33 crosses 24 and 20 crosses were found positive and significant heterosis and heterobeltiosis for grain yield per plant. The cross

combination SU-1596 x SU-1601 had highest positive and significant value for grain yield with respect to relative and better parent heterosis. Further, analysis for dry fodder yield per plant revealed that 24 and 17 sorghum hybrids displayed significantly positive average parent heterosis and better parent heterosis. Maximum estimate of mid parent and better parent heterosis in positively significant direction for harvest index was reported for hybrid SPV-2165 x SU-1601 (39.14 % and 31.32 %). Over all 11 and 9 hybrids manifested significant heterosis and heterobeltiosis in positive direction for protein content in grain. None of the hybrids showed positive significant heterosis and heterobeltiosis for protein content in fodder. The significant and positive relative heterosis for grain yield and its components characters were also found for the crosses across and over the environment. Similar results were reported by (7).

Conclusion

Overall, it can be concluded from the present study that grain and fodder yield per plant and its component traits recorded in thirty-three sorghum crosses were view of the high heterosis values observed for the different characters, the importance of non-additive genetic effects in their expression can be inferred. This indicates that the hybrids for yield and other characters may be tested for yield and other economic traits under different

agro-climatic conditions for commercial exploitation of hybrid vigour.

References

1. Price H.J., Dillon S.L., Hodnett G., Rooney W.L., Ross L. and Johnston J.S. (2005). Genome evolution in the genus *Sorghum* (Poaceae). *Annals of Botany*, 95(1): 219-227.
2. Patil, S.Y., Ambhure, R.G., Rasale, V.R., Khotkar, M.R. and Mehtre, S.P. (2020). Estimation of genetic variability, heritability and genetic advance in F_4 progenies for shoot fly tolerance and grain yield in rabi Sorghum (*Sorghum bicolor*). *Frontiers in Crop Improvement*, 8(1): 68-72.
3. Anonymous (2020). United States Department of Agriculture Foreign Agricultural Service Circular Series WAP 1-21.
4. Liang G.H., Reddy C.R. and Dayton A. (1972). Heterosis, inbreeding depression and heritability estimates a systemic series of grain sorghum genotypes. *Crop Science*, 12: 400-401.
5. Kempthorne O. (1957). An introduction to genetic statistics. *John Wiley and sons Inc. New York*.
6. Wynne J.C., Emery D.A. and Rice P.W. (1970). Combining ability estimates of *Arachis hypogaea* (L). II field performance of F_1 hybrids. *Crop Science*, 10: 713-715.
7. Arunkumar, B., Gangapp, E., Ramesh, S., Savithramma, D.L. and Nagaraju, N. (2020). Combining ability analysis for yield and yield components in single cross hybrids of Maize (*Zea mays*). *Frontiers in Crop Improvement*, 8(1) : 45-48.



Sustainable Membrane Filtration Technology for Wastewater Treatment for Agriculture Production

Mohd. Ayub Ansari^{1*}, Anuradha Singh², Afren Ansari³ and Ramesh Kumar Prajapati⁴

¹Department of Chemistry, Bipin Bihari College, Jhansi-284001 (U.P.) India

²Department of Chemistry, M.M.H. College Ghaziabad-201009 (U.P.) India

³Department of Chemistry, S.M.S. Govt. Model Science College, Gwalior-474009 (M.P.) India

⁴Department of Chemistry, Digamber Jain College, Baraut, Baghpat-250611 (U.P.) India

*Email : drayub67@gmail.com

Abstract

Nowadays, membrane filtration technology is used for wastewater treatment for agriculture field in which wastewater is reused for irrigation. For sustainable agricultural production and safe groundwater recharge the waste is further polished by a joined two-stage membrane pilot system. The pilot membrane system consists of two most important in row stages: Ultrafiltration (UF) and Reverse Osmosis (RO). The UF stage is efficient in the removal of the microorganism and suspended organic-inorganic matter while the successive RO stage provides safe removal of the dissolved solids. Wastes of different qualities were applied for agricultural irrigation along with continuous monitoring of the membrane system performance. In regions with shallow groundwater reduced soil salinity in the upper productive layers, maintained by extra membrane treatment, will guarantee smallest dissolved solids migration to the aquifers and minimize salinization processes.

Introduction

Water sustains human life and its purity cannot be compromised at several cost. With the increase in human population, tons and tons of wastewater are produced everyday across the domestic, industrial, and agricultural sectors [1]. In most countries 60–90% of total water consumption is allocated for agriculture production. However, due to limited availability of water this picture is gradually changing and agriculture will soon rely on the additional water sources, primarily domestic effluent. Only recently it was realized that treated wastewater is a valuable water source for reuse for diverse purposes. Membrane technology has emerged as a favorite choice for reclaiming water from different wastewater streams for re-use. Most of available waters in many regions around the world are consumed for agricultural production [2,3].

Water scarcity and quality is associated with breakouts of a variety of waterborne diseases, jeopardizing human health and safe quality food consumption. Water scarcity and mostly the frequent droughts events and the unexpected huge floods jeopardize agriculture production. Agriculture is still one of the major sources for food in most communities. Advanced wastewater treatment is required in order to maintain adequate levels of sustainable agriculture production, decelerated salinization processes of the ground waters and to prevent long range adverse effects of gradual environmental pollution [4].

In this article we have discussed the sustainable agriculture production and in order to prevent wastewater

contamination effluent should be further treated by removing most dissolved solids.

Membrane technology for waste polishing : Secondary waste commonly still contains low levels of microorganism, nutrients and dissolved solids that when reused for irrigation and/or groundwater recharge on long time scales risk sustainable agriculture production and aquifers' water quality [5]. Subject to the wastes qualities, crop pattern, soil properties and groundwater characteristics extra (advanced) treatment is required for unlimited irrigation reuse. It can be achieved primarily by implementing the membrane technology, consisting of a combination of UF and RO [6-9]. The UF stage is efficient in the removal of the suspended matter, organic matter and the microorganism while the successive RO stage provides safe removal of the dissolved solids (salinity) [10,11]. Effluent of various qualities is applied for agricultural irrigation along with continuous monitoring of the membrane system performance.

The pilot membrane system : Secondary waste can be polished for unrestricted reuse primarily by implementing the membrane technology. A two stage pilot membrane systems was operated, consisting of an UF stage and a complementary RO stage as shown in fig-1. The RO stage is implemented for the removal of most dissolved solids (including nutrients). Extra treatment is required for complete removal of some specific constituents such as boron.

The UF membrane consists of three layers: a polyester support web, a micro porous polysulfone

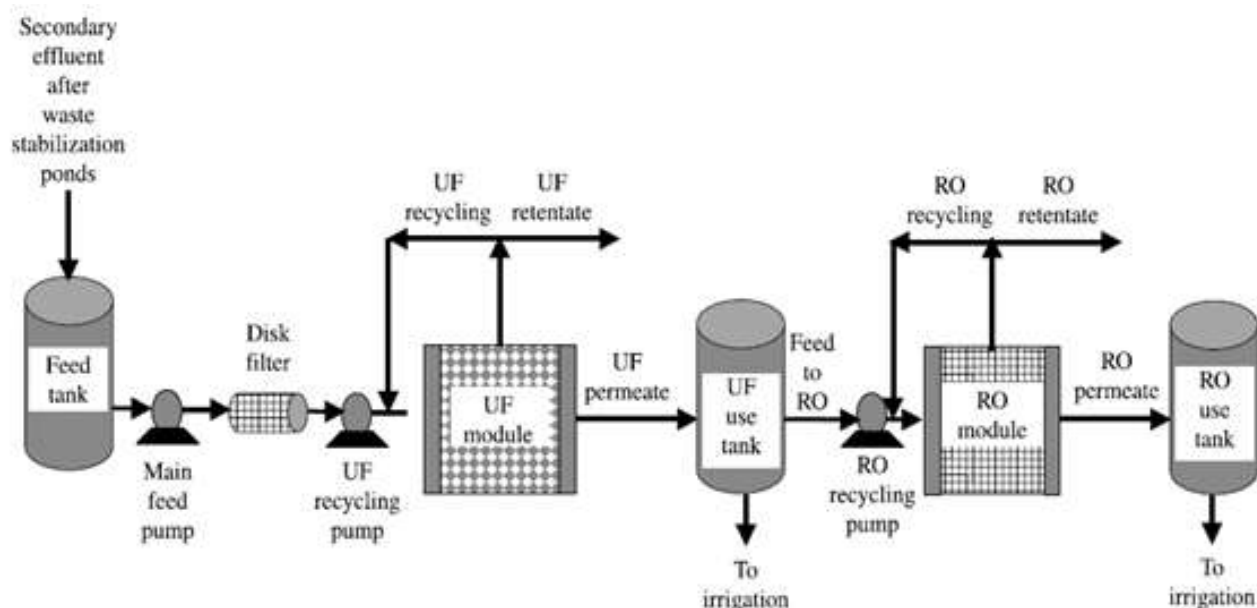


Fig-1 : The components of a membrane treatment system for wastewater polishing (adopted from ref. no. 11)

interlayer, and an ultrathin barrier coating on the top surface. Two-stage spiral wound UF membrane modules were used for irrigation and supplying around 8 m³/hr. Except for the chemical cleaning process, the UF component runs automatically under the control of an on-board Programmable Logic Controller (PLC).

Ultrafiltration membrane fouling : One of the major problems faced during secondary effluent polishing with UF membranes is their fouling [12-15]. Fouling effects can be reduced by adjusting the membrane surface or by common backflush (or high quality water circulation) and chemical flushing in order to maintain reasonable flow [16-19]. The chemical flushing allows removing part of the membrane blocking. Fouling is a time dependent process and on a long run it is required to replace the membrane due to reduction in flux which turns the system into a non-economic venture. The time dependent fouling and related flushing procedures is well explained in Fig.-2.

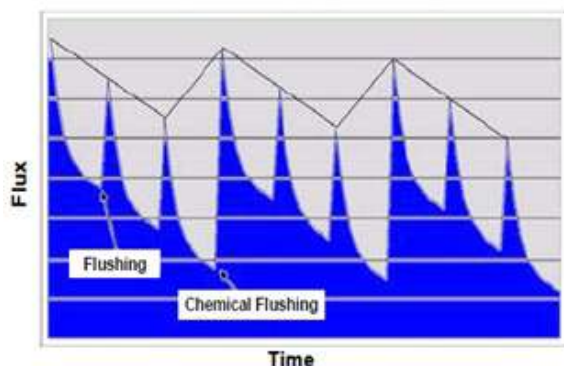


Fig.-2. Membrane time dependent flux variation due to fouling and flushing (adopted from ref. no. 2)

Wastewater quality improvement for unhindered reuse

Treated effluent can be reused primarily for agriculture, gardens, green belts and parks irrigation, aquifers recharge and maintaining aquatic life in reserve sites. In order to cope with health, environmental issues and agricultural production the treated effluent has to meet high quality standards. Membrane treatment is an efficient process to separate between the liquid and the solids contained in the wastewater. Membrane technology can be implemented as part of the biological treatment in bioreactors and also as a separate component for removal of the suspended matter and microorganism from the effluent. It is anticipated that the membrane technology will be the predominantly vehicle for better treatment of industrial wastewater and removal of the hazardous contained constituents from any kind of liquid.

Quality requirements for agricultural water

Water to be utilized in the agricultural sector has to address specific quality requirements in order to obtain an optimal production rate of irrigated crops. At the same time, taking into account the huge amount of water necessary in agriculture, a proper and sustainable management of water resources together with an efficient water distribution network is necessary to minimize losses, leaching and drainage (phenomena that can cause elevated concentrations of salts and nutrients in nearby soils and water bodies).

On the other hand, when using poor quality irrigation water, it is necessary to apply extra water to prevent salt accumulation in the soil which can have a negative effect on the crops [20]. Natural water resource degradation owing to a high concentration of nitrogen and phosphorus

is mainly caused by agricultural practices, sewage and industrial effluents. The increase in nutrients in water resources entails an increase in algal blooms which has a severe negative effect on the aquatic environment [21].

Membrane operations for desalination in agriculture :

Desalination and wastewater reuse provide an additional opportunity to avoid complete depletion and contamination of natural water resources. Desalination is an opportunity to reduce water stress in coastal and inland regions through the production of fresh water from seawater, saline groundwater, drainage water and treated wastewater.

Membrane technology has grown in recent years due to its outstanding alignment with sustainable development and process intensification. Moreover, it offers concrete benefits in the production processes, such as significant reduction of equipment size, boosting efficiency, energy savings, reducing capital costs, minimizing environmental impact, increasing safety, and using remote control and automation [18]. Membrane operations are already recognized worldwide as powerful tools to solve some important global problems and develop new industrial processes needed for a sustainable industrial growth. In seawater desalination, membrane operations or their combination in integrated systems are already a successful approach to solve freshwater demand at lower costs and minimum environmental impact.

Conclusions

Membrane filtration technology is used for wastewater treatment for agriculture field. Sustainable agricultural production requires new advanced techniques for the applied low water quality which is the main production factor along with environmental control. These can be accomplished by combining various treatment technologies and subject to economic considerations. Membrane treatment is a promising technology for environmental friendly removal of the microorganism and the dissolved solids. In the process of secondary wastewater polishing minimal fouling of the UF membrane has to be maintained. Adequate cleaning policy of the UF membrane allows obtaining reasonable treatment costs. Wastewater treatment by membrane operations can also address the removal of substances harmful to human health.

References

1. Elorm Obotey Ezugbe and Sudesh Rathilal (2020). Membrane Technologies in Wastewater Treatment: A Review, *Membranes*, 10, 89; doi:10.3390/membranes10050089.
2. Gideon Oron, Leonid Gillerman, Nissan Buriakovsky, Amos Bick, Moti Gargir, Yonathan Dolan, Yossi Manor, Ludmilla Katz, Josef Hagin (2008). Membrane technology for advanced wastewater reclamation for sustainable agriculture production, *Desalination* 218, 170–180.
3. T. Goto (2002). East and South East Asia. *Desalination & Water Reuse*, 12(1), 28–30.
4. Rebhun, M. (2004). Desalination of reclaimed wastewater to prevent salinisation of soils and groundwater, *Desalination* 160(2), 143–149.
5. Fane, A.G. (2005). Sustainability and membrane processing of wastewater for reuse. *Paper presented at the IWA Specialty Conference on Wastewater Reclamation and Reuse for Sustainability*, WRRS2005, 8–11, Jeju Island, Korea.
6. Cote P., Masini M. and Mourato, D. (2004). Comparison of membrane options for water reuse and reclamation. *Desalination* 167(1), 1–11.
7. Chae, S.R., Kang S.T., Lee S.M., Lee E.S., Oh S.E., Watanabe Y. and Shin H.S. (2005). High reuse potential of effluent from an innovative vertical submerged membrane bioreactor treating municipal wastewater. *Paper presented at the IWA Specialty Conference on Wastewater Reclamation and Reuse for Sustainability*, WRRS2005, 8–11.
8. Oron, G., Bick, A., Gillerman, L., Buriakovsky, N., Manor, Y., Ben-Yitshak, E., Katz, L. and Hagin, J. (2006). A two-stage membrane treatment of secondary effluent for unrestricted reuse and sustainable agricultural production. *Desalination* 187(1–3), 335–345.
9. Oron, G., Gillerman, L., Bick, A., Manor, Y., Buriakovsky, N. and Joseph Hagin, J. (2007). Advanced low quality waters treatment for unrestricted use purposes: imminent challenge, *Desalination* 213, 189–198.
10. Cho, J., Amy, G. and Pellegrino, J. (2000). Membrane filtration of natural organic matter: comparison of flux-decline, NOM rejection, and foulants during filtration with polyamide, polyethersulfone (PES), and sulfonated PES UF membranes, *Desalination* 127(3), 283–298.
11. Gideon Oron, Leonid Gillerman, Amos Bick, Yossi Manor, Nisan Buriakovsky and Joseph Hagin, (2008) Membrane technology for sustainable treated wastewater reuse: agricultural, environmental and hydrological considerations, *Water Science & Technology-WST*, 57.9, 1383-1388.
12. R. Faibish, S. Hong and M. Elimelech (1997) Kinetics of permeate flux decline in cross flow membrane filtration of colloidal suspensions, *J. Colloid Interf. Sci.*, 196, 267–277.
13. J.L. Wang, H.Ch. Shi and Y. Qian (2000) Wastewater treatment in a hybrid biological reactor (HBR): effect of organic loading rates, *Process Biochem.*, 36, 297–303.
14. S.V. Satyanarayana, P.K. Bhattacharya and D. Sirshendu (2000). Flux decline during ultrafiltration of craft black liquor using different flow modules, *Separ. Purif. Technol.*, 20, 155–167.
15. K.N. Bourgeois, J.L. Darby and G. Tchobanoglous (2001). Ultrafiltration of wastewater: effects of particles, mode of operation, and backwash effectiveness, *Wat. Res.*, 35(1) 77–90.

16. R.W. Field, D. Wu, J.A. Howell and B.B. Gupta (1995). Critical flux concept for microfiltration fouling, *J. Membr. Sci.*, 100, 259–272.
17. Z. Amjad (1997). RO systems current fouling problems and solutions, *Desalination & Water Reuse*, 6(4) 55–60.
18. A. Hamza, V.A. Pham, T. Matsuura and J.P. Santerre (1997). Development of membranes with low surface energy to reduce the fouling in ultrafiltration applications, *J. Membr. Sci.*, 131, 217–227.
19. H.M. Ma, C.N. Bowman and R.H. Davis (2000). Membrane fouling reduction by backflushing and surface modification, *J. Membr. Sci.*, 173, 191–200.
20. J. Letey, G.J. Hoffman, J.W. Hopmans, S.R. Grattan, D. Suarez, D.L. Corwin, J.D. Oster, L. Wu, C. Amrhein (2011). Evaluation of soil salinity leaching requirement guidelines, *Agric. Water Manag.* 98, 502–506.
21. United Nations Environment Programme (UNEP), Excess nitrogen in the environment, UNEP Year Book, Emerging Issues in our Global Environment, 2014.



Genetic Diversity Studies through D² Analysis in Chickpea (*Cicer arietinum* L.) Germplasm

Mayuri Megha Taidalwar and Gaibriyal M. Lal

Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Naini, Prayagraj, U.P.

Abstract

A set of thirty five genotypes of Chickpea were evaluated for studying of “Genetic Diversity Studies Through D² Analysis In Chickpea (*Cicer arietinum* L.) Germplasm”. The experiment was conducted in a Randomized Block Design with three replications during the Rabi season, 2020 at Department of Genetics and Plant Breeding, SHUATS, Naini. Analysis of variance exhibited significant differences among the genotypes for all the 13 characters. Among all the characters, high GCV and PCV were observed for number of seeds per plant followed by number of pods per plant, seed yield and biological yield. High genetic advance as % mean was recorded for number of seeds per plant, followed by number of pods per plant along with high heritability. Mahalanobis's D² analysis revealed considerable amount of diversity in the material. On the basis of D² values the 35 genotypes of chickpea studied were grouped in 5 clusters. Cluster I with 31 genotypes emerged as the largest cluster followed by cluster II, cluster III, cluster IV, and cluster V constitutes one genotype in each indicating the presence of genetic diversity among the genotypes. Variance of cluster means among thirteen different traits studied, number of pods per plant, followed by biological yield, plant height, number of seeds per plant, days to 50% flowering, days to maturity had maximum contribution towards divergence in the present material. Based on the inter cluster D² value was maximum between cluster III and V (16.49) followed by cluster IV and V (16.04), cluster I and V (14.62) were most diverse from each other and maximum intra cluster distances were recorded for cluster I (4.86). Therefore, it is concluded that the genotypes belonging to these clusters provide a broad spectrum of variability in segregating generations and may be used as parents in future hybridization programme to develop desirable genotypes for yield improvement in chickpea.

Key words : Chickpea, genetic variability, heritability, genetic advance and diversity.

Introduction

The word Cicer is a derivative from the Greek word kiros referring to a well-known roman family Cicero. Arietinum is derived from the Latin word arise meaning ram which refers to the ram's head shape of the chickpea (Singh, 1985). Chickpea (*Cicer arietinum* L.) is known by different names in various countries such as gram, Chana, Bengal gram, Kadle etc. Chickpea is an important Rabi season legume having extensive geographical distribution. Chickpea is a diploid species with a chromosome number 2n= 14. It is a self pollinated crop and it belongs to family leguminaceae. Chickpea is the third most important pulse crop in the world after beans and peas. It is cultivated on an area of 12 million hectares with 8.9 million tons of annual production. Chickpea plays an important role to improve soil fertility by fixing atmospheric nitrogen with the help of root nodules (Anabessa *et al.*, 2006). Chickpea is native of south-eastern Turkey and Syria (Saxena and Singh, 1987). Chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fiber and 2% ash. It is also reported to contain high mineral content: phosphorus (340 mg/100 g), calcium (190 mg/100 g), magnesium (140 mg/100 g), iron (7 mg/100 g), zinc (3 mg/100 g) by Jukanti *et al.* (2012). Young plants and pods are eaten like

spinach. The green seeds are cooked as a vegetable, mature seeds are used as dry pulse, parched boiled, fried or in various dishes, dhal is the split chickpea seed without the coat and is eaten cooked in thick soup. The flour, known as *besan* is used in many curry products, sweets and ceremonial dishes. India ranks first in terms of production and productivity, followed by Pakistan, Myanmar, Ethiopia, Mexico, Australia, Canada and United States. Maharashtra is the second largest producing state of chickpea in the country, the first being Madhya Pradesh. Maharashtra shares 12% to the country's total chickpea production (DES, Ministry of Agri. & FW, Govt. of India; 2018-19).

Genetic diversity is the base for survival of plants in nature and for crop improvement. In plants, genetic diversity determines the potential for improved efficiency and hence their use for breeding which eventually may result in enhanced food production. The knowledge of genetic diversity has a significant impact on the improvement of crop plants and this information has been successfully used for efficient germplasm management, fingerprinting, genotype selection (Rajkumar *et al.*, 2015). Genetic diversity among parents, which is heritable, is a pre-requisite for any successful breeding programme. The proper choice of parents in the breeding programme is of paramount importance. Genetic divergence among

Table-1 : Analysis of variance for 13 characters in Chickpea.

Sr. No.	Characters	Mean Sum of Squares		
		Replication (d.f=2)	Treatment (d.f=34)	Error (d.f=68)
1.	Days to 50% flowering	7.21	35.95**	2.35
2.	Days to 50% pod setting	1.55	50.97**	7.28
3.	Days to maturity	1.67	53.19**	2.43
4.	Plant height	30.83	150.06**	9.86
5.	Number of primary branch per plant	0.14	0.21**	0.12
6.	Number of secondary branches per plant	0.36	1.01**	0.54
7.	Number of pods per plant	47.49	1391.3**	63.62
8.	Number of seeds/pod	0.07	0.24**	0.05
9.	Number of seeds per plant	86.83	3811.35**	265.97
10.	Seed Index	31.06	23.98**	14.55
11.	Biological yield	20.05	303.16**	22.45
12.	Harvest index	78.6	269.06**	55.88
13.	Seed yield(kg/ha)	13.21	84.92**	8.22

**, * Significant at P=0.01

the parents plays a vital role in cultivar improvement because crosses involving genetically diversified parents are likely to produce high heterotic effects and also more variability in segregating generations, which can be exploited for the desired improvement. (Nimbalkar *et al.*, 2017). If the parent selected for hybridization have diverse background the more are the chances of improving the characters under consideration (Chowdhary *et al.*, 2002).

Generally, plant breeder select the parents on the basis of phenotypic divergence, but for effective breeding, the knowledge of genetic diversity among the parents with respect to the characters which are to be improved is essential. Mahalanobis's (1936) reported that D^2 statistics is a powerful tool for estimating the divergence between two populations, many studies based on this technique also indicated that geographical isolation is not necessarily related to genetic diversity. It thus gives better idea about the magnitude of divergence and is independent of size of sample and provides the basis for selection of parental lines for further breeding programmes. (Saha *et al.*, 2018) Several workers studied the genetic diversity, clustering pattern and relative contribution of different characters toward divergence and effectiveness of selection (Anita *et al.*, 2015; Johnson *et al.*, 2015; Agrawal *et al.*, 2018).

The knowledge about the source of genetic diversity for the different characters is of considerable importance, since the prime aim of the plant breeder is to improve the yield and the quality by evolving superior varieties. An investigation into the nature and the degree of divergence is useful for understanding of the course of evolution and for classifying population into groups on the basis of diversity, particularly, when they are overlapping for one or more characters. The present study was, therefore, conducted with a view to identify divergent parents for

future hybridization programmes for yield improvement of chickpea.

Materials and Methods

The experiment was carried out at field experimentation center of the department of genetics and plant breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj (UP), during *Rabi*, 2020-21. Naini is situated between the parallels of $20^{\circ} 33' 40''$ to $21^{\circ} 50' N$ latitude and $73^{\circ} 27' 58''$ and $73^{\circ} 56' 36''$ E longitude. Prayagraj is located in the south-eastern of Uttar Pradesh and has a sub-tropical climate with extremes of summer and winter. The experimental material for present investigation comprised of 35 genotypes of chickpea (*Cicer arietinum* L.) obtained from Department of Genetics and Plant Breeding, SHUATS, Prayagraj. The experiment was laid out in Randomized Block Design (RBD) with three replications. A spacing of 30 cm between rows and 10 cm between plants within the row was maintained. The data were recorded on five randomly selected plants of each replication for all characters such as days to 50% of flowering, days to 50% pod setting, Days to maturity, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Number of pods per plant, Number of seeds per plant, Number of seeds per pod, Seed Index (g), Biological yield per plant (g), Harvest index (%), Seed yield per plant (g). The statistical analysis was carried out as per the equation suggested: Analysis of variance was carried out as per standard procedure (Fisher, 1936). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) (Burton, 1952), Heritability (Broad sense) (Burton and De Vane (1953), Genetic advance (Johnson *et al.*, 1955), and D^2 analysis by Mahalanobis (1936).

Results and Discussions

Analysis of variance : The analysis of variance revealed significant differences among the genotypes for all the characters under study viz., days to 50% of flowering, days to 50% pod setting, Days to maturity, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Number of pods per plant, Number of seeds per plant, Number of seeds per pod, Seed Index (g), Biological yield per plant (g), Harvest index (%), Seed yield per plant (g). From the analysis of variance it was observed that mean sum of squares due to genotypes was Significant ($\alpha = 0.01$) for all characters indicating the presence of substantial amount of genetic variability among the Chickpea genotypes presented in the table-1.

Genetic variability : The results pertaining to genetic parameters viz., genotypic variance, phenotypic variance, phenotypic coefficient of variation, genotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean were calculated to estimate the amount of genetic variability for different characters. In the present investigation, it is depicted from the Table-2 that in general, estimates of the phenotypic coefficient of variation was found higher than their corresponding genotypic coefficient of variation, indicating that the influence of environment on the expression of these characters.

Data obtained from the experiment showed high PCV and GCV have in Number of seeds per plant (40.871; 39.419) followed by number of pods per plant (37.823; 36.948), seed yield (27.56; 26.2) and biological yield (26.237; 25.247). Remaining characters exhibited moderate to low values of PCV and GCV.

High heritability was exhibited by number of seeds per plant and days to maturity (95.4). High genetic advance as per cent of mean was recorded for number of seeds per plant (78.319) followed by number of pods per plant (74.352), along with high heritability, GCV, PCV. The high value of genetic advance indicates additive gene action where as low value indicates non-additive gene action.

Composition of clusters : The D^2 values showed adequate genetic diversity among the genotypes studied. Grouping of the genotypes was carried-out by Tocher's method as per suggested by Rao, 1952. On the basis of D^2 values all the 35 genotypes were grouped into the five clusters shown in the table-3. Cluster I with 31 genotypes emerged as the largest cluster followed by cluster II constitutes 1 genotype, cluster III constitutes 1 genotype, cluster IV constitutes 1 genotype, cluster V constitutes 1 genotype in each. The pattern of grouping genotypes in

Table-2 : Genetic Parameters for different characters in chickpea.

	DF50	DPS50	DM	PH	NPBP	NSBP	NPP	NSPP	NSPPI	SI	BY	SY	HI
Variation Environmental	0.782	2.426	0.81	3.287	0.039	0.182	21.206	0.015	88.656	4.849	7.484	2.739	18.627
ECV	1.764	2.647	1.024	4.245	16.474	14.355	14.009	12.105	18.7	18.262	12.367	14.85	14.518
Variation Genotypical	11.199	14.565	16.918	46.732	0.032	0.156	442.56	0.065	1181.795	3.144	93.569	25.568	71.061
GCV	3.853	3.745	2.701	9.241	8.613	7.689	36.948	14.431	39.419	8.49	25.247	26.195	16.372
Variation Phenotypical	11.982	16.991	17.729	50.019	0.07	0.338	463.767	0.08	1270.451	7.993	101.054	28.306	89.688
PCV	3.985	4.045	2.765	9.561	12.832	11.305	37.823	16.034	40.871	13.537	26.237	27.563	18.393
h^2 (Broad Sense)	0.935	0.857	0.954	0.934	0.451	0.463	0.954	0.81	0.93	0.393	0.926	0.903	0.792
Genetic Advancement 5%	6.665	7.279	8.277	13.612	0.246	0.554	42.334	0.471	68.302	2.291	19.175	9.9	15.457
Genetic Advancement 1%	8.542	9.328	10.608	17.444	0.315	0.71	54.253	0.604	87.532	2.936	24.573	12.687	19.809
Genetic Advance as % of Mean 5%	7.673	7.143	5.436	18.401	11.91	10.772	74.352	26.756	78.319	10.968	50.045	51.285	30.02
Genetic Advance as % of Mean 1%	9.833	9.154	6.966	23.582	15.263	13.805	95.266	34.289	100.37	14.056	64.136	65.725	38.472

Table-3 : Distribution of the 35 chickpea genotypes into different clusters.

Sl. No.	Cluster No.	No. of Genotypes	Genotypes included
1	I	31	IPC-71, IPC-10-134, BDG-72, ILC-32-79, ICC-30-70, IPC-05-59, IPC-2000-33, HG-5, IPC-04-52, IPC-49-58, IPC-0566, KPG-59, ICCV-96030, ILC-5411, PDG-8416, IPC-11-09, ICCV-15614, GNG-1958, NBEG-49, RVG-204, NBEG-47, HC-2, IPC-0528, Phule Vikram, ICCV-10, PUSA-209, Anethyst, Vaibhav, JG-14, GC-38341.
2	II	1	IPC-0459
3	III	1	JG-11
4	IV	1	IPCK-1185

Table-4 : Cluster Mean.

Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Days to 50% flowering	87.2	89.33	86.67	88.33	72.67
Days to 50% pod setting	101.97	100.67	112.67	99.67	92.67
Days to maturity	153.03	151	153.67	152.33	128.67
Plant height	74.47	67.33	82.77	76.43	53.93
Number of primary Branches per plant	2.04	2.13	2.2	2.2	2.47
Number of secondary branches per plant	5.11	5.67	4.93	6.47	4.53
Number of pods per plant	55	78.8	51.8	131.53	25.73
Number of seeds per pod	1.82	1.07	1.33	1.67	1.27
Number of seeds per plant	87.74	98.67	53.7	147.07	33.07
Seed index	20.89	22	24	18	19.33
Biological yield	38.21	25.87	38.07	55.33	37.33
Seed yield	19.01	13.6	23.53	31.53	17.67
Harvest index	51.08	52.48	61.39	57.13	47.54

Table-5 : Intra and Inter Cluster Distance.

Groups	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	4.86	5.92	6.26	8.11	14.62
Cluster II		0	7.6	6.27	13.69
Cluster III			0	9.07	16.49
Cluster IV				0	16.04
Cluster V					0

Table-6 : Contributions of different characters towards divergence in chickpea.

S. No.	Source	Times Ranked 1 st	Contribution %
1.	DF50	39	6.55%
2.	DPS50	22	3.70%
3.	DM	34	5.71%
4.	PH	87	14.62%
5.	NPBP	3	0.50%
6.	NSBP	6	1.01%
7.	NPPP	140	23.53%
8.	NSPP	22	3.70%
9.	NSPPI	60	10.08%
10.	SI	2	0.34%
11.	BY	100	16.81%
12.	SY	63	10.59%
13.	HI	17	2.86%

DF50 = Days to 50% flowering, DP50 = Days to 50% Pod setting, DM = Days to maturity, PH = Plant height NPBP = No. of primary branches, NSBP = No. of secondary branches per plant, NPPP = No. of pods per plant, NSPP = No. of seeds per pod, NSPP = No. of seeds per plant, SI = Seed index, BY = Biological yield per plant, SYPP = Seed yield per plant, HI = Harvest index.

different clusters proved that geographical distribution and genetic divergence didn't follow same pattern and the existence of significant amount of variability.

Greater the divergence between the two clusters, wider is the genetic diversity in the genotypes. The crosses involving the parents with extreme divergence have also been reported to exhibit decrease in heterosis. Therefore, while selecting the parents by considering the genetic diversity, their performance and cluster mean for the characters also need due consideration in the crop improvement programme.

Cluster mean : The cluster means for thirteen characters among thirty five genotypes are presented in table-4. The cluster mean for days to 50% flowering varied from 72.67 to 89.33. The genotypes in cluster V showed early flowering as the group had taken minimum number of (72.67) days to flowering. The genotypes in cluster V showed minimum number of (92.67) days to 50% pod setting followed by cluster IV (99.67). The early maturing genotypes were involved in cluster V (12.67). The tallest genotypes were grouped in cluster III (82.77) followed by

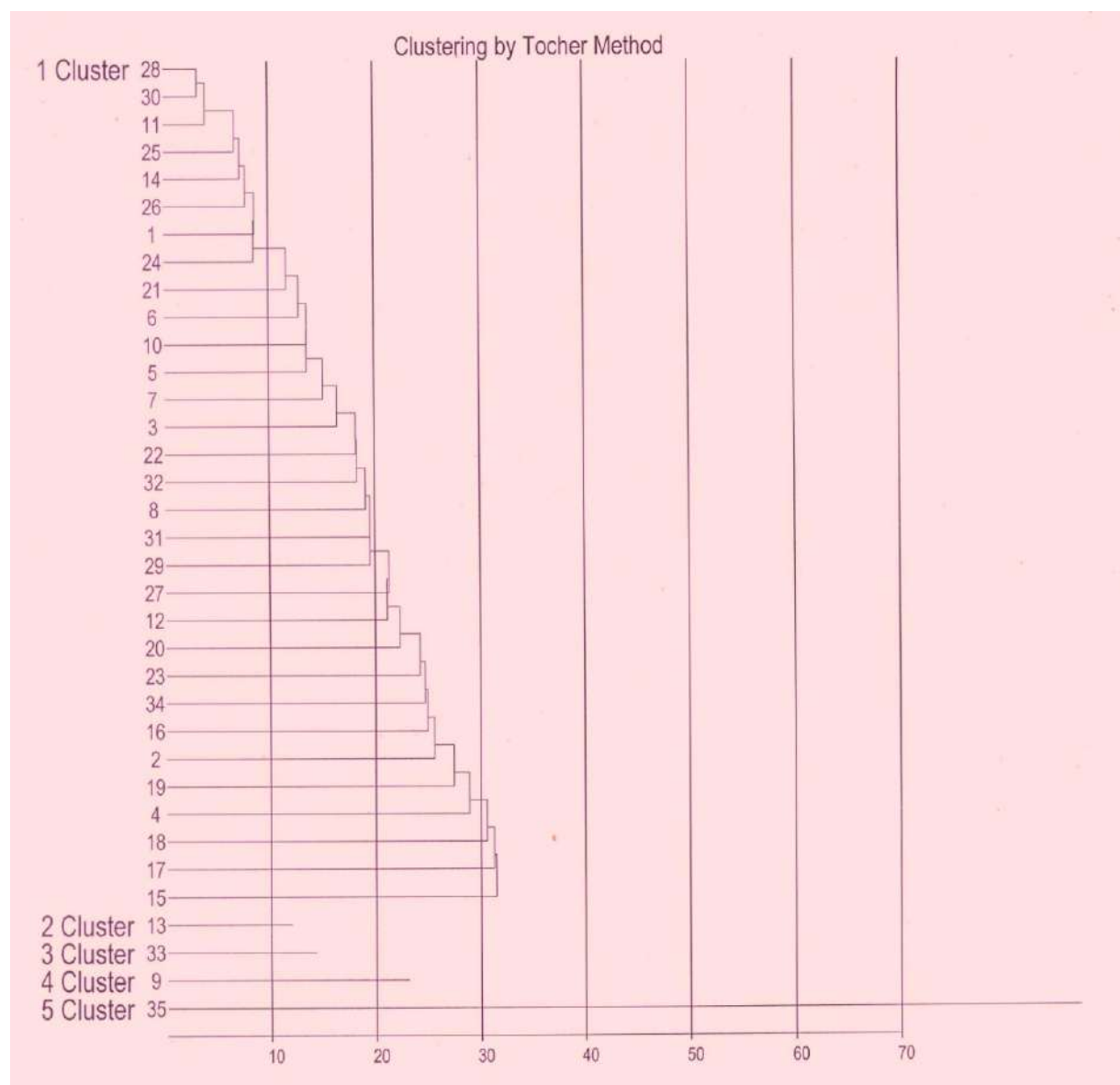


Fig.-1 : Clustering Pattern in Chickpea (*Cicer arietinum* L.) by Tocher Method.

cluster IV (76.43), cluster I (74.47). The maximum cluster mean for number of primary branches per plant was observed in cluster V (2.47) followed by cluster II (2.13) and minimum cluster mean was observed in cluster I (2.04) followed by cluster III and IV (2.2). The maximum cluster mean for number of secondary branches per plant was observed in cluster IV (6.47) followed by cluster II (5.67) and cluster I (5.11) and minimum cluster mean was observed in cluster V (4.53) followed by cluster III (4.93). The maximum cluster mean for number of pods per plant was observed in cluster IV (131.53) followed by cluster II (78.8). The minimum cluster mean for number of pods per plant was observed in cluster V (25.73). The maximum cluster mean for number of seeds per pod was observed in cluster I (1.82) followed by cluster IV (1.67). The minimum cluster mean for number of seeds per pod

was observed in cluster II (1.07) followed by cluster V (1.27) and cluster III (1.33). The minimum cluster mean for number of seeds per plant was observed in cluster V (33.07) and maximum cluster mean was observed in cluster IV (147.07) followed by cluster II (98.67) and cluster I (87.74). The minimum cluster mean for seed index was observed in cluster IV (18) and maximum cluster mean was observed in cluster III (24). The maximum cluster mean for biological yield was observed in cluster IV (55.33) and minimum cluster mean was observed in cluster II (25.87). The maximum cluster mean for seed yield was observed in cluster IV (31.53) and minimum cluster mean was observed in cluster II (13.6). The maximum cluster mean for harvest index was observed in cluster III (61.39) and minimum cluster mean was observed in cluster V (47.54).

Intra and inter cluster distances : The intra and inter cluster distances D^2 between all possible pairs of five clusters were computed and presented in table-5 .The inter cluster D^2 value was maximum between cluster III and V (16.49) followed by cluster IV and V (16.04), cluster I and V (14.62). Suggesting that the genotypes present in these clusters may be used as parents for hybridization programme to develop desirable type as heterosis can be best exploited and chance of getting transgressive segregants are maximum when generating diverse lines are crossed (Lal *et al.* 2001). The maximum intra cluster distances were recorded for cluster I (4.86) and for remaining clusters it is zero as they are mono clusters. In present study, intra cluster distance values were lower than the inter cluster distances which indicated substantial diversity present among the genotypes studied. Therefore, for getting more heterotic combination and most promising segregants in segregating generations, selection of genotypes should be from between cluster possessing maximum genetic divergence.

Contributions of various characters towards genetic divergence : The utility of D^2 analysis, which is a potent tool to quantify the extent of divergence in biological population at genetic level. The percent contribution of 13 characters towards total genetic divergence is presented in Table-6. The selection and choice of parents mainly depend upon the contribution of characters towards divergence (Nayak *et al.*, 2004).

The highest contribution in the manifestation of genetic divergence was exhibited by number of pods per plant (23.53%), followed by biological yield (16.81), plant height (14.62), number of seeds per plant (10.08%), days to 50% flowering (6.55%), days to maturity (5.71%) which over all contributed 77.3% to the total divergence needed to be focused in the selection of these traits for hybridization program. Greater the divergence between the two clusters, wider is the genetic diversity in the genotypes. The crosses involving the parents with extreme divergence have also been reported to exhibit decrease in heterosis.

Therefore, while selecting the parents by considering the genetic diversity, their performance and cluster mean for the characters also need due consideration in the crop improvement programme. However, while considering genetic diversity among the parent to be included in the hybridization program, parents with high yielding potential and wide genetic diversity are likely to yield superior segregants within a short period. (Roy and Panwar, 1993). The success and usefulness of Mahalanobis D^2 analysis in quantifying genetic divergence in chickpea has been studied by Devendrappa *et al.* (2011), Prakash and Shekhawat

(2012), Jain and Indapurker (2013), Parhe *et al.* (2014), Johnson *et al.* (2015), Dan Singh *et al.* (2016), Ishwar *et al.* (2017), Ambilwade *et al.* (2018), Mayuri ben *et al.* (2019), Tinkeshwari *et al.* (2020).

Conclusions

The results from the present investigation conclude that significant differences recorded for all the characters among the 35 chickpea genotypes included in the study, indicating presence of sufficient variation among them. High genetic advance as % mean coupled with heritability was recorded for number of seeds per plant followed by number of pods per plant, along with GCV, PCV. The inter cluster D^2 value was maximum between cluster III and V followed by cluster IV and V were most diverse from each other and the genotypes present in these clusters provide a broad spectrum of variability in segregating generations and may be used as parents in future hybridization programme to develop desirable genotypes, for yield improvement in chickpea.

References

1. Agrawal T., Kumar A., Kumar S., Kumar A., Kumar M. and Perween S. (2018). Assessment of genetic diversity in chickpea (*Cicer arietinum* L.). *International Journal of Current Microbiology in Applied Sciences*, 7(4): 3552-3560.
2. Ambilwade B., Magar A.S., Gadade S.B. and Suresh B.G. (2018). Genetic Diversity studies in chickpea (*Cicer arietinum* L.) germplasm. *International Journal of Current Microbiology and Applied Sciences*, 7(9): 2757-2763.
3. Anita B., Andey S. and Singh R. (2015). Genetic studies on chickpea genotypes grown in late sown under rice fallow conditions of Madhya Pradesh, *Electronic Journal of Plant Breeding*, 6(3): 738-748.
4. Burton G.W. (1952). Quantitative inheritance in pearl millet (*P. glaucum* L.). *Agronomy Journal*, 501-503.
5. Chaudhry M.A., Vanderberg V. and Warkentin T. (2002). Cultivar identification and genetic relationship among selected breeding lines and cultivar in chickpea (*Cicer arietinum* L.) *Euphytica*, 172: 317-325.
6. Devendrappa J., Viswanatha K.P., Mallikarjun B.P., Ambika D.S. and Choudki V.M. (2013). Assessment of genetic diversity in chickpea (*Cicer arietinum* L.). *Bioinfolet : A quarterly Journal of life sciences*, 10(1b): 227-230.
7. Fisher R.A. (1930). The genetic theory of natural selection. *Genetics by Strickberger, M.W. published by McMillan Co., New York.* 772.
8. Jain S. and Indapurkar Y.M. (2013). Assessment of genetic divergence in chickpea genotypes (*Cicer arietinum* L.). *Trends in Biosciences*, 6(1): 68-69.
9. Johnson H.W., Robinson H.F. and Comstock R.E. (1995). Estimates of genetic and environmental variability in soybean. *Agronomy Journal*, 47: 314-318.
10. Johnson P.L., Sharma R.N. and Nanda H.C. (2015). Genetic diversity and association analysis for yield Traits chickpea

- (*Cicer arietinum* L.) Under rice based cropping system. *The Biosen*, 10(2): 679-884
11. Lal D., Ram Krishna and Gurpreet S. (2001). Genetic divergence in chickpea. *Indian Journal of Pulses Research*, 14(1): 63-64.
 12. Mahalanobis P.C. (1936). On the generalized distance in statistics. *Proceedings of the National Academy of Sciences India*, 2: 49-55.
 13. Mayuriben R.T., Sunayan R.P., Sunil S.P., Arpan J.N. and Harshad N.P. (2019). Diversity study through D² analysis in chickpea. *The Pharma Innovation Journal*, 8(9): 140-143.
 14. Nimbalkar R.D., Katre Y.Y., Phad D.S. (2017). Genetic diversity in Chickpea (*Cicer arietinum* L.). *Bioinfolet*, 14(1): 60-63.
 15. Prakash V. and Shekhawat U.S. (2012). Genetic divergence in yield and yield contributing traits in chickpea. *Journal of Progressive Agriculture*, 3(1): 55-58.
 16. Rajkumar K., Suneeta P., Anita B. and Vijay P. (2015). Genetic diversity analysis in chickpea grown under heat stress conditions of Madhya Pradesh. *Electronic Journal of Plant Breeding*, 6(4): 962-971.
 17. Rao C.R. (1952). Advanced statistical method in biometry. *John Wiley* New York. 50-55.
 18. Saha S., Babbar A. and Singh S. (2018). Genetic diversity in elite lines of chickpea (*Cicer arietinum* L.) for phenological and quantitative traits. *Journal of Pharmacognosy and Phytochemistry*, 7(2): 2705-2709.
 19. Singh R.K. and Choudhary B.D. (1985). Biometrical methods in quantitative genetics analysis (3rd Ed.). *Kalyani publishers*, New Delhi, 318.



Effect of Foliar Spray of Nutrients and Plant Growth Regulator on Vegetative, Reproductive Growth, Physical Character and Leaf Chlorophyll Content of Acid Lime (*Citrus aurantifolia* Swingle)

Naresh Meena, R.N. Kanpure, R.P. Patel, B.K. Kachouli and B.K. Patidar

RVSKVV-College of Horticulture, Mandsaur (M.P.)

Abstract

The present study was conducted to see the effect of foliar spray of nutrients and plant growth regulator on flowering, yield and quality of Acid lime (*Citrus aurantifolia* Swingle). Result revealed that maximum increase in plant height (0.52 m), increase in plant spread East-West direction (0.55 m), increase in plant spread North-South direction (0.57 m) and canopy volume (82.80 m³), maximum number of flowers per shoot (18.03), fruit set(s) per shoot (8.95), minimum fruit drop (24.33%) and maximum fruit retention (75.67%), maximum fruit length (4.82 cm) and fruit diameter (4.37 cm), juice content per fruit (27.72ml), volume of fruit (37.52 ml), chlorophyll content in leaves (70.51), were found with foliar spray of KNO₃ @ 2% + GA₃ @ 75 ppm + ZnSO₄ @ 0.6% (T₁₅).

Key words : Acid lime, reproductive, physical, chlorophyll content, leaf.

Introduction

Acid lime (*Citrus aurantifolia* Swingle) is mainly cultivated for its multi-fold nutritional and medicinal values which made acid lime more important among the fruits. It is good appetizer, anti helmentic and it checks biliousness and stomach ache. 100 grams of fruit juice contains 80 per cent of water, carotene 26 IU, Vitamin A, Vitamin B₁ 20 mg, Riboflavin 0.1 mg, Vitamin C 63 mg, Iron (Fe) 1.83 mg, Copper (Cu) 0.16 mg, Oxalo-acetic acid 0.30%, Malic acid and alkaline salt 8.2% therefore it is very essential for human health. (Ranganna *et al.*, 2017).

They are also rich source of bioflavonoid, acid and volatile oils. Special interest in limes has been flavonoids called flavonol glycosides, including many kaempferol-related molecules. While these flavonoids have been shown to stop cell division in many cancer cell lines, they are perhaps most interesting for their antibiotic effects. They also contain coumarins such as bergapten which sensitive the skin to sunlight. Bergapten is sometimes added to tanning preparation since it promotes pigmentation in the skin, though it can cause dermatitis or allergic responses in some people (Venu *et al.*, 2014).

In India, acid lime is grown in a variety of agro-climates comprising from the northern plains and central highlands having hot semi arid eco-region with black and red soils. Acid limes are grown commercially in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Bihar and West Bengal. It is cultivated in Badawani, Khargon, Khandwa, Ujjain, Ratlam, Mandsaur, Neemach, Shajapur, Gwalior, Burhanpur, Hoshangabad, Morena, Guna, Jabalpur and Bhopal districts of Madhya Pradesh. The total area, production and productivity of acid

lime/lemons in India are about 286000 hectares, 3148000 million tonnes (MT) and 11.0 MT/ha., respectively (Indiaagristat, 2017-18). The total area and production of acid lime/lemon in Madhya Pradesh has 17700 hectares and 230840 MT, respectively (Indiaagristat, 2016-17).

Acid lime is considered to be continuous bloomer due to its peculiar cyclic flushing behaviour but the main blooming period starts from February to March with lean period from July to August. The flowering percentage of ambe, mrig and hasta bahar occurs 47%, 36% and 17 % respectively. The fruits of hasta bahar are ready to harvest in the months of April – May when there is heavy demand and are sold at premium prices (Rai *et al.*, 2018).

A very little work has been made to words the effect of zinc and GA₃ on yield with better quality of kagzi lime (Singh *et al.*, 2011). Severe deficiency of Zn was noted long ago in the citrus orchards of Madhya Pradesh. Zinc is an important element for flowering, fruiting, growth and quality of fruits.

Effective use of micronutrients in kagzi lime is one such research gap. Micronutrients can tremendously boost kagzi lime flowering and fruiting quality. The problem of micronutrients deficiency in kagzi lime causes great concern to the fruit growers and also flower drop as well as fruit drop is a major problem. Use of micronutrients will boost up the yield and quality of kagzi lime than ultimately farmers will get economical benefits (Venu *et al.*, 2014).

Materials and Methods

The present investigation entitled effect of foliar spray of nutrients and plant growth regulator on flowering, yield

and quality of acid lime (*Citrus aurantifolia* Swingle) was conducted during 2018-2019 at the Instructional cum Research Fruit Orchard, Department of Fruit Science, College of Horticulture, Mandsaur (MP). The experiment was laid out in randomized block design (RBD) with three replications consisted sixteen treatments i.e. T₁-KNO₃ @ 1%, T₂-KNO₃ @ 1.5%, T₃-KNO₃ @ 2%, T₄-GA₃ @ 25 ppm, T₅-GA₃ @ 50 ppm, T₆-GA₃ @ 75 ppm, T₇-ZnSO₄ @ 0.2%, T₈-ZnSO₄ @ 0.4%, T₉-ZnSO₄ @ 0.6%, T₁₀-KNO₃ @ 1% + GA₃ @ 25 ppm, T₁₁-KNO₃ @ 1% + GA₃ @ 25 ppm + ZnSO₄ @ 0.2%, T₁₂-KNO₃ @ 1.5% + GA₃ @ 50 ppm, T₁₃-KNO₃ @ 1.5% + GA₃ @ 50 ppm + ZnSO₄ @ 0.4%, T₁₄-KNO₃ @ 2% + GA₃ @ 75 ppm, T₁₅-KNO₃ @ 2% + GA₃ @ 75 ppm + ZnSO₄ @ 0.6%, T₁₆-Control (Water Spray). The details of material used and techniques employed in the experiments are described as follows. The canopy volume was calculated as per the Westwood *et al.* (1963).

$$\text{Canopy volume (m}^3\text{)} = \frac{4}{3} a^2 b$$

Where : = 22/7

a = ½ of the plant height

b = average of East-West and North-South spread

The fruit drop per cent was calculated by the following equation :

$$\text{Fruit drop (\%)} = \frac{\text{Total no. of fruit set} - \text{Total no. of fruits at harvest time}}{\text{Total number of fruuits set}} \times 100$$

Formula given by Khattab *et al.* 2011

Fruit retention was calculated as per method given by Westwood *et al.* (1993).

$$\text{Fruit retention (\%)} = \frac{\text{Number of fruits at harvest}}{\text{Initial number of fruit set}} \times 100$$

Chlorophyll content in leaves was estimated by using instrument SPAD chlorophyll meter by simple clamping the meter over leafy tissue.

Results and Discussion

The results of an experiment have been discussed in the light of acceptable principles and available literature as under.

Vegetative Parameters : Data presented in Table-1 revealed that the increase vegetative parameters of acid lime increased gradually in the subsequent higher concentrations of nutrients and PGR, alone or in their combinations. Amongst alone treatments T₆ (GA₃ @ 75 ppm) was recorded maximum plant height (0.42 m), increase in plant spread East-West direction (0.45 m), increase in plant spread North-South direction (0.46 m) and canopy volume (67.80 m³). As concern to combined

foliar spray of KNO₃ @ 2% + GA₃ @ 75 ppm + ZnSO₄ @ 0.6% (T₁₅) recorded the maximum increase in plant height (0.52 m), increase in plant spread East-West direction (0.55 m), increase in plant spread North-South direction (0.57 m) and canopy volume (82.80 m³), in plant height treatment T₁₄ was found at par with T₁₅ whereas minimum value for vegetative characters under control (T₁₆) may be due to lack of supply of nutrients.

The improved vegetative growth was recorded mainly due to beneficial effect of GA₃ which promotes cell elongation, increase in both cell size and number and also increase cell multiplication (Knoche *et al.*, 2000).

Potassium is involved in cell enlargement and in triggering the young tissues or be due to that potassium is involved in plant meristematic growth (Mengel and Kirkby, 1987).

Involvement of Zn in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis (IAA) resulted in increased apical growth and thus increased height and spread, consequently it increased tissue growth and development. It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008). The results are in close conformity with the findings of Kadam *et al.* (2010) in Kagzi lime, Deshmukh *et al.* (2015) in acid lime, Gurjar *et al.* (2015) in Kinnow mandarin, Madarakhandi *et al.* (2015) in Kinnow mandarin, Gurung *et al.* (2016) in Darjeeling mandarin, Neware *et al.* (2017) sweet orange cv. Mosambi, Rai *et al.* (2018) in acid lime and Singh *et al.* (2018) in Kinnow mandarin.

Reproductive Parameters : Amongst alone treatments T₉ (ZnSO₄ @ 0.6%) was recorded maximum number of flower(s) per shoot (15.39), maximum fruit set per shoot (7.07), minimum fruit drop (32.78%) and maximum fruit retention (67.22%). Among combined treatments T₁₅ (KNO₃ @ 2% + GA₃ @ 75 ppm+ ZnSO₄ @ 0.6%) was recorded maximum number of flowers per shoot (18.03), fruit set(s) per shoot (8.95), minimum fruit drop (24.33%) and maximum fruit retention (75.67%) were recorded under. Followed by T₁₃ (number of flower(s) per shoot 17.25, fruit set per shoot 8.39, fruit drop 26.13% and fruit retention 73.87%, respectively). The minimum value for reproductive characters under control (T₁₆) may be due to lack of supply of nutrients.

Zinc improves the biological machines, and these are consisting of proteins and enzymes (Stout, 1962). The Chlorophyll production, pollen function and fertilization require zinc (Kaya *et al.*, 2005).

GA intensifies an organ ability to function as a nutrient sink, it also increases the biosynthesis of IAA in

Table-1 : Effect of foliar spray of nutrients and plant growth regulator on vegetative, reproductive growth, physical character and leaf chlorophyll content of Acid lime (*Citrus aurantifolia* Swingle).

Treatments	Plant height (m)	Plant spread E-W direction (m)	Plant spread N-S direction (m)	Canopy volume (m ³)	Number of flower(s) per shoot	Fruit(s) set per shoot	Fruit drop (%)	Fruit retention (%)	Fruit length (cm)	Fruit diameter (cm)	Juice content per fruit (ml)	Fruit Volume (ml)
T ₁	0.32	0.38	0.39	55.77	12.87	5.30	43.42	56.58	4.26	4.03	22.90	31.94
T ₂	0.34	0.39	0.40	57.33	13.12	5.51	42.09	57.91	4.28	4.05	23.12	32.29
T ₃	0.36	0.41	0.42	59.35	13.36	5.72	40.76	59.24	4.32	4.08	23.31	32.68
T ₄	0.37	0.42	0.43	62.85	13.75	6.08	39.43	60.57	4.36	4.12	23.57	32.86
T ₅	0.39	0.43	0.44	65.99	13.97	6.24	38.10	61.90	4.42	4.15	23.98	33.33
T ₆	0.42	0.45	0.46	67.80	14.39	6.44	36.77	63.23	4.46	4.20	24.38	33.80
T ₇	0.29	0.34	0.35	49.73	14.73	6.72	35.44	64.56	4.13	3.86	21.67	30.11
T ₈	0.30	0.35	0.36	51.98	15.17	6.92	34.11	65.89	4.16	3.89	22.33	30.53
T ₉	0.32	0.37	0.38	53.84	15.39	7.07	32.78	67.22	4.21	3.94	22.87	31.17
T ₁₀	0.44	0.46	0.47	70.35	15.69	7.25	31.45	68.55	4.69	4.23	24.69	34.67
T ₁₁	0.46	0.48	0.49	73.46	17.02	8.15	27.46	72.54	4.71	4.27	25.10	35.37
T ₁₂	0.47	0.50	0.51	76.21	16.34	7.59	30.12	69.88	4.75	4.29	25.74	35.83
T ₁₃	0.49	0.52	0.53	78.63	17.25	8.39	26.13	73.87	4.78	4.32	26.22	36.39
T ₁₄	0.51	0.53	0.54	80.36	16.85	8.03	28.79	71.21	4.80	4.35	26.92	36.81
T ₁₅	0.52	0.55	0.57	82.80	18.03	8.95	24.33	75.67	4.82	4.37	27.72	37.52
T ₁₆	0.26	0.30	0.33	43.98	11.85	4.39	44.75	55.25	3.95	3.75	20.56	27.19
S. Em. ±	0.008	0.010	0.008	0.54	0.18	0.25	0.94	0.80	0.12	0.09	0.33	0.42
C.D. at 5%	0.023	0.028	0.023	1.57	0.52	0.71	2.72	2.30	0.35	0.27	0.97	1.20

plant tissues which delays the formation of the separation layer (Wasfy, 1995). Higher fruit set by application of GA₃ which might have influenced pollen germination and pollen tube growth.

The application of gibberellic acid and KNO₃ in the present investigation has increased the intensity of flowering, better fruit set, better fruit retention, reduce fruit drop, which might have better due to ethylene biosynthesis and optimum nutrient availability to the plants. It has been long known that carbohydrate levels in trees affected floral initiation in buds, thus carbohydrate levels must be high in plant tissue at the time of flora initiation to stimulate bud initiation, also potassium influence meristematic tissue growth and photosynthesis (Ruiz, 2006). Similarly results were obtained by Gurjar *et al.* (2015) in Kinnow mandarin, Pawar *et al.* (2016) in acid lime cv. Phule Sharbati, Bhosale *et al.* (2018) in pomegranate cv. Phule Bhagwa Super, Singh *et al.* (2018) in Kinnow mandarin, Singh and Kaur (2018) in peach cv. Shan-e-Punjab and Sharma *et al.* (2019) in aonla cv. NA-7.

Physical Parameters : The physical characteristics of fruit are an expression of a plants vegetative activity which was also significantly influenced by KNO₃, GA₃ and ZnSO₄. Result show that amongst alone treatments T₉ was recorded maximum fruit length (4.21 cm), fruit diameter (3.94 cm) juice content per fruit (22.87ml) and volume of fruit (31.17 ml). Under combined treatments T₁₅ (KNO₃ @ 2% + GA₃ @ 75 ppm + ZnSO₄ @ 0.6%) noted maximum fruit length (4.82 cm) and fruit diameter (4.37 cm), juice content per fruit (27.72ml), volume of fruit (37.52 ml), followed by T₁₄ (fruit length 4.80 cm, fruit diameter 4.35 cm, juice content per fruit 26.92ml and volume of fruit 36.81 ml, respectively). However, minimum value for physical characters under control may be due to lack of supply of nutrients.

Increase in weight and fruit volume was mainly due to the fact that GA₃ and ZnSO₄ are known as growth promoting chemicals, playing a significant role in development of fruits (Krishnamoorthy, 1993). The possible reason for enhancement of fruit size (length

& diameter) with NAA, GA₃ and zinc might be due to their involvement in hormonal metabolism, increased cell division, elongation and expansion of cells. The increase in juice percentage with GA₃ and K spray might be due to their influence on enhancing cell wall expansion, which increases the vesicle capacity for juice accumulation (Agusti *et al.*, 2002). KNO₃ has been reported to enhance the photosynthetic efficiency of the plants. The increase in fruit size due to KNO₃ treatments may be due to the reason that K helped in increasing the entry of water into the cells by osmotic processes, and increased cell expansion which affected fruit size (Ruiz, 2006). These results are also affirmed by Jagtap *et al.* (2013) in acid lime cv. Kagzi lime, Gurjar and Rana (2014) in Kinnow mandarin, Venu *et al.* (2014) in acid lime cv. Kagzi lime, El-Din *et al.* (2017) in Washington navel orange, Singh *et al.* (2018) in Kinnow mandarin and Singh and Kaur (2018) in Baramasi lemon.

Chlorophyll Content : Amongst alone treatments T₃ (KNO₃ @ 2%) was noted maximum chlorophyll content in leaves (66.52) followed by 65.89 chlorophyll content in leaves in T₂. Under combined treatments T₁₅ (KNO₃ @ 2% + GA₃ @ 75 ppm + ZnSO₄ @ 0.6%) was noted maximum chlorophyll content in leaves (70.51), followed by 69.36 in T₁₄. Whereas, minimum values of chlorophyll content in leaves was noted in control. The chlorophyll SPAD value increased to its maximum with potassium nitrate application. N content was maximum in treatment potassium nitrate. They found that increasing in vegetative growth, net photosynthetic rate, NPK content and chlorophyll content were associated with increasing of K levels. Potassium affects respiration, photosynthesis, leaf NPK content, chlorophyll development, water content of leaves, carbon dioxide (CO₂) assimilation and carbon movement (Sangakkara *et al.*, 2000).

References

- Agustí, M., Fuentes, A.M. and Mesejo, C. (2002.) Citrus fruit quality: Physiological basis techniques of improvement. *Agrociencia* 2: 1–16.
- Alloway, B.J. (2008). Zinc in soils and crop nutrition. *International Zinc Association Brussel*, Belgium.
- Bhosale, S.S., Patil, D.R.V., Palghadmal, S.M., Pujari, D.C.V. and Patil, D.S.D. (2018). Studies on foliar application of plant growth regulators and chemicals on yield & quality of pomegranate cv. Phule Bhagwa Super. *Int. J. Chem. Stud.* 6(5): 613-616.
- Deshmukh, H.K., Nimbolkar, P.K., Paithankar, D.H. and Dewangan, R.K. (2015). Effect of plant growth regulators and micronutrients on growth and yield of acid lime (*Citrus aurantifolia* Swingle) in hasta bahar. *Int. J. Agric. Envir. Biotech.* 8(3): 615-620.
- El-Din, K.A., Omar and El-Enin, M.S.A. (2017). Foliar spray with different agrochemicals on fruit quality and exportability of 'Washington' navel orange fruit (*Citrus sinensis* L.). *Int. J. Fruit Sci.* Pp: 01-16.
- Gurjar, M.K., Kaushik, R.A. and Baraily, P. (2015). Effect of zinc and boron on the growth and yield of Kinnow mandarin. *Int. J. Sci. Res.* 4(4): 207- 208.
- Gurjar, P.S. and Rana G.S. (2014). Influence of foliar application of nutrients and growth regulator on fruit drop, yield and fruit size and quality in Kinnow mandarin. *Indian J. Horti.* 71(1): 109-111.
- Gurung, S., Mahato, S.K., Suresh, C.P. and Chettri, B. (2016). Impact of foliar application of growth regulators and micronutrients on the performance of Darjeeling mandarin. *American J. Exper. Agric.* 12(4): 1-7.
- Jagtap, V.M., Patel, H.C., Nehete, D.S. and Godage, S.S. (2013 a). Effect of foliar application of plant growth regulators and micronutrients on yield and quality of acid lime cv. Kagzi (*Citrus aurantifolia* Swingle). *Asian J. Horti.* 8(1): 57-59.
- Kadam, A.B., Singh, D.B. and Kade, R.A. (2010). Effect of plant growth regulators and potassium nitrate on growth of seedling of Kagzi lime. *Asian J. Horti.* 5(2): 431-434.
- Kaya, M., Atak, K., Mahmood, C., Ciftci, Y. and Ozcan, S. (2005). Effects of pre-sowing seed treatment with zn and foliar spray of humic acids on yield of common bean (*Phaseolus vulgaris* L.). *Int. J. Agric. Bio.* 10: 56-65.
- Khattab, Magda M., Shaban, Ayman E., El-Shrief, A.H. and Mohamed, A.S.E. (2011). Growth and productivity of pomegranate trees under different irrigation levels I: vegetative growth and fruiting. *J. Horti. Sci. Ornament. Pl.* 3(2): 194-198.
- Knoche, M., Lownds, N.K. and Bukovac, M.J. (2000). Spray application factors and plant growth regulator performance: IV. Dose response relationships. *J. American Soc. Horti. Sci.* 125(2): 195-199.
- Krishnamoorthy, H.N. (1993). Physiology of plant growth and development. Atma Ram and Sons Publishers.
- Madarakhandi, S., Patil, D.R.; Madawal, S.I. and Sridhar (2015). Effect of chemicals and growth regulators on Kinnow mandarin. *Environ. Ecol.* 33(4A): 1693 -1697.
- Mengel, K. and Kirkby, E.A. (1987). Principle of plant nutrition. 4th Ed. *International Potash Institute*, Bern, Switzerland.
- Neware, S., Yadav, I. and Meena, B. (2017). Effect of plant growth regulators and micronutrients on growth and yield of sweet orange (*Citrus sinensis* L. Osbeck) cv. Mosambi. *Chem. Sci. Rev. Lett.* 6(21): 213-218.
- Panwar, P.S., Bhise, P.B. and Dalal, N.R. (2016 a). Effect of plant growth regulators and chemicals on acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sarbati. *BIOINFOLET.* 13(4): 606-609.
- Rai, O., Patil, S.N., Patil, D.R., Venkatshalu, Awati M. and Kiran K.C. (2018). Effect of plant growth regulators and chemical on vegetative and reproductive parameters during hasta bahar in acid lime (*Citrus aurantifolia* Swingle). *Int. J. Curr. Microbiol. App. Sci.* 7(9): 2640-2650.
- Ranganna, G., Venkataramana, K.T., Mukundalakshmi, L., Swarajyalakshmi, K. and Sudhakar, P. (2017 b). Effect of plant growth regulators on fruit set and yield of summer

- crop in acid lime (*Citrus aurantifolia* Swingle) cv. Balaji. *Int. J. Curr. Microbiol. App. Sci.* 6(6): 2208-2214.
21. Ruiz, R. (2006). Effects of different potassium fertilizers on yield, fruit quality and nutritional status of "Fairlane" nectarine trees and on soil fertility. *Acta. Horti.* 721:185-190.
 22. Sharma, A., Prasad, D., Chaurasiya, R., Goyal, G., Bhadauria, A.S., Tiwari, S., Singh, A.P. and yadav, A. (2019). Influence of foliar application of zinc, calcium and GA₃ on fruit drop, yield and quality attributes of aonla cv. NA-7. *Int. J. Curr. Microbiol. App. Sci.* 8: 135-146.
 23. Singh, J. and Kaur. A. (2018). Influence of foliar sprays on yield and quality of baramasi lemon. *Int. J. Adv. Res.* 6(6): 293-298.
 24. Singh, P., Kachwaya, D.S., Singh, M.C., Singh, S. and Singh, A. (2018). Impact of foliar application of growth regulators and micronutrients on fruit yield and quality of Kinnow. *Int. J. Chem. Stud.* 6(6): 2545-2549.
 25. Singh, V.K., Tyagi, P.K., Singh, S.K. and Singh, A.K. (2011). Effect of zinc and GA₃ on fruit yield of Kagzi lime (*Cirtus aurantifolia* Swingle). *New Agriculturist.* 22 (1): 103 -104.
 26. Stout, P.R. (1962). Introduction to the micronutrient elements. *J. Agric. Food Chem.* 10: 170-175.
 27. Venu, A., Delvadia, D.V., Sharma, L.K., Gardwal, P.C. and Makhmale, S. (2014). Effect of micronutrient application on flowering, fruiting and yield of acid lime (*Citrus aurantifolia* Swingle.)" cv. Kagzi lime. *Int. J. Trop. Agric.* 32(3-4): 331-334.
 28. Wasfy, E.H. (1995). Growth regulators and flowering. *Academic Bookshop, Egypt*, pp. 560 – 580 (In Arabic).
 29. Westwood, M.N., Reimer, F.C. and Quacken, B. (1963). Long term yield as related to ultimate tree size for three pear varieties grown on rootstocks of five pear species. *Proc. Amer. Soc. Hort. Sci.* 82: 103-113.



Guni Cultivation of Finger Millet : An Indigenous Practice for Sustained Productivity and Scientific Evaluation

Sukanya T.S., Chaithra C. and Pratima Ningaraddi Morab

Project Coordinating Unit, ICAR-AICRP on Small Millets, GKV, Bangalore-560 065

Email : tssukanya@gmail.com, sukanyats2002@gmail.com

Abstract

An experiment was conducted at All India Coordinated Research Project on Small Millets, Bengaluru during *Kharif* 2020. The experiment was laid out in Factorial Randomized Complete Block Design with eighteen treatment combination comprising three spacing levels (30cmX10cm, 30cmX30cm, S3:45cm x 45cm), two planking (no planking, planking at 20 and 40 days after planting) and three levels of Farm yard manure (7.5 t/ha, 10 t/ha, 12.5 t/ha). Results showed that plant growth parameters viz., plant height (108 cm), number of productive tillers per plant (7.87), number of fingers per ear head (8.93), ear length (13.00) and yield parameters viz., grain yield (2993 kg/ha), straw yield (2901 kg/ha) and harvest index (43.41%) were found significantly higher in treatment receiving the spacing of 30 cm x 30 cm, planking at 20 and 40 days after planting and farm yard manure at 12.5 t/ha when compared to other treatment combinations. Further, the results obtained were also found economically superior i.e., gross returns (Rs.94280 /ha), net returns (Rs.60212/ha) and B:C ratio (2.77).

Key words : Spacing, planking, FYM, growth, yield.

Introduction

Finger millet is a vastly nutritious cereal crop which can be grown throughout India, specially in the southwest monsoon season, and in summer under irrigated situations. Finger millet has superior nutritional value compared to major cereals like rice and wheat because of higher source of calcium and iron among cereals in addition to calories. Finger millet-nutri cereal is better adopted to both low rainfall and high rainfall conditions and has higher genetic variability to suit vagaries of climate. In India, area of finger millet is about of 11.94 lakh hectares with an annual average production of 19.85 lakh tons and the productivity of 1662 kg ha⁻¹. Karnataka is the leading state of India in the production finger millet by covering an area of 7.78 lakh hectares and production of 12.86 lakh tons accounting 58 per cent of its global production and productivity of 1653 kg ha⁻¹. It ranks 3rd in the area (58 %) and production (44.9 %) after rice and sorghum in Karnataka (1).

Farmers have continuously practicing need-based and location specific cultivation practices on their farms to satisfy the diverse need of their family. Among them, guni method of finger millet cultivation is one of the good examples. This guni method is square planting which is found as a traditional agronomic practice followed in few pockets of finger millet grown areas of Karnataka state for enhancement of yield than conventional method (Line sowing). Guni method of planting is nothing but the system of Ragi (Finger millet) intensification or SRGI where in, finger millet is cultivated by applying the cultivation practices and principles adopted in SRI

(System of Rice Intensification) in order to get higher productivity.

In guni method, young seedlings of about 19-21 days old are transplanted (two in each guni). An ox-drawn wooden implement (planking) is passed over the seedlings at 20 and 40 days after transplanting in different directions. This practice is largely seen in few patches of Karnataka specially in Kolar, Haveri, Shimoga and Dharwad districts where farmers grow finger millet in square planting from 22.5 cm to 60 cm apart with an intension of easy field operations, more tillers and for enhanced production of grain and straw. By going for this operation, upward growing stems are bent over the ground, where root and shoot meet and where the plants meristematic tissue which produces new tillers. Passing a wooden plank across the cropped area during initial period of plant growth (third to sixth week) also stimulates to produce higher number of tillers and also adventitious root system which enables the panicles to be larger and better grains filling, size and quality of the ear heads also improved due to steady and continuous available of nutrients and moisture. To explore the potential of crop for better yield and also to know the advantages of guni system, a scientific study was conducted at AICRP on Small Millets, Bangalore.

Materials and Methods

The field experiment was conducted during *kharif* 2020 to study the "Guni cultivation of Finger millet – An Indigenous practice for sustained productivity" at AICRP on Small millets, ZARS, UAS, GKV, Bengaluru. The farm is

Table-1 : Growth and yield parameters as influenced by planting geometry, planking and manure requirement under Guni cultivation of finger millet.

Treatment details	Plant height (cm) at harvest	No. of productive tillers/ plant	No. of fingers per ear head	Ear length (cm)	Days to 50 % flowering	Days to physiological maturity
S ₁ P ₁ F ₁	95	3.17	7.67	9.90	58	120
F ₂	101	3.60	7.87	10.30	59	121
F ₃	102	4.80	8.17	12.13	59	121
P ₂ F ₁	100	3.23	8.13	10.87	58	121
F ₂	97	3.73	7.87	11.80	58	121
F ₃	101	4.63	7.23	12.43	58	122
S ₂ P ₁ F ₁	95	5.00	8.00	10.97	58	124
F ₂	97	5.37	8.27	11.10	58	125
F ₃	105	6.07	8.37	12.13	58	125
P ₂ F ₁	102	5.20	8.23	11.10	58	125
F ₂	101	5.47	8.10	12.77	58	125
F ₃	108	7.87	8.93	13.00	58	126
S ₃ P ₁ F ₁	95	6.87	7.43	9.40	58	127
F ₂	98	6.43	7.67	10.67	60	128
F ₃	102	6.93	8.20	11.47	58	128
P ₂ F ₁	94	6.53	7.20	10.10	58	128
F ₂	94	6.57	7.27	11.57	58	129
F ₃	102	6.87	7.67	12.57	58	129
SEm±	1.29	0.59	0.43	0.98	0.72	1.47
C.D. (5%)	3.74	1.72	NS	2.9	NS	NS
S ₁ : 30cm 10cm	99	3.86	7.82	11.24	58	121
S ₂ : 30cm 30cm	101	5.83	8.32	11.84	58	125
S ₃ : 45cm 45cm	97	6.70	7.57	10.96	59	128
SEm±	1.42	0.44	0.36	0.42	0.26	1.61
C.D. (5%)	NS	1.28	NS	NS	0.78	4.63
P ₁ : No planking	99	5.36	7.85	10.90	58	124
P ₂ : 20 and 40 Days after transplanting	100	5.57	7.96	11.80	58	125
SEm±	1.08	0.09	0.23	0.35	0.22	0.32
C.D. (5%)	NS	NS	NS	NS	0.64	0.94
F ₁ : 7.5 t/ha	97	5.00	7.78	10.39	58	124
F ₂ : 10 t/ha	98	5.19	7.84	11.37	59	125
F ₃ : 12.5 t/ha	103	6.19	8.09	12.29	58	125
SEm±	1.06	0.36	0.10	0.38	1.24	1.32
C.D. (5%)	2.90	1.05	0.28	0.94	NS	NS

Spacing- S₁: 30 cm x 10 cm, S₂: 30 cm x 30 cm, S₃: 45 cm x 45 cm

Planking- P₁: No Planking, P₂: Planking at 20 and 40 days after transplanting

FYM-F₁: 7.5 t/ha, F₂: 10 t/ha, F₃: 12.5 t/ha **NS**-Non significant

located between 12° 51' N Latitude and 77° 35' E Longitude at an altitude of 930 m above mean sea level (MSL) which comes under Eastern Dry Zone of Karnataka. The soil of the experimental site was sandy loam with medium soil fertility. Composite soil samples were drawn at random from the experimental site before experimentation and analyzed for physico-chemical properties. The experiment was laid out in a factorial RCBD design with three replications. The experiment consisted of three factors; spacing (S₁: 30cm x 10cm, S₂: 30cm x 30cm S₃: 45cm x 45cm), planking (P₁: Without

planking, P₂: 20 and 40 Days After Planting) and Farm yard manure (F₁: 7.5 t/ha, F₂: 10 t/ha, F₃: 12.5 t/ha) involving 18 treatment combinations.

Plant height was measured from base of the plant to base of panicle at harvest and expressed in cm. Number of productive tillers (ear bearing tillers) per hill was counted for five randomly selected plants and the mean was calculated and expressed as number of productive tillers per hill. Number of fingers per ear head was counted in the entire five randomly selected hill and the mean was computed. Grains from the net plot were

Table-2 : Yield and Yield parameters influenced by planting geometry planking and manure requirement under Guni cultivation of finger millet.

Treatment details	1000 seed weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
S ₁ P ₁ F ₁	2.93	1372	3506	33.08
F ₂	2.87	1545	3328	34.47
F ₃	3.07	1705	3852	34.35
P ₂ F ₁	2.97	1476	3877	32.26
F ₂	2.80	1552	3725	31.77
F ₃	3.03	1997	3980	35.88
S ₂ P ₁ F ₁	3.13	2267	3254	41.06
F ₂	3.07	2356	3600	39.56
F ₃	2.97	2640	3358	42.02
P ₂ F ₁	3.00	2356	3210	42.33
F ₂	3.07	2390	3642	39.63
F ₃	2.93	2993	3901	43.41
S ₃ P ₁ F ₁	2.93	2373	2775	40.36
F ₂	2.97	2025	2938	37.83
F ₃	2.97	2156	3259	35.89
P ₂ F ₁	2.97	2074	3099	34.85
F ₂	3.03	2311	3333	38.28
F ₃	3.07	2420	3568	37.81
SEm±	NS	77.53	106.22	0.97
C.D. (5%)	0.24	224	30	2.80
S ₁ : 30cm x 10cm	2.94	1608	3711	37.50
S ₂ : 30cm x 30cm	3.03	2500	3494	41.71
S ₃ : 45cm x 45cm	2.99	2227	3162	33.71
SEm±	0.03	71.34	79.65	1.15
C.D. (5%)	0.10	208	232	3.23
P ₁ : No planking	2.99	2049	3319	37.38
P ₂ : 20 and 40 Days After Planting	2.99	2174	3593	37.70
SEm±	0.02	47.96	80.68	0.17
C.D. (5%)	NS	142	NS	NS
F ₁ : 7.5 t/ha	2.99	1986	3287	37.67
F ₂ : 10 t/ha	2.97	2030	3428	37.19
F ₃ : 12.5 t/ha	3.01	2319	3653	38.83
SEm±	0.03	74.46	92.60	0.42
C.D. (5%)	NS	216	223	1.20

Spacing- S₁: 30 cm x 10 cm, S₂: 30 cm x 30 cm, S₃: 45 cm x 45 cm

Planking- P₁: No Planking, P₂: Planking at 20 and 40 days after transplanting

FYM-F₁: 7.5 t/ha, F₂: 10 t/ha, F₃: 12.5 t/ha **NS**-Non-significant

randomly counted and 1000 seed weight is expressed as 1000 seed weight in grams. Harvested seeds from the net plot were dried and weighed. The grain yield per hectare was computed based on grain weight from the net plot, and expressed in kilogram per hectare. Plant dry matter from the net plot was collected, after sun drying for 8-10 days. Straw yield was computed and expressed in kg ha⁻¹. Harvest index of the crop was obtained by using the formula given by Donald (2) where, economic yield (kg ha⁻¹) was divided by biological yield (kg ha⁻¹).

Based on the prevalent market price, gross return was computed. Net returns were worked out by

subtracting the total cost of cultivation from gross return. The benefit cost ratio was calculated by using the formula Gross returns (Rs. ha⁻¹) divided by cost of cultivation (Rs. ha⁻¹). The data collected from the experimental field was analyzed statistically (3). The level of significance used in 'F' and 't' test was P=0.05. Critical differences were calculated wherever 'F' test was significant.

Results and Discussion

Spacing : Among different planting geometry, significantly higher number of productive tillers, days to 50% flowering, days to physiological maturity, 1000 seed weight which all cumulated to the highest grain yield (2500

Table-3 : Economics as influenced by planting geometry, planking and manure requirement under Guni cultivation of finger millet.

Treatment details	Gross return (Rs)	Net return (Rs)	B:C Ratio	Cost of cultivation (Rs. /ha)
S ₁ P ₁ F ₁	43218	21876	2.03	21342
F ₂	48678	24836	2.04	23842
F ₃	53708	27366	2.04	26342
P ₂ F ₁	46494	23952	2.06	22542
F ₂	48888	23846	1.95	25042
F ₃	62906	35364	2.28	27542
S ₂ P ₁ F ₁	71411	43543	2.56	27868
F ₂	74214	43846	2.44	30368
F ₃	83170	50302	2.53	32868
P ₂ F ₁	74214	45146	2.55	29068
F ₂	75295	43727	2.39	31568
F ₃	94280	60212	2.77	34068
S ₃ P ₁ F ₁	74750	49056	2.91	25694
F ₂	63798	35604	2.26	28194
F ₃	67914	37220	2.21	30694
P ₂ F ₁	65331	38437	2.43	26894
F ₂	72786	43392	2.48	29394
F ₃	76230	44336	2.39	31894
S ₁ : 30cm x 10cm	50648	26206	2.07	24442
S ₂ : 30cm x 30cm	78764	47796	2.54	30968
S ₃ : 45cm x 45cm	70135	41341	2.45	28794
P ₁ : No planking	64540	37072	2.34	27468
P ₂ : 20 and 40 Days after transplanting	68492	39824	2.37	28668
F ₁ : 7.5 t/ha	62570	37002	2.37	25303
F ₂ : 10 t/ha	63943	35875	2.26	27803
F ₃ : 12.5 t/ha	73034	42466	2.42	30303

Spacing- S₁: 30 cm x 10 cm, S₂: 30 cm x 30 cm, S₃: 45 cm x 45 cm

Planking- P₁: No Planking, P₂: Planking at 20 and 40 days after transplanting

FYM-F₁: 7.5 t/ha, F₂: 10 t/ha, F₃: 12.5 t/ha

kg/ha) at spacing i.e., 30 cm x 30 cm which was found significantly higher than yield obtained at regular spacing 30 cm x 10 cm (1608 kg/ha) and at the wider spacing 45 cm x 45 cm (2227 kg/ha). However, straw yield obtained at 30 cm x 10 cm (3711 kg/ha) was found significantly higher than 30 cm x 30 cm (3494 kg/ha) and 45 cm x 45 cm (3162 kg/ha). The results obtained were again confirmed with having higher gross return (Rs.78764/ha), net return (Rs.47796/ha) and B:C ratio (2.54). Due to optimum spacing between the individual plants resulted in the development of massive and healthy root which in turn resulted in healthy plant growth with more productive tillers. Similar findings were also reported previously by researchers (6,7).

Planking : Though crop with planking did not show significant result for plant height, number of productive tillers, number of fingers per ear head, ear length but was found with significant response for days to 50% flowering, days to maturity, 1000 seed weight as compared to treatment which has not received planking at 20 and 40

days after planting. Planking operation has resulted in realizing significantly higher grain yield (2174 kg/ha) than without planking treatment (2049 kg/ha) but showed numerically higher values of straw yield. The economic attributes also proved that the planking operation in guni method of ragi cultivation is the feasible practice for enhanced productivity of the crop. Similar findings was also reported by earlier worker (5).

Farmyard Manure : The results indicated that the response of crop to different quantity of Farmyard manure (FYM) under guni method varied significantly among the treatments imposed. The crop yielded significantly higher (2319 kg/ha) at 12.5 t/ha as compared to FYM@10 and 7.5 t/ha. The response of crop under lesser quantity of FYM @ 7.5 t/ha has resulted in significantly lower yield (1986 kg/ha) when compared to yield obtained at higher manure levels. Higher economics i.e., gross return, net return and B: C ratio also showed higher values which are statistically superior at higher quantity of FYM @ 12.5 t/ha and the next best was found at FYM @ 10 t/ha. Due to

application of higher rate of farm yard manure resulted in improved physico-chemical and biological properties of soil which intern results in the higher uptake and utilization of applied nutrient (4,8,9).

Interaction : Among different treatment combinations, treatment with 30cm x 30cm, planking at 20 and 40 days after planting and farm yard manure @ 12.5 t/ha recorded higher plant height (108cm), no. of productive tillers/plant (7.87), no. of fingers per ear head (8.93), ear length (13cm), significantly higher grain yield (2993 kg/ha), straw yield (3901 kg/ha), harvest index (43.41%), higher gross return (94280 Rs./ha), higher net return (60212 Rs./ha) as compared to other treatment combinations confirming the beneficial effect of crop at optimum spacing of 30 cm x 30 cm coupled with planking operation at higher level of FYM.

Conclusion

The treatment combination i.e., 30cm x 30cm spacing coupled with planking at 20 and 40 days after transplanting and application of 12.5 t FYM /ha enhanced the productivity of Finger millet under Guni method cultivation and the technology also emerged as the cost-effective technology for sustainable production.

Acknowledgements

The authors are thankful to the Indian Council of Agricultural Research, New Delhi and ICAR-IIMR, Hyderabad for providing financial support to carry out the research.

References

1. Anonymous (2017). Annual Report, All India Coordinated Research Project for Small Millets, *University of Agricultural Science*, Bengaluru, Karnataka, India.
2. Donald C.N. (1962). In search of yield. *J. Aust. Inst. Agric. Sci.* 28: 1971-1978.
3. Gomez K.A. and Gomez A.A. (1984). Statistical Procedures for Agric. Res. 2nd Ed. *John Wiley & Sons, Inc.* New York.
4. Kalaraju K. (2007). Response of finger millet genotypes to methods of planting under organic farming. *M.Sc. (Agri.) Thesis, University of Agricultural Sciences.*, Bengaluru, Karnataka.
5. Mallikarjun Hosapalya (2005). Netti Ragi- An introduction to farmers method of ragi cultivation, *Dhanya Pub.* Sadashivanagar, Tumkur, Karnataka.
6. Narasimhamurthy and Hegde, B.R. (1981). Tillering in relation to intra-row competition in ragi under rainfed conditions. *Indian J. Agron.*, 26(3): 337-338
7. Prakasha G., Kalyana Murthy K.N., Prathima A.S. and Rohani N. Meti (2018). Effect of spacing and nutrient levels on growth attributes and yield of finger millet (*Eleusine coracana* G.) cultivated under Guni planting method in red sandy loamy soil of Karnataka. India. *Int. J. Curr. Microbiol. App. Sci.*, 7(5): 1337-1343.
8. Prashanth D.V., Krishnamurthy R. Naveen D.V. Anand Kumar L., Harsha B.R. and Savitha M. (2018). Long term effect of integrated nutrient management on growth and yield of finger millet (*Eleusine coracana* G.) in eastern dry zone of Karnataka, India. *Int. J. Curr. Microbiol. App. Sci.* 8(8): 2362-2367.
9. Sweta Shikta Mahapatra (2017). Nutrient management through organics for sustained productivity of finger millet (*Eleusine coracana* G.). *M.Sc. (Agri.) Thesis, University of Agricultural Sciences*, Bengaluru, Karnataka.



Effect of GA₃ With and Without Boron on Fruiting, Yield, Quality of Guava (*Psidium guajava* L.) cv. Sardar

Ankit Verma, J.P. Singh, Swatantra Yadav and Siddhartha Gautam

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur, Uttar Pradesh

Email : ankit.verma.9515@gmail.com

Abstract

A field study was conducted at Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during 2020- 21 to study the response of GA₃ with and without Boron on fruiting, yield, quality of Guava (*Psidium guajava* L.) cv. Sardar. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice in the month of June, 2020. The results clearly indicated that the use of GA₃ with and without Boron had significant effect on the fruiting, yield and quality of guava. Maximum number of flower (48.89), fruit set (63.41%), fruit retention (63.69%), fruit length (6.89 cm), width of fruits (6.75cm), fruit weight (144.98g), yield (53.40kg/tree), TSS content (13.22° Brix), ascorbic acid (184.17 mg/100g pulp) and minimum fruit drop (36.31%) and acidity content (0.480%) were recorded in sprays of GA₃ 30 ppm + boron 0.2%. The control exhibited minimum values in this regard.

Key words : GA₃, boron, quality, yield, guava.

Introduction

Guava (*Psidium guajava* L.) is one of the most common fruit of India and belongs to the family Myrtaceae. It is native to Mexico, Central America, Northern South America and gradually became a crop of commercial importance. Guava trees are hardy, prolific bearer, long lived, drought tolerant and one of the most delicious and popular fruit in tropical and subtropical region of the country that is why it is also called “The Apple of subtropics”. Rather than, the guava fruit is an excellent source of vitamin C (90–350 mg/100 g). Apart from vitamin C, it is also a rich source of minerals like calcium, phosphorus, iron. In processing sector to develop products of high quality, it is imperative to use fruits enriched in physico-chemical attributes. Spraying of Boron and plant growth regulator like GA₃ has various effect on Guava fruit with respect to its growth, yield, quality like TSS, acidity, ascorbic acid, specific gravity, reducing sugar and also shelf-life in guava. Thus, in this experiment an attempt has been made to assess the response of fruiting, yield and quality of Guava (*Psidium guajava* L.) cv. Sardar to spray of GA₃ with and without Boron.

Materials and Methods

The present investigation was carried out at guava orchard of Horticulture garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) India, during the year 2020-2021. The experiment was laid out in Randomized Block Design with three replications and ten treatments

viz., T₁- GA₃ (10ppm), T₂- GA₃ (20ppm), T₃- GA₃ (30ppm), T₄-GA₃ (40ppm), T₅-Boron (0.2%), T₆- GA₃ (10ppm) + Boron (0.2%), T₇-GA₃ (20ppm) + Boron (0.2%), T₈-GA₃ (30ppm) + Boron (0.2%), T₉-GA₃ (40ppm) + Boron (0.2%) and T₁₀- Control (Distilled Water). Nutrient application and other orchard management practices were followed as per recommended package and practices for guava viz., FYM-30kg/plant, N- 500g/plant, P- 350g/plant, K- 250g/plant.

Number of flowers per shoot was calculated by count method from selected branches in each direction and in each treatment and their average was expressed as number of flower per shoot. Fruit set percentage was calculated as number of fruits set, divided by number of flowers and multiplied by hundred. Fruit retention was computed as number of fruit retained till maturity, divided by number of fruit set. The fruits were weighed and volume of fruits was determined by water displacement method whereas fruit size was recorded by measuring length and diameter of fruits with the help of vernier calipers. The weight of fruits was recorded at every harvesting under each treatment and total yield per plant was calculated at the final harvesting. The TSS of pulp was determined with the help of Erma Hand Refractometer. However, the rest quality parameters such as ascorbic acid and acidity content were analyzed by using standard methods (A.O.A.C. 1990).

Results and Discussion

Gibberellin has been mainly used for manipulating many physiological events and is commercially used to improve the quality of fruits in crops like, grapes, citrus, litchi,

Table-1 : Effect of foliar application of GA₃ with and without boron on reproductive and physical characters of guava cv. Sardar.

Treatments	Number of flowers per shoot	Fruits set (%)	Fruit drop (%)	Fruit retention (%)	Fruit length (cm)	Fruit width (cm)
GA ₃ 10ppm (T ₁)	44.10	54.84	45.48	54.52	6.26	6.13
GA ₃ 20ppm (T ₂)	45.33	56.48	42.12	57.88	6.53	6.44
GA ₃ 30ppm (T ₃)	47.61	58.39	39.56	60.44	6.71	6.64
GA ₃ 40ppm (T ₄)	47.48	58.13	40.03	59.97	6.65	6.57
Boron 0.2% (T ₅)	45.13	55.73	43.24	56.76	6.18	6.09
GA ₃ 10ppm + Boron 0.2% (T ₆)	46.61	56.11	43.19	56.81	6.41	6.17
GA ₃ 20ppm + Boron 0.2% (T ₇)	47.24	58.33	40.12	59.88	6.61	6.52
GA ₃ 30ppm + Boron 0.2% (T ₈)	48.89	63.41	36.31	63.69	6.89	6.75
GA ₃ 40ppm + Boron 0.2% (T ₉)	48.51	62.88	37.09	62.91	6.83	6.68
Control water spray (T ₁₀)	42.23	53.41	60.12	39.88	5.61	5.53
S.E. (m) ±	1.032	1.54	1.29	1.80	0.309	0.143
C.D. at 5%	2.17	3.25	2.71	3.79	0.65	0.30

Table-2 : Effect of foliar application of GA₃ with and without boron on fruit weight, yield and Chemical characters of guava cv. Sardar.

Treatments	Fruit weight (g)	Yield (kg/tree)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100 gm pulp)
GA ₃ 10ppm (T ₁)	121.57	38.52	11.17	0.524	166.35
GA ₃ 20ppm (T ₂)	124.41	41.80	11.63	0.513	172.32
GA ₃ 30ppm (T ₃)	129.30	48.92	12.08	0.482	178.71
GA ₃ 40ppm (T ₄)	128.87	47.83	11.93	0.491	176.89
Boron 0.2% (T ₅)	124.63	37.61	11.25	0.556	170.55
GA ₃ 10ppm + Boron 0.2% (T ₆)	123.48	40.44	11.38	0.520	169.88
GA ₃ 20ppm + Boron 0.2% (T ₇)	129.21	46.39	11.77	0.518	174.31
GA ₃ 30ppm + Boron 0.2% (T ₈)	144.98	53.40	13.22	0.480	184.17
GA ₃ 40ppm + Boron 0.2% (T ₉)	144.21	52.86	12.96	0.487	182.37
Control water spray (T ₁₀)	118.26	35.28	10.03	0.710	151.55
S.E. (m)±	2.838	2.065	0.302	0.025	5.161
C.D. at 5%	5.97	4.34	0.63	0.06	10.85

apples etc. In grape it has manipulated three physiological events *i.e.*, rachis cell elongation, flower thinning and berry enlargement (Menzel 1984). Boron deficiency induced a decrease in the amount of Ca associated with pectin constituents. Most of boron in pectin fraction obtained by pectinase treatment was found in free form, suggesting that boron plays an important role in Ca metabolism in cell wall (Yamaguchi *et al.*, 1986). In spite of this boron also enhance yield and quality attributes of horticultural crops.

Reproductive parameters : In present investigation number of flowers per shoot influenced significantly with different treatments as compared to control. Significantly maximum (48.89) number of flowers per shoot were recorded under the treatment of GA₃ 30 ppm + boron 0.2% followed by treatment of GA₃ 40 ppm + boron 0.2% recording 48.51 flowers per shoot. The minimum number of flowers per shoot was revealed under untreated plant *i.e.*, control (42.23) (Table-1). The application of plant growth regulator GA₃ coupled with boron when providing

in right amount during the investigation causing enhancement of vegetative growth of the plants and GA₃ hastening the production of more photosynthates which helps greater amount of food materials translocation towards the fruit bearing area which contributed positively in enhancement of number of flower per panicle as well as boron also induced nutritional status of fruit crops which might be helpful in maximum flowers production. These findings are in line with the reports of Ali *et al.*, (2014) in olive, Lal *et al.*, (2013) in guava, Kumar and Tripathi (2009) in strawberry and Tiwari *et al.*, (2017) in aonla. Fruit set percent in guava significantly and consistently maximized (63.41%) with the sprays of combined treatment GA₃ 30ppm + boron 0.2% followed by GA₃ 40ppm + boron 0.2% exhibited 62.88% whereas minimum percent of fruit set was recorded under control (53.41%) (Table-1). Foliar application of boron might be have helpful in maintaining better nutritional status of guava plant which ultimately grouped in enhancing attitude of higher number of fruit setting. GA₃ is very helpful in

successful fertilization of the ovule and it accelerated cell division and cell expansion considerably resulting promotion of better fruit set and growth of fruits (Adams *et al.*, 1975).

Application of combined treatment GA₃ 30 ppm + boron 0.2% exhibited lesser fruit drop recorded 36.31% closely followed by treatment of GA₃ 40ppm + boron 0.2% (37.09%). The plants which were deprived with hormonal treatments *i.e.*, control expressing the maximum of 60.12% fruit drop (Table-1). In present investigation GA₃ sprays possibly increase auxin synthesis which may prevents fruit drop. These findings are in agreement with the reports of Narayan *et al.*, (2013) and Gaur *et al.*, (2014) in guava. Application of various treatments significantly increased the percentage of fruit retention and the treatment of GA₃ 30ppm + boron 0.2% significantly induced (63.69%) fruit retention closely followed by treatment of GA₃ 40ppm + boron 0.2% recorded 62.91% fruit retention in guava fruits. Minimum (39.88%) fruit retention was obtained under the plants which were untreated *i.e.* control (Table-1). It is obviously due to the application of growth regulator GA₃ and micronutrient boron which helped to improve their nutritional status of the treated plants causing better fruits set, fruit development thereby reducing the fruit drop and ultimately fruit retention increased.

Physical parameters : The plants which were treated with GA₃ 30 ppm + boron 0.2% significantly hastened length of fruits registering 6.89cm and second effective treatment was observed GA₃ 40 ppm + boron 0.2% which indicated 6.83 cm fruit length. In this regard untreated plants (control) exhibiting the minimum 5.61 cm length. Combined treatment of GA₃ 30 ppm + boron 0.2% significantly maximized (6.75cm) width of fruits closely followed by GA₃ 40 ppm + boron 0.2% recorded 6.68cm width. Control showed significantly poorest (5.53 cm) width of fruits (Table 1). This increase in size of fruits with the application of Gibberellic acid might be due to significantly increase in cell division and cell elongation. Boron also responded more prominent role in translocation of carbohydrates and auxin synthesis which emphasized to enhancing the size of fruits and fruiting parameters. These findings are in line with the reports of Shukla *et al.*, (2011) in aonla, Dubey *et al.*, (2017), Tripathi and Shukla (2007) in strawberry and Goyal *et al.*, (2020) in guava.

Fruit weight was significantly increased (144.98 g) with the application of combined treatment GA₃ 30 ppm + boron 0.2% closely followed by GA₃ 40 ppm + boron 0.2% revealed 144.21 g fruits weight of guava against the poorest fruits weight was revealed under control (118.26 g) (Table-2). GA₃ enhanced deposition of solids with

increase cell size by increasing the accumulation of water in intracellular space which might be possibly enhanced to fruits weight (Sayed *et al.*, 2004) in Valencia orange.

The plants which were treated with GA₃ 30 ppm + boron 0.2% induced significantly maximum (53.40 kg) fruit yield per plant closely followed by treatment of GA₃ 40 ppm + boron 0.2% recorded 52.86 kg fruits per tree. Untreated plants *i.e.*, control recording significantly lesser (35.28 kg) fruits yield per tree (Table-2). Increase in yield by growth regulator GA₃ associated with higher rate of enzymatic activities as well as involvement of biosynthesis of auxin, increase in number and size of fruits which ultimately enhanced the yield (Mahaveer *et al.*, 2017). Micronutrient boron appeared to have indirect role in increasing progressive process of cell division and cell elongation, due to which fruits size, weight and volume could have improved and in this context yield of fruits per plant was enhanced. These findings are in line with the reports of Lal *et al.*, (2013), Dubey *et al.*, (2017) in strawberry and Goyal *et al.*, (2020) in guava.

Chemical parameters : It is apparent from data showed in finding that the plants which were treated with GA₃ 30ppm + boron 0.2% revealed significantly maximum (13.22° Brix) TSS content in guava fruits closely followed by GA₃ 40 ppm + boron 0.2% (12.96° Brix). Whereas poorest in control (10.03° Brix) (Table-2). Micronutrient boron apart from physical changes effected to chemical changes in fruits which has decreased in total carbohydrates content, formation of single sugar from polysaccharides, decrease in metabolic activity take place during maturity and ripening of fruits. These results are corroborated with the findings of Kaur (2017) in litchi and Sharma and Tiwari (2015) in guava. The acidity content of guava fruits was significantly decreased by influence different treatments. Treatment of GA₃ 30ppm + boron 0.2% significantly minimized (0.480%) acidity content in guava fruits against control registering significantly maximum (0.710%) acidity content in guava fruits. The role of PGR in decreasing acidity of fruits might be either due to conversion of sugar and their derivatives by relation involving reverse glycolytic pathway or growth which may be held responsible for reducing acidity. These findings are in line with the reports of Moradinezhad *et al.*, (2020), Sharma and Tiwari (2015) in guava, Tripathi *et al.*, (2018) in aonla and Tripathi *et al.*, (2019) in mango.

The Ascorbic acid content of guava fruits is significantly affected by variable genotype, nutritional status of plants, soil and environmental condition. In the present investigation coupled treatment of GA₃ 30 ppm + boron 0.2% significantly enhanced (184.17 mg/100g pulp) ascorbic acid in guava fruits closely followed by treatment of GA₃ 40 ppm + boron 0.2% (182.37 mg/100g pulp).

Untreated plants *i.e.*, control showed minimum (151.55 g/100g pulp) ascorbic acid (Table-2). Spraying of boron activate the synthesis of ascorbic acid (Jain *et al.*, 1985). The treatment of GA₃ and boron may have influence the metabolic activities possibly due to these increased endogenous level following external application. These may enhance the process of synthesis, translocation and accumulation of quality constituents like as TSS, sugar and ascorbic acid following a strong source-sink relationship (Shukla *et al.*, 2011).

References

1. A.O.A.C. (1990). Official method of analysis. Association of Official Analytical Chemists 12th ed.), Washington, D.C.
2. Adams, P.A.; Montague, M.J.; Tepfer, M.; Rayle, D.L.; Ikuma, H.; Kaufman, P.B. (1975). Effect of gibberellic acid on the plasticity and elasticity of Avena stem segments. *Plant Physiology*, 56:757-760.
3. Ali, M.; Ahmad, M.; Anjam, N.; Hafeez-ur-Rehman, M.; Kasana, I.; Tariq, S. and Ramzan, A. (2014). Efficacy of Boron & Gibberellic Acid on growth and fruit yield in olive (*Olea europaea* L.) cv. Gemlik. *International Journal of Biology and Biotechnology*, 11(2/3), 295-298.
4. Bisen, S.; Thakur, R.S. and Tembhare, D. (2014). Effect of calcium nitrate and gibberellic acid application on growth, fruit quality and post-harvest behaviour of guava fruit. *The ecoscan*, 6, 55-62.
5. Dubey, Vishal; Meena, M.L. and Tripathi, V.K. (2017). Effect Of Plant Bio-Regulators and Micronutrient on Vegetative Growth, Yield and Quality of Strawberry cv. Chandler. *Progressive Research-An International Journal*, 12 (3): 330-332.
6. Gaur, B.; Hada, T.S.; Karma, B.; Neeharika, K. and Syamal, M.M. (2014). Studies on the effect of foliar application of micronutrients and GA₃ on yield and reproductive parameters of winter season guava. *Trends in Biosciences*, 7(21), 3386-3389.
7. Gaur, B.; Hada, T.S.; Karma, B.; Neeharika, K. and Syamal, M.M. (2014). Studies on the effect of foliar application of micronutrients and GA₃ on yield and reproductive parameters of winter season guava. *Trends in Biosciences*, 7(21), 3386-3389.
8. Goyal, S.; Singh, K.V.; Mandloi, V. and Vishvkarma, D. (2020). Effect of foliar application of boron and GA₃ on morphological and quality parameters of guava (*Psidium guajava* L.) cv. Lalit. *Journal of Pharmacognosy and Phytochemistry*, 9 (1), 655-658.
9. Jain, B.P.; Das, S.R. and Verma S.K. (1985). Effect of growth substances and zinc on the development and quality of litchi fruits. *Indian Journal of Horticulture*, 32: 146-151.
10. Kaur, S. (2017). Effect of micronutrients and plant growth regulators on fruit set, fruit retention, yield and quality attributes in litchi cultivar Dehradun. *Chemical Science Review and Letters*, 6 (22), 982-986.
11. Kumar, Raghu and V.K. Tripathi (2009). Influence of NAA, GA₃ and boric acid on growth, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, 41 (1): 113-115.
12. Lal, N.; Das, R. and Verma, L.R. (2013). Effect of plant growth regulators on flowering and fruit growth of guava (*Psidium guajava* L.) cv. Allahabad. *Journal of Horticulture*, 8 (1), 55.
13. Mahaveer, S.; Pency, D.S.; Meghawal, D.R. and Sahu, O.P. (2017). Effect of plant growth regulators on fruit crops. *Journal of Pharmacognosy and Phytochemistry*, 6 (2):331-337.
14. Moradinezhad, F.; Mohammadian, M. and Khayyat, M. (2020). Influence of GA₃ and boric acid foliar application on bioactive compounds and quality of pomegranate fruit (*Punica granatum* L.). *Journal of Horticulture and Postharvest Research*, 3 (1), 101-114.
15. Munzel, C.M. (1984). The pattern and control of reproductive development in lychee: a review. *Scientia Horticulture*. 22: 333-346.
16. Narayan, L.; Das, R.P. and Verma, L.R. (2013). Effect of plant growth regulators on flowering and fruit growth of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Asian Journal of Horticulture*, 8(1), 54-56.
17. Sayed, R.A.; Solaiman B.M. and Abo-El Komsan, E.O. (2004). Effect of foliar sprays of some mineral nutrients, GA₃ and or bio stimulant on yield and fruit quality of Valencia orange trees grown in sandy soil. *Egypt Journal of Applied Science*, 19 (5):222-238.
18. Sharma, R. and Tiwari, R. (2015). Effect of growth regulator sprays on growth, yield and quality of guava under malwa plateau conditions. *Ann. Plant and Soil Res*, 17 (3): 287-291.
19. Shukla, H. S.; Kumar, V. and Tripathi, V.K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits 'Banarasi'. *Acta Horticulturae*, 890, 375-380.
20. Tiwari, Prakash; Tripathi, V.K. and Singh, A. (2017). Effect of Foliar Application of Plant Bio-Regulators and Micronutrients on Fruit Retention, Yield and Quality Attributes of Aonla. *Progressive Research-An International Journal*, 12 (Special IV): 2565-2568.
21. Tripathi, V.K. and Shukla, P.K. (2010). Influence of Plant Bio-Regulators, Boric Acid and Zinc Sulphate on Yield and Fruit Characters of Strawberry cv. Chandler. *Progressive Horticulture*, 42 (2). 186-188.
22. Tripathi, V.K.; Pandey, S.S.; Kumar, A.K.; Dubey, Vishal and Tiwari, Prakash. (2018). Influence of Foliar Application of Gibberellic Acid, Calcium and Boron on Fruit Drop, Yield and Quality Attributes of Aonla (*Emblia officinalis*) cv. NA7. *Indian Journal of Agricultural Sciences*, 88 (11): 1784-1788.
23. Tripathi, V.K.; Singh, A.; Bhadauria, A.S. and Gupta, S. (2019). Influence of GA₃ and naphthalene acetic acid alone and in combination on fruit drop, yield and quality of mango cv. Amrapali. *Progressive Research-An International Journal*, 14 (1): 10-13.
24. Yamaguchi, S.K.; Jain, B.P. and Das, S.R. (1986). Preliminary studies on the evaluation of the effect of growth substances with miner elements in controlling fruit drops in litchi (*Litchi chinensis* Sonn.). *Haryana Journal of Horticulture Science*, 10 (1-2): 10-12.



Estimation of Combining Ability in Sorghum [*Sorghum bicolor* (L.) Moench]

B.L. Meena^{1*}, P.B. Singh², B.R. Ranwah² and S.P. Das³

¹ICAR-DRMR, Bharatpur Rajasthan-321303, India

²MPUAT, Rajasthan College of Agriculture, Udaipur Rajasthan-313001, India

³ICAR-RC for NEH Region Tripura Centre, Lembucherra

*Corresponding authors Email : blmeena.icar@gmail.com

Abstract

The aim of this study was to evaluate the general combining ability of sorghum lines and the specific combining ability of the hybrids for yield and its related traits. Three fertility restorer lines, ten male-sterile lines, and their hybrids from line x tester mating design crosses were evaluated in RBD with three replications in four environments. There was a significant effect of GCA and SCA for most of the traits evaluated, indicating the participation of additive or dominant genes in inheritance. The restorer line SPV 1822 and five male sterile lines ICSA 29003, ICSA 29004, ICSA 29011, ICSA 29014 and ICSA 29016 show potential for use as parents in sorghum breeding programs. Crosses ICSA 29004 × SPV 1822 and ICSA 29012 × SPV 1822 were identified for multilocation testing.

Key words : *Sorghum bicolor*, parent selection, line x tester, hybrid breeding.

Introduction

Sorghum bicolor (L.) Moench (2n = 20), family poaceae is one of the most important crops in the world because of its adaptation to a wide range of ecological conditions, suitability for low input cultivation and diverse uses (Doggett, 1988). Sorghum occupies fifth position after wheat, rice, maize and barley at world level, both in area and production. The crop is widely grown for food, feed, fodder, forage and fuel in the semi-arid tropics (SAT) of Asia, Africa, America and Australia. It occupies 42.14 m ha area in the world with an annual grain production of 59.34 m tones and productivity of 1408 kg/ha (FAO, 2018). In India, it covers about 4.96 m ha with an annual grain production of 5.80 m tonnes and productivity of 967 kg/ha (FAO, 2018). Sorghum green fodder is one of the cheapest sources of feed for milch, meat and draft animals. Among the cereals, sorghum plays an important role being grain cum fodder crop. Breeding for wide adaption is important aspect in genetic improvement of crop plants.

It is well known that a specific genotype may not exhibit the same performance in all the environments nor all the genotypes respond alike to a specific environment. Such differential response of genotypes to varying environmental conditions reduces the agricultural production. Therefore, knowledge about behavior of genotypes in different environment is essential for their recommendation and their further use in breeding programme. For this, it is desirable to see the impact of various environments on the sorghum genotypes in order to identify the parents and /or crosses for further utilization

in breeding programme. L x T for combining ability is most appropriate mating design for the type of genetic material used in present investigation and information to be derived. Maintenance of plant population in per unit area is very difficult. Buffering ability of the genotypes is the only way to cope up with the available space. Therefore, breeding for buffering ability is another important aspect in genetic improvement of crop plants. Development of such a hybrid/variety, which gives a constant and desirable performance over wide range of spacing, is needed. For this, it is desirable to see the impact of various spacing on the yield of sorghum genotypes and identification of genotypes having buffering ability. The purpose of the present study was to evaluate the general combining ability of elite lines of sorghum and the specific combining ability of the hybrid combinations for yield and yield related components.

Materials and Methods

Lines and hybrids evaluated and experimental design

: The experimental material comprised of 10 male sterile lines viz., ICSA 29003(L₁), ICSA 29004 (L₂), ICSA 29006 (L₃), ICSA 29010 (L₄), ICSA 29011(L₅), ICSA 29012 (L₆), ICSA 29013 (L₇), ICSA 29014 (L₈), ICSA 29015 (L₉) and ICSA 29016 (L₁₀), three restorer testers viz., SPV 245 (T₁), SPV 1430 (T₂) and SPV 1822 (T₃) and three checks viz. CSV 23, CSV 27, and CSH 25. These 10 lines and three testers were crossed in factorial fashion to obtain the 30 hybrids. The crossing programme was attempted at RCA, MPUAT, Udaipur, India during kharif 2014 and at IIMR off season nursery, Warangal, India during rabi 2015.

Table-1: Mean square for different characters in individual environment.

S. No.	Characters	Env	Rep	Genotype	Checks	P Vs Chk	Parents	Tester	Lines	L Vs T	P Vs C	Crosses	Tester	Lines	L X T	Error
			[2]	[45]	[2]	[1]	[12]	[2]	[9]	[1]	[1]	[29]	[2]	[9]	[18]	[90]
1.	Days to 5% flowering	1	26.81	66.02	5.44	32.59	29.17	21.78	29.94	36.98	165.55**	80.04**	270.00**	128.93**	34.48	23.60
		2	47.44**	56.87**	104.11**	3.59	40.73**	2.78	53.66**	0.25	259.47**	52.91**	153.68**	62.04**	37.15**	6.62
		3	24.93*	58.85	0.33	38.94*	3.97	1.44	4.89	0.72	642.40**	58.09**	51.73**	120.94**	27.36**	6.05
		4	12.53	63.23*	37.33*	22.89	87.69**	18.11	100.24**	113.87**	81.51**	53.88**	112.90**	78.85**	34.84**	11.55
2.	Days to maturity	1	3.98	52.30	1.00	48.08**	88.47**	18.11**	111.19**	24.70**	162.24**	38.68**	18.34**	23.07**	48.74**	2.62
		2	2.89	46.51	0.44	42.78**	81.30**	16.33**	102.55**	20.01**	153.39**	33.04**	39.70**	19.44**	39.11**	1.66
		3	0.90	44.15	1.33	45.24**	76.92**	8.78**	97.29**	29.89**	109.86**	32.45**	42.34**	21.36**	36.90**	1.62
		4	1.62	43.18	2.33	43.39**	77.08**	21.78**	95.65**	20.53**	164.41**	29.12**	17.21**	19.38**	35.32**	1.61
3.	Plant height	1	228.38	4664.01**	5502.78**	7116.72**	5575.03**	5875.11**	5262.23**	7790.05**	19602.69**	3829.78**	21578.80**	3368.44**	2088.34**	244.59
		2	367.75	4622.98**	2000.44**	20733.39**	1592.25**	2890.11**	837.29**	5791.12**	34104.20**	4964.34**	37406.34**	4636.55**	1523.57**	199.05
		3	1213.36**	2775.89*	1119.44*	15204.18**	1417.53**	1058.33*	1242.02**	3715.58**	37223.73**	2246.41**	15802.50**	523.61*	1601.57**	244.42
		4	1767.07**	4656.56**	4381.00**	30724.92**	2012.15**	4999.00**	1026.33**	4910.78**	38078.42**	4342.94**	26938.84**	1495.11**	3256.19**	329.84
4.	Green fodder yield	1	1613.83	101741.42**	71415.11**	199062.19**	142641.08**	9216.33*	183051.48**	45796.92**	37.91	86105.58**	126505.54**	91646.25**	78846.36**	2013.91
		2	456.96	72389.61*	5140.11*	404832.18**	53678.03**	26850.33**	23243.63**	381243.08**	72638.53**	75741.33**	404461.48**	68137.56**	43018.75**	1117.98
		3	80.92	22701.12**	29206.33**	59073.85**	13472.35**	3814.78*	25020.87**	137290.83**	17983.43**	19578.89**	72515.88**	22224.17**	12374.36**	1171.12
		4	3483.25	28495.85**	49284.78**	59073.85**	13472.35**	23713.44**	9134.24**	32033.23**	39687.14**	32715.42**	38902.81**	42038.61**	27386.34**	2109.41
5.	Dry fodder yield	1	17.07	9575.48**	14802.78**	22051.62**	6866.19**	5594.00**	7877.41**	329.61	1234.86**	10222.36**	4421.01**	7012.23**	12472.02**	122.78
		2	245.42	19555.94**	7159.11**	51838.78**	17175.53**	3073.78**	8013.19**	127840.09**	17213.42**	20862.36**	131459.38**	12450.87**	12779.55**	323.84
		3	179.01	4576.05	261.44	14135.01**	5163.40**	490.78	5950.70**	7422.91**	5959.24**	4412.35**	9663.68**	2616.82**	4726.63**	278.96
		4	83.96	3219.74**	2989.00**	15079.04**	2492.90**	1026.33**	2926.54**	1523.27**	6878.04**	3179.63**	2049.38**	4888.25**	2450.90**	125.49
6.	Ear head length	1	8.90	15.66*	21.78*	63.95**	8.42	19.44*	6.91	0.02	37.14**	16.70**	9.98	26.92**	12.40**	5.26
		2	0.66	19.43**	44.78**	17.12	16.47**	30.11**	15.24**	0.22	41.91**	18.68**	70.63**	14.70**	14.89**	5.44
		3	3.14	26.87**	55.11**	5.67	32.97**	67.00**	25.00**	36.62**	19.52*	23.56**	5.91	30.30**	22.15**	3.61
		4	30.49**	18.93**	57.33**	6.58	26.77**	34.78**	26.50**	13.14	49.49**	12.63**	45.30**	17.71**	6.46	5.98
7.	Number of primaries per plant	1	1.59	473.69**	421.44**	2029.17**	433.80**	318.78**	502.40**	46.40	25.88	438.36**	211.68**	638.64**	363.41**	23.58
		2	8.67	645.40*	140.78*	6961.59**	883.68**	1312.11**	303.04**	5252.51**	1332.93**	384.48**	392.74**	626.35**	262.62**	34.27
		3	35.66	351.62	81.33	2275.69**	454.97**	204.33*	431.89**	1164.01**	795.69**	268.51**	444.90**	446.97**	159.68**	50.43
		4	9.94	557.37**	388.00**	1878.00**	914.80**	1228.44**	751.74**	1755.12**	2243.90**	354.97**	499.08**	679.39**	176.74**	43.53

Table-1 : Contd....

S.No.	Characters	Env	Rep	Genotype	Checks	P Vs Chk	Parents	Tester	Lines	L Vs T	P Vs C	Crosses	Tester	Lines	L X T	Error
			[2]	[45]	[2]	[1]	[12]	[2]	[9]	[1]	[1]	[29]	[2]	[9]	[18]	[90]
8.	Number of seeds per primary	1	441.42**	3396.21	136.11	222.93	2527.18**	3403.11**	2178.00**	3917.85**	3192.81**	4103.56**	682.98**	4133.01**	4468.90**	73.53
		2	136.36*	690.02*	129.78*	1804.62**	370.76**	86.33	302.85**	1550.78**	237.96**	808.51**	1093.34**	760.00**	801.12**	29.84
		3	58.79	1250.89**	430.78**	1435.00**	740.47**	684.33**	747.14**	792.62**	2494.68**	1503.32**	563.41**	3067.79**	825.52**	62.53
		4	21.96	512.69	30.11	1395.01**	624.29**	17.33	533.02**	2659.57**	411.68*	485.23**	109.43	551.98**	493.61**	66.75
9.	Seed index	1	0.31**	0.20**	0.30**	0.06	0.27**	0.74**	0.18**	0.16**	0.35**	0.17**	0.04	0.19**	0.17**	0.02
		2	0.03*	0.59**	0.13**	4.41**	0.55**	0.83**	0.55**	0.02	0.17**	0.52**	0.89**	0.32**	0.57**	0.01
		3	0.12	0.61**	0.48**	2.67**	0.33**	0.40**	0.35**	0.05	2.28**	0.65**	0.89**	1.04**	0.43**	0.06
		4	0.04**	0.46**	0.33**	1.08**	0.34**	0.60**	0.32**	0.01	2.61**	0.46**	0.43**	0.54**	0.42**	0.01
10.	Harvest index	1	0.30	12.72	0.88	192.53**	6.25	2.89	7.42	2.41	12.70	10.37	32.92	9.73	8.19	11.80
		2	6.05	8.18	7.66	1.58	8.96	3.24	10.16	9.55	0.46	8.40	3.59	5.59	10.35	6.79
		3	21.20	134.33**	90.78**	63.35	121.25**	171.38**	111.56**	108.21*	0.00	149.51**	119.97**	229.20**	112.95**	16.49
		4	22.49	40.41	3.67	52.22**	68.98**	3.74	82.48**	78.01**	25.85	31.86**	74.08**	49.64**	18.28**	7.57
11.	Grain yield	1	74.62**	461.03**	280.44**	1198.72**	457.80**	252.11**	553.64**	6.62	254.61**	464.81**	150.10**	468.08**	498.15**	14.56
		2	106.44**	1274.01**	411.11**	4959.51**	707.15**	187.44**	523.61**	3398.32**	3088.38**	1448.98**	8072.43**	1266.35**	804.36**	19.75
		3	3.62	367.96**	835.44**	1252.12**	223.58**	42.33**	277.20**	103.51**	1520.08**	350.45**	1496.70**	359.36**	218.64**	6.38
		4	2.11	411.15**	53.44**	1532.93**	410.45**	995.44**	65.94**	2341.05**	742.28**	404.81**	339.70**	133.73**	547.59**	4.39
12.	Protein content in grain	1	0.85**	5.12**	3.43**	17.06**	6.91**	0.14	9.09**	0.82*	18.02**	3.95**	0.81**	3.92**	4.32**	0.16
		2	0.01	11.31**	2.78**	6.43**	14.24**	0.87**	15.21**	32.27**	21.34**	10.70**	7.01**	21.36**	5.79**	0.06
		3	0.37	8.42**	4.48**	10.72**	9.75**	2.20**	6.92**	50.36**	6.82**	8.27**	4.29**	11.67**	7.02**	0.31
		4	0.01	9.15**	6.37**	10.46**	14.49**	1.73**	14.98**	35.63**	21.93**	6.92**	0.83**	13.23**	4.44**	0.01
13.	Protein content in fodder	1	0.07	3.68**	1.24**	9.52**	1.59**	0.22**	1.84**	2.04**	1.77**	4.65**	1.51**	1.52**	6.56**	0.02
		2	0.07**	3.40**	1.53**	3.95**	3.03**	0.97**	3.77**	0.49**	5.06**	3.69**	4.74**	4.86**	2.99**	0.01
		3	0.01	3.13**	1.37**	2.84**	2.97**	0.87**	3.65**	0.96**	4.02**	3.35**	4.85**	4.39**	2.67**	0.01
		4	1.60**	3.14**	1.79**	3.88**	2.80**	0.47**	3.45**	1.56**	4.87**	3.37**	4.99**	4.65**	2.55**	0.01

*, ** Significant at 5 and 1 percent level of significance.

Table-2 : GCA and SCA effects for days to 50% flowering, days to maturity, plant height and green fodder yield.

S. No.	Genotype	Days to 50% flowering				Days to maturity				Plant height				Green fodder yield				
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4	Pool	E1	E2	E3	E4
1.	T1	0.00	-0.76	-1.07*	-1.27	-0.26	0.03	0.12	0.12	3.62	-6.66	3.18	-0.14	-9.68**	72.62**	-113.86**	-20.79**	-11.72
2.	T2	-3.00**	-1.79**	-0.40	2.23**	0.88*	1.13**	1.12**	0.69*	-0.70	-1.61	3.57	-1.26	-22.57**	-52.48**	-4.39	-35.36**	-28.69**
3.	T3	3.00**	2.54**	1.47**	-0.97	-0.62	-1.17**	-1.24**	-0.81**	-2.92	8.27	-6.75	1.39	32.25**	-20.14*	118.24**	56.14**	40.41**
4.	L1	3.80*	1.34	4.39**	1.06	0.10	-0.04	-0.37	0.69	-17.92	-6.21	9.78	14.36	-16.72**	176.03**	-64.04**	9.59	93.24**
5.	L2	3.02	2.01*	0.83	-0.17	-1.12	-1.49**	-1.26**	-1.20**	-12.39	31.65*	-4.81	-14.45	0.08	-46.08**	-103.60**	65.59**	82.80**
6.	L3	1.13	2.23*	4.72**	1.28	0.99	1.51**	2.19**	1.13*	23.99	5.59	-12.31	-17.28	5.36	124.14**	65.62**	9.81	-32.76*
7.	L4	-5.98**	-2.32*	-2.72**	-1.17	-0.12	0.40	0.19	0.47	14.86	-30.32*	0.78	14.69	-7.72**	-35.86*	-53.16**	-38.19**	-9.76
8.	L5	1.24	-2.21*	0.28	-0.39	-1.01	-0.71	-1.59**	-1.64**	-0.64	11.29	-11.17	0.52	16.44**	-99.52**	156.07**	46.37**	63.24**
9.	L6	-0.42	-1.88*	-2.83**	2.39*	-0.46	-1.04*	-0.48	0.13	10.16	9.65	2.97	-22.78	6.75*	-114.08**	-36.93**	-110.52**	-55.53**
10.	L7	1.91	-1.88*	-1.94*	-1.61	-1.79**	-1.60**	-1.59**	-1.98**	1.36	-3.04	-1.39	3.08	6.11*	-64.74**	72.29**	21.48	-66.09**
11.	L8	-7.64**	-3.66**	-7.06**	-6.61**	0.10	0.40	0.08	-0.31	-15.76	-6.16	5.61	16.30	-0.89	-53.52**	0.62	27.81*	61.02**
12.	L9	1.80	3.57**	2.50**	4.72**	3.99**	3.18**	3.08**	3.02**	-0.78	-6.52	5.25	2.05	-14.42**	4.81	-103.71**	-25.08*	-88.98**
13.	L10	1.13	2.79**	1.83*	0.50	-0.68	-0.60	-0.26	-0.31	-2.87	-5.93	5.28	3.52	5.00	108.81**	66.84**	-6.86	-47.20**
14.	L1 x T1	-1.00	-1.24	-0.82	-1.29	0.03	-0.92	-0.90	0.54	8.44	-3.51	-3.46	-1.47	-13.93*	-14.73	-3.92	-43.32	-12.94
15.	L2 x T1	1.78	1.42	-2.60	-1.73	-2.41*	-2.48**	-2.34**	-1.90*	-33.51	25.22	-5.29	13.58	5.68	-217.29**	38.63	-74.66**	-61.83
16.	L3 x T1	1.67	0.20	0.51	2.16	2.14	2.19*	2.88**	1.77*	11.61	-20.56	18.71	-9.75	-6.09	-2.18	-144.26**	-53.54*	53.72
17.	L4 x T1	3.78	0.09	-1.04	-0.07	2.59*	1.63	1.88*	1.77*	-1.59	-11.98	13.29	0.28	14.32*	120.82**	18.86	14.46	86.39**
18.	L5 x T1	-2.11	-1.36	-0.38	-2.84	-3.19**	-2.59**	-2.01*	-1.79*	-15.51	-6.34	4.15	17.69	4.57	-27.51	6.63	115.57**	-27.28
19.	L6 x T1	-0.44	-0.69	3.73*	-1.29	-0.74	-0.59	-1.12	-1.23	-10.39	7.22	-13.74	16.92	-1.98	-163.96**	4.97	22.46	91.50**
20.	L7 x T1	4.89	-0.36	-1.16	1.04	0.59	0.97	1.32	0.88	-10.42	0.41	4.79	5.22	-8.84	-205.96**	54.41*	4.12	-24.28
21.	L8 x T1	-3.89	6.76**	0.62	1.38	-4.63**	-2.70**	-3.34**	-3.46**	0.52	8.02	2.96	-11.50	-13.68*	168.16**	12.08	-66.21**	-63.06
22.	L9 x T1	-0.67	-5.13**	-2.27	0.04	0.48	0.52	-0.01	-0.46	7.97	9.47	-21.93	4.50	0.10	255.49**	66.41**	60.34*	30.28
23.	L10 x T1	-4.00	0.31	3.40	2.60	5.14**	3.97**	3.66**	3.88**	42.88	-7.95	0.54	-35.47	19.85**	87.16**	-53.81*	20.79	-72.50*
24.	L1 x T2	2.67	-1.88	0.84	3.88	3.90**	3.98**	3.43**	2.98**	5.76	11.44	-5.51	-11.69	-2.71	-87.63**	39.28	25.24	63.36
25.	L2 x T2	1.44	-0.21	0.73	2.77	3.46**	3.42**	3.66**	3.53**	4.14	-13.83	-4.01	13.70	1.90	186.14**	-29.50	58.24*	-7.53
26.	L3 x T2	-0.67	-3.43	-1.16	-6.01*	-3.32**	-2.91**	-2.79**	-3.13**	10.84	-0.03	-3.43	-7.38	-14.79**	2.92	-37.39	0.69	-92.31**
27.	L4 x T2	-6.22	1.79	3.96*	1.10	1.79	1.87*	1.21	1.87*	-13.27	35.31	-7.76	-14.27	-20.46**	-70.41*	-35.28	-35.64	-103.98**
28.	L5 x T2	0.22	1.34	-3.71*	4.99*	3.68**	3.31**	2.99**	2.31*	-3.52	-27.72	2.10	29.14	14.12*	-72.08*	-136.17**	-70.20**	-2.64
29.	L6 x T2	-0.44	-1.32	-3.93*	0.88	1.79	1.98*	1.88*	1.87*	3.59	-5.83	-7.79	10.03	2.90	198.14**	73.50**	37.69	49.13
30.	L7 x T2	-4.11	2.68	4.18*	0.88	-1.54	-1.13	-1.34	-1.02	4.81	-15.06	15.99	-5.74	-2.54	-36.52	-42.06	-25.98	-62.64

Table-2 : Contd.....

S. No.	Genotype	Days to 50% flowering					Days to maturity					Plant height					Green fodder yield				
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4	Pool	E1	E2	E3	E4			
31.	L8 x T2	0.78	-3.88*	0.29	0.21	1.57	0.53	0.99	0.98	3.67	-6.19	0.07	2.45	8.37	-42.41	208.28**	12.02	139.91**			
32.	L9 x T2	2.67	6.90**	2.40	-3.12	-2.32*	-2.58**	-1.68	-1.36	-22.80	-4.67	27.27	0.20	20.07**	-87.41**	49.28*	44.91	75.24*			
33.	L10 x T2	3.67	-1.99	-3.60*	-5.57*	-8.99**	-8.47**	-8.34**	-8.02**	6.78	26.58	-16.93	-16.44	-6.85	9.26	-89.94**	-46.98	-58.53			
34.	L1 x T3	-1.67	3.12	-0.02	-2.59	-3.93**	-3.06**	-2.53**	-3.52**	-14.19	-7.94	8.97	13.16	16.64**	102.37**	-35.36	18.08	-50.41			
35.	L2 x T3	-3.22	-1.21	1.87	-1.03	-1.04	-0.94	-1.31	-1.63	29.36	-11.38	9.31	-27.28	-7.58	31.14	-9.13	16.41	69.37*			
36.	L3 x T3	-1.00	3.23	0.64	3.86	1.18	0.72	-0.09	1.37	-22.44	20.59	-15.28	17.13	20.89**	-0.74	181.64**	52.86*	38.59			
37.	L4 x T3	2.44	-1.88	-2.91	-1.03	-4.38**	-3.50**	-3.09**	-3.63**	14.86	-23.33	-5.53	13.99	6.14	-50.41	16.42	21.19	17.59			
38.	L5 x T3	1.89	0.01	4.09*	-2.14	-0.49	-0.72	-0.98	-0.52	19.03	34.06	-6.25	-46.84	-18.69**	99.59**	129.53**	-45.37	29.92			
39.	L6 x T3	0.89	2.01	0.20	0.41	-1.04	-1.39	-0.76	-0.63	6.81	-1.38	21.53	-26.95	-0.92	-34.19	-78.47**	-60.14*	-140.63**			
40.	L7 x T3	-0.78	-2.32	-3.02	-1.92	0.96	0.17	0.02	0.14	5.61	14.64	-20.78	0.52	11.39*	242.48**	-12.36	21.86	86.92**			
41.	L8 x T3	3.11	-2.88	-0.91	-1.59	3.07**	2.17*	2.36**	2.48**	-4.19	-1.83	-3.03	9.05	5.31	-125.74**	-220.36**	54.19*	-76.86*			
42.	L9 x T3	-2.00	-1.77	-0.13	3.08	1.84	2.06*	1.69	1.81*	14.83	-4.80	-5.33	-4.70	-20.17**	-168.08**	-115.69**	-105.26**	-105.52**			
43.	L10 x T3	0.33	1.68	0.20	2.97	3.84**	4.50**	4.69**	4.14**	-49.67*	-18.63	16.39	51.91*	-13.00*	-96.41**	143.76**	26.19	131.03**			
Standard error																					
	Ti	1.02	0.54	0.52	0.72	0.34	0.27	0.27	0.27	7.52	7.52	7.52	7.52	1.68	9.46	7.05	7.21	9.68			
	Lj	1.70	0.90	0.86	1.19	0.57	0.45	0.44	0.44	12.47	12.47	12.47	12.47	2.79	15.69	11.69	11.96	16.06			
	Sij	3.40	1.80	1.72	2.38	1.13	0.90	0.89	0.89	24.94	24.94	24.94	24.94	5.58	31.38	23.38	23.93	32.11			
	Ti-j	1.25	0.66	0.63	0.88	0.42	0.33	0.33	0.33	9.21	9.21	9.21	9.21	2.06	11.59	8.63	8.84	11.86			
	Li-j	2.29	1.21	1.16	1.60	0.76	0.61	0.60	0.60	16.82	16.82	16.82	16.82	3.76	21.16	15.76	16.13	21.65			
	Ti-Lj	1.85	0.98	0.93	1.29	0.62	0.49	0.48	0.48	13.56	13.56	13.56	13.56	3.03	17.06	12.71	13.01	17.46			
	STi-Tj	4.16	2.20	2.11	2.91	1.39	1.10	1.09	1.09	30.55	30.55	30.55	30.55	6.83	38.43	28.63	29.31	39.33			
	SiL-jL	4.58	2.43	2.32	3.20	1.53	1.22	1.20	1.20	33.63	33.63	33.63	33.63	7.52	42.31	31.52	32.26	43.30			
	Sij-kl	4.75	2.52	2.40	3.32	1.58	1.26	1.24	1.24	34.87	34.87	34.87	34.87	7.80	43.87	32.68	33.45	44.90			

*, ** Significant at 5 and 1 percent level of significance

Table-3 : GCA and SCA effects for dry fodder yield, ear head length, number of primaries per plant and number of seeds per primary.

S. No.	Genotype	Dry fodder yield				Ear head length				Number of primaries per plant				Number of seeds per primary				
		E1	E2	E3	E4	E1	E2	E3	E4	Pool	E1	E2	E3	E4	E1	E2	E3	E4
1.	T1	13.42**	-58.31**	1.51	3.04	0.18	-1.10	-0.04	0.97	-0.47	2.54*	3.68**	-0.10	2.94*	0.24	-6.88**	-4.61**	2.10
2.	T2	-3.21	-13.64**	-18.66**	-9.36**	-0.17	0.68	-0.59	0.08	0.82**	0.21	-3.56**	-3.80*	-4.66**	4.64*	4.42**	3.99*	-1.63
3.	T3	-10.21**	71.96**	17.14**	6.31**	-0.01	0.42	0.64	-1.05	-0.35	-2.76**	-0.12	3.90*	1.71	-4.89**	2.46*	0.62	-0.47
4.	L1	50.29**	-51.84**	29.06**	36.07**	0.08	0.58	-0.23	-0.44	-0.41	12.08**	7.74**	-1.32	3.72	-27.64**	-0.11	-18.68**	10.19**
5.	L2	-0.93	4.60	-11.72*	32.96**	-2.64	0.53	2.05	0.06	0.98*	-2.92	-4.59*	-11.21**	2.50	-18.87**	-3.56	25.99**	5.63
6.	L3	-16.27**	16.82**	0.72	16.40**	1.94	-0.44	-0.48	-1.02	-0.38	3.08	-6.48**	-4.66	-1.28	2.58	-6.44**	-23.79**	-16.48**
7.	L4	-0.27	-44.96**	-32.83**	10.18*	-0.53	-0.58	-0.62	1.73	-0.35	4.86**	13.08**	3.34	3.17	40.47**	-6.89**	24.10**	2.97
8.	L5	-11.16**	35.82**	19.50**	-5.93	-1.08	0.86	-0.06	0.28	1.09**	-8.37**	5.74**	14.12**	18.17**	-23.64**	-7.78**	10.21**	2.97
9.	L6	-36.71**	36.60**	-0.06	-20.49**	1.44	-2.28	0.13	0.70	0.23	11.19**	-4.70*	1.01	3.06	1.91	-2.11	11.54**	-2.81
10.	L7	-23.27**	-10.07	0.06	-28.60**	1.72	-1.22	1.08	-1.58	1.51**	-9.81**	-7.59**	1.68	-14.50**	14.91**	17.11**	10.88**	-1.81
11.	L8	-16.82**	2.27	8.39	-27.71**	-0.50	0.44	-0.59	0.64	0.73	5.30**	-0.59	3.68	-1.28	16.47**	16.22**	-12.79**	8.30**
12.	L9	13.40**	-42.84**	-9.72	-8.04*	0.08	0.69	-0.45	-0.33	-1.85**	-5.14**	-11.70**	1.57	-8.28**	9.02**	-6.11**	-14.01**	-6.37*
13.	L10	41.73**	53.60**	-3.39	-4.82	-0.53	1.42	-0.84	-0.05	-1.57**	-10.26**	9.08**	-8.21**	-5.28*	-15.20**	-0.33	-13.46**	-2.59
14.	L1 x T1	18.58*	23.31	-27.62*	-18.27*	-0.15	1.35	-1.37	0.17	-2.23**	-5.54	1.32	1.99	7.94	16.98**	20.21**	15.28**	-0.32
15.	L2 x T1	-69.87**	-36.47**	-28.18*	-13.49	-1.43	-1.59	3.02	0.01	0.38	-22.54**	5.32	-0.12	2.17	-26.13**	-19.68**	10.94	0.57
16.	L3 x T1	-98.87**	-47.02**	29.04*	-1.93	1.16	-2.12	-0.29	1.26	-1.76*	-3.88	-2.46	-11.68*	2.61	-10.58	-15.12**	10.06	1.01
17.	L4 x T1	-20.53**	49.42**	21.60	32.62**	0.63	-1.32	-0.15	0.84	0.88	9.34**	-0.34	7.99	-2.50	-65.13**	16.99**	-38.50**	-8.10
18.	L5 x T1	74.36**	52.98**	23.60*	-16.93*	0.68	-0.26	0.79	-1.22	1.61*	6.90*	-11.34**	1.88	-2.17	-6.69	-4.79	-7.94	6.23
19.	L6 x T1	5.58	-56.80**	-40.18**	36.62**	0.24	0.96	-2.32	1.12	0.38	-11.66**	-7.57	-2.34	3.94	-14.58*	-1.12	6.72	6.34
20.	L7 x T1	-64.53**	28.53*	-20.62	34.40**	-3.04	2.91	-1.26	1.39	-0.56	-2.99	5.32	-4.68	-2.83	-36.58**	4.32	-0.28	-15.32**
21.	L8 x T1	47.02**	-4.80	3.38	-26.82**	1.10	0.82	-1.34	-0.58	-0.70	9.90**	-2.34	1.99	-5.06	49.20**	7.88*	-12.61*	4.57
22.	L9 x T1	92.13**	27.64*	-2.18	21.51**	-1.07	0.66	2.93	-2.52	1.47	14.34**	9.10*	2.10	0.28	43.64**	-6.46	-2.39	0.23
23.	L10 x T1	16.13*	-36.80**	41.16**	-47.71**	1.88	-1.40	-0.01	-0.47	0.52	6.12	2.99	2.88	-4.39	49.87**	-2.23	18.72**	4.79
24.	L1 x T2	1.21	-6.02	3.88	16.80*	-0.55	-0.85	1.09	0.31	0.57	0.79	-11.78**	0.36	3.54	-21.42**	-18.09**	-20.66**	-12.26*
25.	L2 x T2	36.10**	-48.47**	45.99**	-2.76	0.76	-0.21	-1.60	1.06	0.27	18.79**	-3.44	-1.09	-5.57	43.47**	1.02	-13.32*	-1.37
26.	L3 x T2	46.43**	-7.69	-17.79	8.80	-1.24	4.68	-1.82	-1.61	0.71	-6.21	-6.56	1.36	1.54	4.69	12.24**	2.46	-4.59
27.	L4 x T2	60.77**	-4.58	-23.57*	-35.64**	-0.19	-0.27	1.90	-1.44	-0.57	-2.66	1.89	-4.64	-6.23	41.80**	-17.31**	16.57**	-10.37
28.	L5 x T2	-97.66**	-61.69**	-36.23**	-7.87	-1.88	0.37	1.09	0.42	-1.09	-7.10*	3.56	-3.42	11.77*	-9.76	-7.42	5.79	-1.03
29.	L6 x T2	3.54	-56.47**	14.99	0.02	-0.33	-2.07	2.65	-0.25	-0.65	3.68	-1.33	0.02	-2.12	18.02**	11.24**	7.12	8.74
30.	L7 x T2	6.77	-13.80	2.88	-24.87**	3.23	-0.29	-0.79	-2.14	0.57	8.68*	1.56	4.36	-10.23*	-18.98**	25.02**	10.46	-2.26

Table-3 : Contd....

S. No.	Genotype	Dry fodder yield				Ear head length				Number of primaries per plant				Number of seeds per primary				
		E1	E2	E3	E4	E1	E2	E3	E4	Pool	E1	E2	E3	E4	E1	E2	E3	E4
31.	L8 x T2	-40.01**	60.87**	-5.79	15.24	-0.72	-1.46	1.71	0.47	0.85	-4.77	2.22	-4.98	1.21	-8.87	-10.09**	2.12	3.63
32.	L9 x T2	6.77	59.98**	74.32**	3.58	1.03	-0.38	-2.77	2.11	-0.23	-5.66	-1.33	13.80**	-0.79	-24.42**	-3.42	3.34	22.30**
33.	L10 x T2	-23.90**	77.87**	-58.68**	26.69**	-0.11	0.48	-1.46	1.08	-0.43	-5.54	15.22**	-5.76	6.88	-24.53**	6.80	-13.88*	-2.81
34.	L1 x T3	-19.79*	-17.29	23.74*	1.47	0.70	-0.50	0.28	-0.48	1.66*	4.76	10.46*	-2.34	-11.49*	4.44	-2.12	5.38	12.58*
35.	L2 x T3	33.77**	84.93**	-17.81	16.24*	0.67	1.81	-1.42	-1.06	-0.65	3.76	-1.88	1.21	3.40	-17.33**	18.66**	2.38	0.80
36.	L3 x T3	52.43**	54.71**	-11.26	-6.87	0.09	-2.56	2.11	0.36	1.04	10.09**	9.01*	10.32*	-4.16	5.89	2.88	-12.51*	3.58
37.	L4 x T3	-40.23**	-44.84**	1.97	3.02	-0.44	1.58	-1.75	0.61	-0.32	-6.69	-1.54	-3.34	8.73	23.33**	0.32	21.93**	18.47**
38.	L5 x T3	23.32**	8.71	12.63	24.80**	1.20	-0.11	-1.89	0.80	-0.51	0.20	7.79	1.54	-9.60*	16.44**	12.21**	2.16	-5.20
39.	L6 x T3	-9.12	113.27**	25.19*	-36.64**	0.09	1.11	-0.33	-0.87	0.27	7.98*	8.90*	2.32	-1.82	-3.44	-10.12**	-13.84*	-15.09**
40.	L7 x T3	57.77**	-14.73	17.74	-9.53	-0.19	-2.61	2.06	0.74	-0.01	-5.69	-6.88	0.32	13.07**	55.56**	-29.34**	-10.18	17.58**
41.	L8 x T3	-7.01	-56.07**	2.41	11.58	-0.38	0.64	-0.36	0.11	-0.15	-5.13	0.12	2.99	3.84	-40.33**	2.21	10.49	-8.20
42.	L9 x T3	-98.90**	-87.62**	-72.14**	-25.09**	0.03	-0.28	-0.17	0.41	-1.23	-8.69*	-7.77	-15.90**	0.51	-19.22**	9.88*	-0.96	-22.53**
43.	L10 x T3	7.77	-41.07**	17.52	21.02**	-1.77	0.92	1.47	-0.62	-0.09	-0.58	-18.21**	2.88	-2.49	-25.33**	-4.57	-4.84	-1.98
Standard error																		
	Ti	2.34	3.79	3.52	2.36	1.06	1.06	1.06	1.06	0.24	1.02	1.23	1.50	1.39	1.81	1.15	1.67	1.72
	Lj	3.87	6.29	5.84	3.92	1.76	1.76	1.76	1.76	0.39	1.70	2.05	2.48	2.31	3.00	1.91	2.76	2.86
	Sij	7.75	12.58	11.68	7.83	3.52	3.52	3.52	3.52	0.79	3.40	4.09	4.97	4.61	6.00	3.82	5.53	5.71
	Ti-j	2.86	4.65	4.31	2.89	1.30	1.30	1.30	1.30	0.29	1.25	1.51	1.83	1.70	2.21	1.41	2.04	2.11
	Li-j	5.22	8.48	7.87	5.28	2.37	2.37	2.37	2.37	0.53	2.29	2.76	3.35	3.11	4.04	2.58	3.73	3.85
	Ti-Lj	4.21	6.84	6.35	4.26	1.91	1.91	1.91	1.91	0.43	1.85	2.22	2.70	2.51	3.26	2.08	3.01	3.11
	STi-Tj	9.49	15.41	14.30	9.59	4.31	4.31	4.31	4.31	0.96	4.16	5.01	6.08	5.65	7.34	4.68	6.77	7.00
	SiL-jL	10.45	16.97	15.75	10.56	4.75	4.75	4.75	4.75	1.06	4.58	5.52	6.70	6.22	8.08	5.15	7.46	7.70
	Sij-kl	10.83	17.59	16.33	10.95	4.92	4.92	4.92	4.92	1.10	4.75	5.72	6.94	6.45	8.38	5.34	7.73	7.99

*, ** Significant at 5 and 1 percent level of significance.

Table-4 : GCA and SCA effects for seed index, harvest index, grain yield, protein content in grain and protein content in fodder.

S. No.	Genotype	Harvest index			Grain yield			Protein content in grain			Protein content in fodder		
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
1.	T1	-1.20	0.40	2.15*	1.40*	1.53	-10.53**	7.30**	0.37	0.19*	0.51**	-0.04	0.14**
2.	T2	0.70	-0.21	-1.80*	0.30	1.03	-8.37**	-6.80**	-3.53**	-0.11	-0.07	0.40**	0.05*
3.	T3	0.51	-0.19	-0.35	-1.70**	-2.57**	18.90**	-0.50	3.17**	-0.07	-0.45**	-0.36**	-0.18**
4.	L1	-1.84	-0.41	-4.04**	-3.69**	6.63**	15.72**	-3.61**	1.26	0.84**	2.47**	2.21**	2.12**
5.	L2	1.62	1.00	2.30	0.44	-4.37**	-1.94	5.06**	3.37**	1.06**	0.97**	0.46*	0.42*
6.	L3	-0.64	0.55	-11.36**	-4.18**	11.30**	14.06**	-11.28**	-6.86**	0.16	1.87**	0.84**	1.33**
7.	L4	-0.78	0.10	1.25	2.88**	1.97	-14.61**	-1.39	-3.08**	-0.49**	-0.89**	-0.93**	-0.73**
8.	L5	1.21	-1.78	7.48**	0.11	-3.59**	6.39**	4.94**	-2.30**	-0.60**	-1.54**	-0.73**	-1.56**
9.	L6	0.75	0.80	2.18	0.98	-11.81**	1.61	5.72**	3.81**	-0.64**	-1.05**	-0.07	-1.01**
10.	L7	-0.51	0.37	-0.14	1.58	-7.14**	-5.72**	7.39**	2.59**	-0.13	-0.66**	-0.81**	-0.55**
11.	L8	0.57	-0.13	0.33	2.51*	3.63**	-3.39*	4.17**	-2.52**	-0.03	-1.95**	-1.56**	-1.05**
12.	L9	-0.28	-0.40	-1.66	-0.14	-3.37*	-20.94**	-4.50**	5.37**	-0.79**	-0.61**	-0.47*	-0.13**
13.	L10	-0.10	-0.11	3.65*	-0.49	6.74**	8.83**	-6.50**	-1.63*	0.63**	1.39**	1.06**	1.17**
14.	L1 x T1	-1.88	-0.13	-4.83	-1.25	-2.20	-10.69**	-9.86**	2.08	-0.57*	0.06	0.63	0.47**
15.	L2 x T1	1.23	0.30	3.47	4.10*	-15.53**	-10.69**	7.48**	-19.37**	-1.18**	-0.16	0.50	0.36**
16.	L3 x T1	-1.61	1.54	3.63	-2.59	8.13**	6.98*	4.14*	-10.81**	0.85**	0.87**	0.98*	1.51**
17.	L4 x T1	-1.64	-1.86	-2.77	-1.37	1.13	6.98*	-1.08	-1.59	-1.25**	-0.51**	-0.13	-0.46**
18.	L5 x T1	-0.31	0.54	-1.63	1.93	18.02**	4.64	-2.41	4.63**	1.00**	0.73**	0.05	-0.22**
19.	L6 x T1	1.45	1.21	-1.42	0.55	-5.09	-10.58**	12.14**	24.19**	-0.07	-1.05**	-2.31**	-1.15**
20.	L7 x T1	2.84	-3.08	5.04	-2.49	-15.76**	2.42	-2.52	18.74**	0.94**	-0.52**	-0.18	-0.27**
21.	L8 x T1	1.74	0.29	-4.04	-0.26	3.13	0.42	-13.97**	-4.48**	0.15	-0.24	-0.40	-0.65**
22.	L9 x T1	-0.50	1.57	-5.22	1.65	10.13**	12.31**	-2.97	-1.03	-0.52	0.23	0.21	-0.18*
23.	L10 x T1	-1.33	-0.39	7.76**	-0.27	-1.98	-1.80	9.03**	-12.37**	0.66*	0.59**	0.64	0.59**
24.	L1 x T2	-0.82	-1.23	-5.30	-1.07	-1.03	-19.52**	-3.42	-2.36	1.71**	2.43**	1.83**	1.91**
25.	L2 x T2	-0.14	0.35	-0.17	-1.45	13.30**	-9.19**	-9.42**	15.87**	-1.47**	-1.60**	-1.72**	-1.12**
26.	L3 x T2	0.90	-0.02	5.12	2.91	-2.03	-5.86	-1.09	7.76**	-0.53	-1.62**	-2.38**	-2.22**
27.	L4 x T2	0.83	2.91	2.51	-0.86	5.97*	7.81*	1.69	-11.02**	0.35	0.63**	0.19	0.40**
28.	L5 x T2	-0.17	-0.65	0.83	-1.14	-26.48**	-7.86*	7.69**	-8.47**	-0.86**	-1.14**	0.81*	0.11
29.	L6 x T2	0.04	0.57	5.42	2.60	3.41	-9.08**	-0.76	-2.24	0.37	-0.10	2.51**	0.36**
30.	L7 x T2	-1.26	1.60	-3.62	-1.16	-0.59	3.59	-0.76	-16.69**	-1.09**	0.34	-0.36	0.27**

Table-4 : GCA and SCA effects for seed index, harvest index, grain yield, protein content in grain and protein content in fodder.

S. No.	Genotype	Harvest index				Grain yield				Protein content in grain				Protein content in fodder			
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
31	L8 x T2	-0.90	-1.57	3.48	-0.24	5.30	10.59**	5.80**	3.42*	0.50	0.16	-0.89*	-0.45**	0.68**	0.73**	0.57**	0.52**
32	L9 x T2	1.30	-3.09	-5.07	-1.21	7.97**	9.81**	5.13**	0.87	1.00**	-0.59**	-0.58	-0.03	1.63**	-1.44**	-1.36**	-1.32**
33	L10 x T2	0.22	1.13	-3.22	1.63	-5.81*	19.70**	-4.87**	12.87**	0.02	1.48**	0.58	0.76**	-0.53**	0.34**	0.47**	0.43**
34	L1 x T3	2.70	1.36	10.13**	2.32	3.23	30.21**	13.28**	0.28	-1.14**	-2.49**	-2.46**	-2.38**	-1.12**	-1.19**	-1.12**	-1.11**
35	L2 x T3	-1.09	-0.65	-3.30	-2.65	2.23	19.88**	1.94	3.50*	2.65**	1.76**	1.22**	0.76**	2.18**	0.99**	0.99**	0.92**
36	L3 x T3	0.71	-1.53	-8.75**	-0.31	-6.10*	-1.12	-3.06	3.06*	-0.32	0.75**	1.41**	0.71**	-1.48**	0.73**	0.64**	0.64**
37	L4 x T3	0.80	-1.05	0.27	2.23	-7.10**	-14.79**	-0.61	12.61**	0.90**	-0.12	-0.07	0.05	2.22**	-1.41**	-1.38**	-1.27**
38	L5 x T3	0.48	0.12	0.80	-0.79	8.46**	3.21	-5.28**	3.83*	-0.14	0.41*	-0.86*	0.11	0.15	0.19*	0.21**	0.17**
39	L6 x T3	-1.49	-1.78	-4.01	-3.15	1.68	19.66**	-11.39**	-21.94**	-0.30	1.14**	-0.21	0.79**	-0.71**	-0.01	-0.07	0.00
40	L7 x T3	-1.58	1.48	-1.42	3.65	16.34**	-6.01	3.28	-2.06	0.15	0.18	0.54	0.00	1.15**	0.57**	0.59**	0.54**
41	L8 x T3	-0.84	1.28	0.55	0.50	-8.43**	-11.01**	8.17**	1.06	-0.65*	0.09	1.29**	1.10**	-1.45**	-1.34**	-1.24**	-1.26**
42	L9 x T3	-0.79	1.52	10.28**	-0.43	-18.10**	-22.12**	-2.17	0.17	-0.48	0.36*	0.37	0.22**	-0.35**	1.43**	1.42**	1.36**
43	L10 x T3	1.10	-0.75	-4.54	-1.36	7.79**	-17.90**	-4.17*	-0.50	-0.67*	-2.07**	-1.22**	-1.37**	-0.59**	0.05	-0.02	-0.01
Standard error																	
	Ti	0.72	0.55	0.86	0.58	0.80	0.94	0.53	0.44	0.08	0.05	0.12	0.02	0.03	0.02	0.02	0.02
	Lj	1.20	0.91	1.42	0.96	1.33	1.55	0.88	0.73	0.14	0.09	0.19	0.04	0.05	0.04	0.04	0.03
	Sij	2.40	1.82	2.84	1.92	2.67	3.11	1.77	1.47	0.28	0.18	0.39	0.08	0.11	0.07	0.08	0.06
	Ti-j	0.89	0.67	1.05	0.71	0.99	1.15	0.65	0.54	0.10	0.07	0.14	0.03	0.04	0.03	0.03	0.02
	Li-j	1.62	1.23	1.91	1.30	1.80	2.09	1.19	0.99	0.19	0.12	0.26	0.05	0.07	0.05	0.05	0.04
	Ti-Lj	1.31	0.99	1.54	1.05	1.45	1.69	0.96	0.80	0.15	0.10	0.21	0.04	0.06	0.04	0.04	0.03
	STi-Tj	2.94	2.23	3.48	2.36	3.27	3.81	2.16	1.79	0.34	0.22	0.48	0.09	0.13	0.09	0.09	0.07
	SiL-jL	3.24	2.46	3.83	2.59	3.60	4.19	2.38	1.98	0.37	0.24	0.53	0.10	0.15	0.10	0.10	0.08
	Si-l-kl	3.36	2.55	3.97	2.69	3.73	4.34	2.47	2.05	0.39	0.25	0.54	0.11	0.15	0.10	0.11	0.08

*, ** Significant at 5 and 1 percent level of significance

Traits measured : Following phenological, fodder and quality traits were measured. To record different observation five competitive plants in each plot were tagged at random. Days to 50 % flowering, days to maturity, plant height (cm), green fodder yield ($q\ ha^{-1}$), dry fodder yield ($q\ ha^{-1}$), ear head length (cm), number of primaries per plant, number of seeds per primaries, seed index, harvest index (%), grain yield ($q\ ha^{-1}$), Protein content in fodder (%) and rotein content in grain (%).

Analysis of variance : The plot means of each character were subjected to analysis of variance for individual environment as well as over the environment where error variance in different environment were homogeneous using least square technique of Fisher (1932).

Line x Tester mating design : Griffing's method of diallel (1956) for individual environments and Daljit Singh (1973, 1979) for over the environments were extended for Line x Tester mating design

Results and Discussion

The analysis of variance for experimental design in individual environment revealed significant differences between genotypes for all the characters in all the four environments except for days to 50 % flowering in E_1 and E_3 , days to maturity in all the four environments, dry fodder yield in E_3 , number of primaries per plant in E_3 , number of seeds per primary in E_1 and E_4 , and harvest index in E_1 , E_2 and E_4 . This indicated significant variation between genotypes for all the characters in all the environments except above. Partitioning of genotypic variance into parents, crosses and parent's vs crosses revealed that for all the characters under study there were significant difference between parents in all the environments except for days to 50 % flowering in E_1 and E_3 , ear head length in E_1 and harvest index in E_1 and E_2 . Difference between crosses was also significant for all the characters in all the environments except for harvest index in E_1 and E_2 . Difference between parents and crosses was also significant in most of the cross which indicates existence of average heterosis for these characters in different environments. The error variance was homogeneous for plant height and ear head length therefore, pooled analysis was carried out only for these two characters. The differences between genotypes, parents, cross and parent's vs crosses were significant for both the characters over the environments. This indicates variation among parents and crosses and existence of average heterosis for these two characters. The significance of $G \times E$ interaction for both the characters indicated that different genotypes influenced by the environment differentially. Non-significant parent's vs cross $\times$ environment interaction mean square indicated that the

difference between mean of parents and hybrids was constant and in same direction for ear head length. Significance of this mean squares for plant height indicated differential response of parents and crosses in different environments.

Combining Ability

Combining ability variance : Analysis of variance for combining ability revealed significant difference among the crosses for all the characters in all the environment except harvest index in E_1 and E_2 (Table-1). Partitioning of this variance in lines, testers and line $\times$ testers revealed significant different among GCA of lines for all the characters except harvest index in E_1 and E_2 . GCA of tester for all the characters except ear head length in E_1 and E_3 , number of seeds per primary and seed index in E_1 and harvest index in E_1 and E_2 . Significant difference for SCA was observed for all the characters in all the environments except days to 50% flowering in E_1 , ear head length in E_4 and harvest index in E_1 and E_2 . This indicates that both additive as well as non additive variance were important in the inheritance of various traits. Similar results were obtained by Biradar *et al.* (2000), Kenga *et al.* (2004), Mohamed *et al.* (2007), Mahmoud *et al.* (2007), Abd-El-Mottaleb (2009), Essa (2009) and Mahdy *et al.* (2011).

The contribution of lines, testers and line $\times$ testers in sum of square of cross revealed that line $\times$ tester's contribution was maximum in all the characters in all the four environments (table 4) except days to 50% flowering in E_1 , E_3 and E_4 , Ear head length in E_1 , E_4 and pool, number of primaries per plant in E_2 , E_3 and E_4 , number of seeds per primary in E_3 , seed index in E_3 , harvest index in E_3 and E_4 , protein content in grain in E_2 and E_4 . In above exceptional cases contribution of lines was maximum, whereas for Plant height in E_1 , E_2 , E_3 and pool, green fodder yield, dry fodder yield and grain yield in E_2 contribution of tester was maximum. This indicate major role of non additive gene effects in inheritance of these characters. Further, the magnitude of ^{2} SCA was higher than the ^{2} GCA for all the characters in all the environments which further confirmed the preponderance of non additive gene effects in the inheritance of these traits. Preponderance of non-additive effects in the expression of different traits in sorghum have also been reported by Rao *et al.* (1968), Shahane and Bapat (1981), Patel *et al.* (1988), Shivana and Patil (1988), Amsalu and Bapat (1990), Pillai *et al.* (1995), Chhimpi (1998), Karale *et al.* (1998), Ravindrababu *et al.* (2001), Bhavsar and Borikar (2002), Rafiq *et al.* (2002), Umakanth *et al.* (2002) and Kaul *et al.* (2003).

Combining ability effects : For green fodder yield the GCA effects was significant and desirable for 3, 4, 3 and 4

lines in E₁, E₂, E₃ and E₄ respectively. L₅ and T₃ having significant and positive GCA effects in E₂, E₃ and E₄. The estimates of SCA effects was significant and positive for 7, 7, 5 and 7 crosses in E₁, E₂, E₃ and E₄ respectively. Crosses viz., L₉ x T₁, L₂ x T₂, L₆ x T₂, L₈ x T₂, L₉ x T₂, L₃ x T₃, L₅ x T₃ and L₇ x T₃ exhibited significant and positive SCA effects in more than one environments (Table-2). For dry fodder yield GCA effects were significant and positive for 4, 5, 3 and 5 lines in E₁, E₂, E₃ and E₄, respectively. T₃, L₁, L₃, L₅, L₆, L₈ and L₁₀ having significant and positive GCA effects in more than one environment. The SCA effects were significant and positive for 12, 10, 6 and 9 crosses in E₁, E₂, E₃ and E₄, respectively. Crosses viz., L₅ x T₁, L₉ x T₁, L₂ x T₃ and L₆ x T₃ exhibited significant and positive SCA effects in more than two environments.

For grain yield GCA effects were significant and positive for 4, 4, 5 and 4 lines in E₁, E₂, E₃ and E₄, respectively. L₁, L₂, L₅, L₆, L₈ and L₁₀ having significant and positive GCA effects in more than one environment and T₃ in E₂ and E₄. The SCA effects for grain yield were significant and positive for 8, 10, 9 and 11 crosses in E₁, E₂, E₃ and E₄, respectively. Crosses viz., L₃ x T₁, L₈ x T₂ and L₉ x T₂ exhibited significant and positive SCA effects in more than two environments (table 4). For protein content in grain GCA effects were significant and positive for 4, 5, 5 and 6 lines in E₁, E₂, E₃ and E₄, respectively. T₃, L₁, L₃, L₅, L₆, L₇, L₈ and L₁₀ having significant and positive GCA effects in more than one environment. The SCA effects were significant and positive for 8, 10, 9 and 10 crosses in E₁, E₂, E₃ and E₄, respectively. Crosses viz., L₃ x T₁, L₉ x T₁, L₂ x T₂, L₄ x T₂, L₉ x T₂, L₁₀ x T₂ and L₁ x T₃ exhibited significant and positive SCA effects in more than two environments (table 4). For protein content in fodder the estimates GCA effects among lines ranged from -0.62 (L₆) to 0.47 (L₂) in E₁, -1.25 (L₆) to 1.17 (L₇) in E₂, -1.17 (L₆) to 1.12 (L₇) in E₃ and -1.22 (L₆) to 1.18 (L₇) in E₄. It was significant and positive for 5, 4, 4 and 3 lines in E₁, E₂, E₃ and E₄, respectively. L₂, L₇ and T₁ having significant and positive GCA effects in all the four environments. The SCA effects ranged from -2.03 (L₄ x L₁) to 2.22 (L₄ x L₃) in E₁, -1.44 (L₉ x L₂) to 1.43 (L₉ x L₃) in E₂, -1.38 (L₄ x L₃) to 1.42 (L₉ x L₃) in E₃, and -1.32 (L₉ x L₂) to 1.36 (L₉ x L₃) in E₄. It was significant and positive for 14, 12, 12 and 13 crosses in E₁, E₂, E₃ and E₄, respectively. Crosses viz., L₁ x T₂, L₈ x T₁, L₁ x T₂, L₆ x T₂, L₈ x T₂ and L₂ x T₃ exhibited significant and positive SCA effects in all the four environments (Table-4).

Lines L₁, L₂, L₅, L₈ and L₁₀ and tester T₃ were good general combiner for grain yield and most of the yield contributing characters. Therefore, these parents were noted as good sources of favourable genes for increasing grain yield through various yield contributing characters

and use of these parental lines would be more rewarding for boosting grain yield in sorghum. It was further noted that involvement of these parents had resulted into hybrids expressing useful heterosis for various traits. Therefore, developing dual purpose and early genotypes tester T₃ could be identified. Kukadia *et al.*, (1983), Pillai *et al.*, (1995), Bhadouriya and sexena (1997), Patil (2000), Salunke and Deore (2000), Ravindrababu *et al.*, (2001), Pahuja *et al.*, (2003) and Iyanar and Fazlullah (2005) also identified lines with good GCA effects for grain yield along with other attributes.

SCA effects were significant in 314 combinations considering 30 crosses and four environments. Frequency of good SCA effects in E₁, E₂, E₃ and E₄ were 82, 83, 63 and 86, respectively. Frequency of good SCA effects were maximum in protein content in fodder (51) followed by protein content in grain (40), grain yield (39), dry fodder yield (38), days to maturity (31) and number of seeds per primary (27). In E₂ ten crosses had good SCA for grain yield. Out of these seven crosses also had good SCA for dry fodder yield. Cross L₁₀ x T₂ having good SCA for dry fodder yield, days to maturity, protein content in grain, protein content in fodder and seed index L₂ x T₃ for dry fodder yield, protein content in grain, protein content in fodder and seed index along with grain yield. In E₃, 9 crosses having good SCA effects for grain yield. Out of these cross L₃ x T₁ also having good SCA effects for dry fodder yield, seed index, protein content in grain, cross L₁ x T₃ for dry fodder yield, protein content in grain and seed index and L₁₀ x T₁ for dry fodder yield, harvest index and number of seeds per primary. For seed index and days to maturity SCA was good in L₉ x T₂ and for green fodder yield and protein content in fodder in L₈ x T₃. In E₄, 11 crosses having good SCA for grain yield. Among these one or other cross also having good SCA for seed index, protein content in fodder, dry fodder yield, days to maturity, protein content in grain, green fodder yield and days to 50 % flowering. Cross L₁₀ x T₂ having good SCA for dry fodder yield, protein content in grain, protein content in fodder, seed index, days to 50 % flowering, days to maturity along with grain yield followed by L₂ x T₃ for dry fodder yield, green fodder yield, protein content in grain, protein content in fodder and seed index. Cross L₅ x T₃ for dry fodder yield, protein content in fodder and seed index. Across the environments cross L₃ x T₁, L₉ x T₁, L₄ x T₂ and L₉ x T₂ were having good SCA for grain yield in E₁, E₂ and E₃ where as cross L₈ x T₂ having good SCA in E₂, E₃ and E₄. There were nine crosses which had good SCA in all the four environments but for different characters. Remaining 12 crosses having good SCA in single environment only, that too varies from cross to cross. For plant height SCA was significant in seven crosses over the environments where as for ear head length the SCA

was significant only in two crosses. Presence of good SCA indicates that the above crosses having role of non additive gene action in inheritance of these characters in respective environments. In past Govil and Murty (1973), Rao *et al.* 1976), Singhania (1980), Amsalu and Bapat (1990), Pillai *et al.* (1995), Karale *et al.* (1998), Bhavsar and Borikar (2002), Rafiq *et al.* (2002) and Kaul *et al.* (2003) also reported importance of SCA in inheritance of one or other characters.

Cross $L_2 \times T_3$ and $L_6 \times T_3$ having economic heterosis for grain yield and dry fodder yield and $L_1 \times T_3$ for grain yield having good SCA effects and involving at least one good general combiner in E_2 parent may be utilized as hybrid for medium spacing i.e. 30 x 10 cm after testing at multi locations. Such hybrids having good SCA and involving at least one good general combiner parent were also identified by Reddy and Joshi (1993), Patel *et al.* (1993), Senthil and Palamisamy (1994), Bhadouriya and Saxena (1997), Chaudhary *et al.* (2006) and Yadhav and Pahuja (2007). In a specific environmental conditions

Acknowledgements

Indian Council of Agricultural Research (ICAR), is sincerely acknowledged for financial support of the study, International Crops Research Institute for Semi-Arid Tropics (ICRISAT) for providing lines (ms) for the study, Maharana Pratap University of Agriculture and Technology (MPUAT) is sincerely acknowledged for providing facility and support for the study.

References

- Anonymous 2018. FAOSTAT, Food and Agriculture Organization of the United Nations Statistics Division, Rome.
- Bahadure DM, Marker S, Umakanth AV, Prabhakar, Ramteke PW, Patil JV and Rana BS (2015) Combining ability and heterosis on millable stalk and sugar concentration for bioethanol production across environments in sweet sorghum (*Sorghum bicolor* (L.) Moench). *Electronic Journal of Plant Breeding* 6: 58-65.
- Bhadouriya, N. S. and Saxena, M.K. (1997). Combining ability studies in sorghum through diallel analysis. *Crop Res.*, 14(2): 253-256.
- Biradar, B.D., Vastrad, S.M., Balikai, R.A and Nidagundi, J.M. (2000). Combining ability studies in rabi sorghum. *Karnataka Journal of Agricultural Sciences*, 13: 721-723.
- Bunphan D, Jaisil P, Sanitchon J, Knoll JE and Anderson WF (2015) Heterosis and combining ability of F1 hybrid sweet sorghum in Thailand. *Crop Science* 55: 178-187.
- Daljit Singh. 1979. Diallel analysis for combining ability over environments. *Indian J. Genet.*, 39(3): 383-386.
- Bhavsar, V.V. and Borikar, S.T. (2002). Combining ability studies in sorghum involving diverse cytotosteriles. *J. Maharashtra Agric. Univ.*, 27(1): 35-38.
- Chaudhary, S.B., Patil, J.V., Thombare, B.B. and Kulkarni, V.M. (2004). Selection of parents based on combining ability in sorghum [*Sorghum bicolor* L. Moench]. *Annals of Plant Physiology* 20 (1): 95-97.
- Doggett H, 1988. Sorghum. Longman Scientific & Technical, London. *Cereal Sci* 44: 236-251.
- Fisher, R.A. (1932). The Genetical Theory of Natural Selection. Clarendon, Oxford.
- Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. *Aust. J. Biol. Sci.*, 9: 463-493.
- Iyanar, K., Gopalan, A. and Ramasamy, P. (2001). Combining ability analysis in sorghum [*Sorghum bicolor* (L.) Moench]. *Annals of Agriculture Research New Series*, 22 (3): 341-345.
- Indhubala M, Ganesamurthy K and Punitha D (2010) Combining ability studies for quality traits in Sweet Sorghum (*Sorghum bicolor* (L.) Moench). *The Madras Agricultural Journal* 97: 17-20.
- Karale, M.U, Suryavanshi, Y.B. and Mehtre, S.S. (1998). Combining ability studies in sorghum (*Sorghum bicolor* (L.) Moench). *Andhra Agric. J.*, 45: 42-46.
- Kaul, S.L., Rafiq, F.M. and Singh, K. (2003). Heterobeltiosis and combining ability for grain yield components in post rainy season sorghum. *International Sorghum and Millets News Letter*, 44: 21-23.
- Kenga, R., Alabi, S.O and Gupta, S.C. (2004). Combining ability studies in tropical sorghum [*Sorghum bicolor* L. Moench]. *Field Crops Research*, 88 (3): 251-260.
- Leonilo V. Gramaje, Joanne D. Caguiat, John Oscar S. Enriquez, Quirino D. dela Cruz, Reneth A. Millas, Jake E. Carampatana, Dindo Agustin A. Tabanao. (2020). Heterosis and combining ability analysis in CMS hybrid rice. *Euphytica* 216:14.
- Mahdy, E. E., Ali M. A. and Mahmoud A. M. (2011). The effect of environment on Combining ability and heterosis in gran sorghum (*Sorghum bicolor* L. Moench). *Asian Journal of Crop Science*, 3 (1):1-15.
- Mara Jane da Rocha¹, José Airton Rodrigues Nunes, Rafael Augusto da Costa Parrella, Pakizza Sherma da Silva Leite, Gabrielle Maria Romeiro Lombardi, Mayra Luiza Costa Moura, Robert Eugene Schaffert and Adriano Teodoro Bruzi (2018). General and specific combining ability in sweet sorghum. *Crop Breeding and Applied Biotechnology*, 18: 365-372.
- Meena B.L., B.R. Ranwah, S.P. Das, S.K. Meena, R. Kumari, Rumana Khan, V.K. Bhagasara and A. Gangarani Devi (2017). Estimation of Heterosis, Heterobeltiosis and Economic Heterosis in Dual Purpose Sorghum [*Sorghum bicolor* (L.) Moench]. *Int. J. Curr. Microbiol. App. Sci.* 6(5): 990-1014.
- Meena B.L., Ranwah, B.R., Das S.P., Meena H S, Meena, S.K., Kumari R. and Nath, Anamika (2018). Assessment of Economic Heterosis in Dual Purpose Sorghum [*Sorghum bicolor* (L.) Moench]. *Int.J. Curr. Microbiol. App. Sci.* 7(7): 3196-3205.
- Pillai, M.A., Rangaswamy, P., Nadarjan, N., Vannirajan, C and Ramalingam, J. (1995). Combining ability analysis for

- ear head characters in sorghum. *Indian Journal of Agricultural Research*, 29 (2): 98-102.
23. Patel, S.D.; Patel, A.I.; Patel, R.H.; Mali, S.C.; Patel, V.S. and Kshirsagar, R.M. (2006). Study of heterosis in sorghum. *Crop Prot. Prod.*, 2(2): 59-63.
 24. Premalatha, N., Kumaravadeivel, N. and Veerabhadhiran, P. (2006). Heterosis and combining ability for grain yield and its components in grain sorghum [*Sorghum bicolor* (L.) Moench]. *Indian Journal of Genetics and Plant Breeding*, 66 (2): 123-126.
 25. Rafiq, S.M.; Thete, R.Y.; Madhusudhana, R. and Umakanth, A.V. (2002). Combining ability studies for grain yield and its components in post rainy season where sorghum grown in medium deep and shallow soils. *International Sorghum and Millet News Letter*, 43: 33-37.
 26. Ravindrababu, Y.; Pathak, A.R. and Tank, C.J. (2001). Studies on combining ability for yield and yield attributes in sorghum (*Sorghum bicolor* (L.) Moench). *Crop Res.*, 22 (2): 274-277.
 27. Salunke, C.B. and Deore, G.N. (2000). Combining ability studies for physiological traits, harvest index and grain yield in rabi sorghum. *Ann. Plant Physiol.*, 14 (2): 190-195.
 28. Thakare, D.P., Ghorade, R.B. and Bagade A.B. (2014). Combining ability studies in Grain Sorghum using line X tester analysis. *Int.J. Curr.Microbiol. App.Sci* 3(10): 594-603.
 29. Yadav, R .and Pahuja, S.K. (2007). Combining ability for fodder yield and its components in forage sorghum. *Forage Research*, 32 (4): 220-223.



Characterization of Wheat (*Triticum* Spp.) Varieties on the Basis of Seed Morphology

N.M. Magar*, S.S. Dodake, R.D. Lokhande and U.G. Kachole

Agricultural Research Station, Kundewadi, MPKV, Niphad, Nashik-422303 Maharashtra

*Corresponding author's Email : [magamm@gmail.com](mailto:magammm@gmail.com)

Abstract

An experiment was carried out at the Agricultural Research Station, MPKV, Niphad Dist Nashik (MS) to characterize 19 wheat varieties [12 varieties of *Triticum aestivum* (Phule Samadhan, Phule Satwik, Trimbak, Netravati, Tapovan, NIAW 34, MACS 6222, MACS 6478, AKAW 4627, AKAW 3722, PDKV Washim and PDKV Sardar), 6 varieties of *Triticum durum* (NIDW 1149, Panchvati, Godavari, MACS 3949, MACS 3125 and 1 variety of *Triticum dicoccum* (MACS 2971)] released for commercial cultivation under different ecological conditions of Maharashtra. Based on the seed colour, the varieties were grouped into amber (18) and white (1). On the basis of seed shape, wheat varieties were grouped in to oblong (10) ovate (6), and elliptical (3). According of seed size, varieties were grouped into small (1), medium (7) and large (11). On the basis of seed hardness, varieties were grouped into very soft (1), semi-hard (3) and hard (15). Based on the seed germ width, varieties were grouped into narrow (5), medium (11) and wide (3). Wheat varieties were grouped in to four different groups viz., none (5), medium (3), dark (6) and very dark (5). On the basis of brush hair length, wheat varieties were grouped as short (6), medium (10) and long (3) brush hair length types.

Key words : Wheat varieties, seed morphology, characterization.

Introduction

Wheat is a major source of energy and important staple food crop and for Indian population. India has achieved remarkable progress in wheat production during the last 4 decades and is continue to be second largest wheat producing nation in the world. The wheat production has increased manifold from 6.60 million tonnes at the time of independence to 107.18 million tonnes in during 2019-20 (1). It is the most widely cultivated food crop of the world. It is known for its remarkable adoption to a wide range of environments and its role in world economy. Wheat is the major source of carbohydrate in a majority of countries, and, globally, it is the leading source of vegetal protein in human food, having a protein content of about 13%, which is relatively high compared to other major cereals (2). Wheat, eaten as a whole grain, is also a source of micronutrients and dietary fibers, it contains minerals, vitamins and fats (lipids), and with a small amount of animal or legume protein added is highly nutritious (3). Roughly 90 to 95% of the wheat produced in the world is common or bread wheat (*Triticum aestivum* L.), which can be classified as hard wheat or soft wheat, depending on the grain hardness. Bread wheat is utilized mainly as flour (whole grain or refined) for the production of a large variety of leavened and flat breads, and for the manufacture of a wide variety of other baked products. The total world production also includes about 35–40 million tonnes *T. durum* Desf., which is well adapted to the hot, dry conditions surrounding the Mediterranean Sea and similar climates in other world regions. This species is mainly

used for making pasta medium-dense breads and biscuits. Other wheat species are less cultivated although they play a major role in the expanding market in health foods. These are einkorn (*T. monococcum*), emmer (*T. dicoccum*), and spelt (*T. aestivum* subsp. *spelta* (L.)). Maintenance of genetic purity of varieties is of primary importance for preventing varietal deterioration during successive regeneration cycles and for ensuring varietal performance at an expected level. The aspects of Distinctness, Uniformity and Stability (DUS) are fundamental for characterization of varieties. In countries having Plant Breeder's Right in operation, a new variety is registered only, if it is distinct from other varieties, uniform in its characteristics and genetically stable. In the light of the above facts, the present study on documentation of characters for wheat varieties of three different species was planned with the objective to identify stable diagnostic characteristics of seed morphology of wheat varieties.

Materials and Methods

The experiment was conducted at Seed Testing Laboratory, Agricultural Research Station, MPKV; Niphad during *rabi* 2020-21 to study the varietal characterization in 19 wheat varieties (Table-1) released for commercial cultivation under different ecological conditions of Maharashtra.

Observations were recorded for different seed morphological characters viz., seed colour, seed shape, seed size (test weight), seed hardness, seed germ width, phenol reaction colour and brush hair length following the DUS testing guidelines in wheat crop (4) and (5). Among

Table-1 : Details of the wheat varieties selected for present experiment.

S.No.	Name of the variety	Suitability
A.	<i>Triticum aestivum</i>	
1.	Phule Samadhan (NIAW 1994)	Timely Sown/Late Sown, Irrigated
2.	Phule Satwik (NIAW 3170)	Timely Sown, Restricted Irrigation
3.	Trimbak (NIAW 301)	Timely Sown, Irrigated
4.	Netravati (NIAW 1415)	Timely Sown, Restricted Irrigation/Rainfed
5.	Tapovan (NIAW 917)	Timely Sown, Irrigated
6.	NIAW 34	Late Sown, Irrigated
7.	MACS 6222	Timely Sown, Irrigated
8.	MACS 6478	Timely Sown, Irrigated
9.	AKAW 4627	Late Sown, Irrigated
10.	Vimal (AKAW 3722)	Timely Sown, Rainfed
11.	PDKV Washim (WSM 1472)	Timely Sown, Restricted Irrigation/Rainfed
12.	PDKV Sardar (AKAW 4210-6)	Late Sown, Irrigated
B.	<i>Triticum durum</i>	
13.	NIDW 1149	Timely Sown, Restricted Irrigation
14.	Panchvati (NIDW 15)	Timely Sown, Rainfed
15.	Godavari (NIDW 295)	Timely Sown, Irrigated
16.	MACS 3949	Timely Sown, Irrigated
17.	MACS 3125	Timely Sown, Irrigated
18.	Sharad (AKDW 2997-16)	Timely Sown, Rainfed
C.	<i>Triticum dicoccum</i>	
19.	MACS 2971	Timely Sown, Irrigated

Table-2 : Grouping of wheat varieties based on seed colour, seed shape and seed size.

S. No.	Variety	Seed Colour	Seed Shape	Seed Size	
				Test weight (g)	Group
A.	<i>Triticum aestivum</i>				
1.	Phule Samadhan (NIAW 1994)	Amber	Ovate	43.2	Large
2.	Phule Satwik (NIAW 3170)	White	Oblong	39.5	Medium
3.	Trimbak (NIAW 301)	Amber	Ovate	43.1	Large
4.	Netravati (NIAW 1415)	Amber	Ovate	36.3	Medium
5.	Tapovan (NIAW 917)	Amber	Oblong	43.3	Large
6.	NIAW 34	Amber	Ovate	39.5	Medium
7.	MACS 6222	Amber	Oblong	41.8	Large
8.	MACS 6478	Amber	Oblong	40.6	Large
9.	AKAW 4627	Amber	Oblong	40.5	Large
10.	Vimal (AKAW 3722)	Amber	Oblong	34.2	Small
11.	PDKV Washim (WSM 1472)	Amber	Oblong	39.3	Medium
12.	PDKV Sardar (AKAW 4210-6)	Amber	Oblong	43.3	Large
B.	<i>Triticum durum</i>				
13.	NIDW 1149	Amber	Elliptical	47.2	Large
14.	Panchvati (NIDW 15)	Amber	Ovate	48.9	Large
15.	Godavari (NIDW 295)	Amber	Elliptical	43.5	Medium
16.	MACS 3949	Amber	Oblong	49.8	Large
17.	MACS 3125	Amber	Oblong	47.9	Large
18.	Sharad (AKDW 2997-16)	Amber	Ovate	44.0	Medium
C.	<i>Triticum dicoccum</i>				
19.	MACS 2971	Amber	Elliptical	41.4	Medium
	SE+			0.42	
	CD at 5%			1.19	
	CV			1.92	

Table-3 : Grouping of wheat varieties based on seed hardness, seed germ width, phenol reaction colour and brush hair length.

S. No.	Variety	Grain Hardness	Seed Germ Width	Phenol Reaction colour	Brush Hair length
A. <i>Triticum aestivum</i>					
1.	Phule Samadhan (NIAW 1994)	Hard	Wide	Dark	Short
2.	Phule Satwik (NIAW 3170)	Very Soft	Narrow	Dark	Medium
3.	Trimbak (NIAW 301)	Semi Hard	Medium	Very dark	Medium
4.	Netravati (NIAW 1415)	Hard	Medium	Dark	Medium
5.	Tapovan (NIAW 917)	Hard	Medium	Very dark	Medium
6.	NIAW 34	Hard	Medium	Very Dark	Medium
7.	MACS 6222	Hard	Medium	Very dark	Medium
8.	MACS 6478	Hard	Wide	Dark	Long
9.	AKAW 4627	Semi Hard	Medium	Very Dark	Long
10.	Vimal (AKAW 3722)	Hard	Medium	Dark	Medium
11.	PDKV Washim (WSM 1472)	Hard	Medium	Medium	Short
12.	PDKV Sardar (AKAW 4210-6)	Hard	Medium	Dark	Medium
B. <i>Triticum durum</i>					
13.	NIDW 1149	Hard	Narrow	None	Medium
14.	Panchvati (NIDW 15)	Hard	Narrow	None	Medium
15.	Godavari (NIDW 295)	Hard	Narrow	None	Short
16.	MACS 3949	Semi Hard	Medium	None	Short
17.	MACS 3125	Hard	Narrow	None	Short
18.	Sharad (AKDW 2997-16)	Hard	Medium	Medium	Short
C. <i>Triticum dicoccum</i>					
19.	MACS 2971	Hard	Wide	Medium	Long

all above mentioned characters, seed size (test weight) was the only quantitative character, which was analyzed using Completely Randomized Design suggested by Cochran and Cox, 1957 (6).

Results and Discussion

All the varieties were grouped in to different categories according to their morphological characteristics (Table-2 and 3). On the basis of the seed colour, the varieties were grouped into amber (18) and white (1). Based on seed shape, wheat varieties were grouped in to oblong (10) ovate (6), and elliptical (3). Wheat varieties were grouped into small (1), medium (7) and large (11) according to seed size. Based on seed hardness, varieties were grouped into very soft (1), semi-hard (3) and hard (15). Based on the seed germ width, varieties were grouped into narrow (5), medium (11) and wide (3). The varieties were grouped in to four different groups based on phenol reaction colour viz., none (5), medium (3), dark (6) and very dark (5). On the basis of brush hair length, wheat varieties were grouped as short (6), medium (10) and long (3) brush hair length types.

With help of seed morphological characteristics, 19 wheat varieties were categorized in to different groups and their identification keys are presented in Fig.-1. The varieties viz., Tapovan and MACS 6222 were grouped into similar seed morphology having amber seed colour, oblong seed shape, large seed size, hard seed, medium seed germ width, very dark phenol coloration and medium brush hair length. The Variety PDKV Sardar was different

from above both varieties only in respect to phenol coloration having dark phenol coloration, while Netravati with respect to seed shape (ovate) and seed size (medium). The varieties Phule Samadhan, Trimbak, Netravati, NIAW 34, Panchvati and Sharad were having same seed colour (amber) and seed shape (ovate). Out of them three varieties viz., Phule Samadhan, Trimbak and Panchvati have large seed size and Netravati, NIAW 34 and Sharad have medium seed size. Phule Samadhan and Panchvati have hard grains but both the varieties were different in seed germ width, phenol reaction and brush hair length. The varieties Netravati and NIAW 34 were found identical in seed morphology except phenol reaction Netravati was having dark and NIAW 34 shown very dark phenol reaction. Wheat varieties Netravati, NIAW and Sharad were having same seed colour, seed size, grain hardness and seed germ width but were distinct to each other in respect to phenol reaction and brush hair length. MACS 6478 and MACS 3125 were similar in respect of seed colour (amber), seed shape (oblong), seed size (large) and grain hardness (hard) but they are unique in remaining characters. Variety MACS 6478 recorded wide seed germ width, dark phenol coloration and long brush hair length while, MACS 3125 was narrow in seed germ width, no phenol coloration and it has short brush hair length. The varieties AKAW 4627 and MACS 3949 were amber in seed colour, oblong seed shape, large seed size, semi hard grain and medium seed germ width but both varieties were different in phenol coloration and brush hair length. AKAW 4627 showed

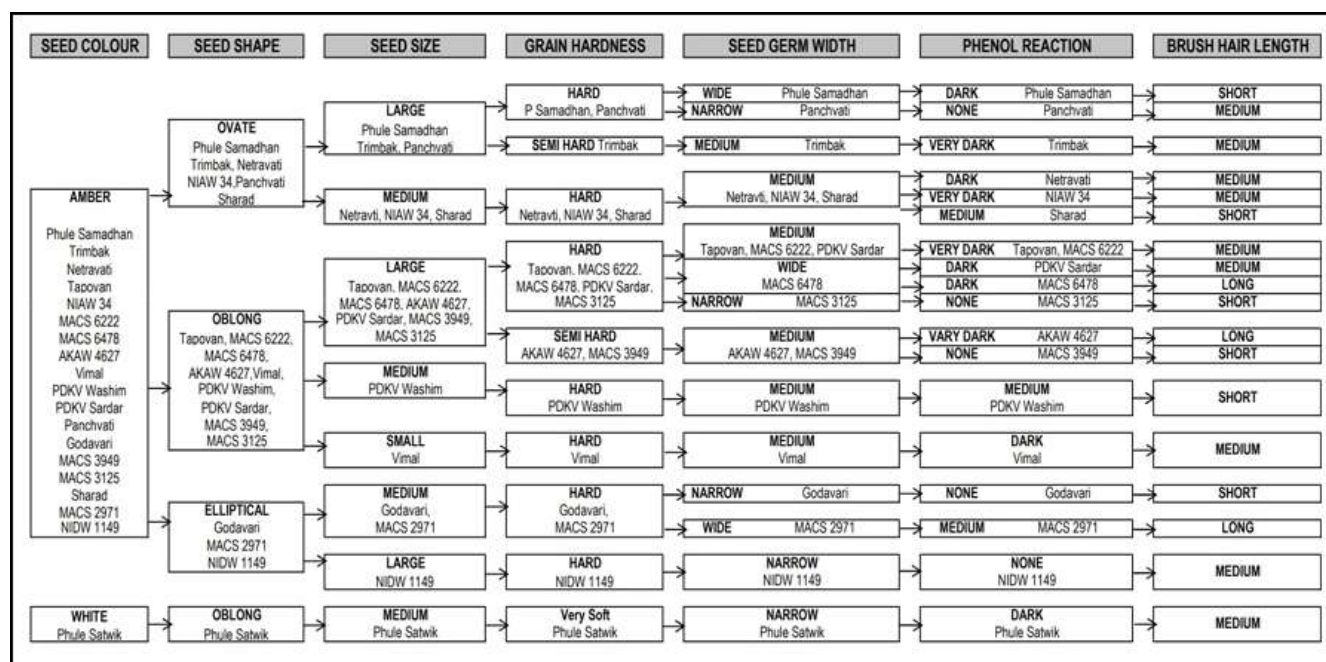


Fig-1 : Wheat varieties identification keys on the basis of seed morphological characters.

very dark phenol coloration and was long brush hair length while, MACS 3949 recorded no phenol reaction and it has short brush hair length. The varieties PDKV Washim and Vimal were found identical to each other in respect of seed colour (amber), seed shape (oblong), grain hardness (hard) and seed germ width (medium) but were different in seed size, phenol reaction and brush hair length. The variety PDKV Washim was medium in seed size, while variety Vimal was small seeded. The variety PDKV Washim showed medium phenol coloration and has short brush hair length, whereas the variety Vimal recorded dark phenol coloration and it has medium brush hair length.

The varieties Godavari, MACS 2971 and NIDW 1149 were amber colored seed, elliptical seed shape and hard grains but were distinct in respect of remaining characters. The variety Godavari recorded medium seed size, narrow seed germ width, no phenol coloration and short brush hair length while, the variety MACS 2971 has medium seed size wide seed germ width, shown medium phenol coloration and long brush hair length, whereas NIDW 1149 recorded large seed size, narrow seed germ width, no phenol coloration and medium brush hair length. Only white seeded variety was Phule Satwik and it was found oblong in seed shape, medium in seed size, very soft grains, narrow seed germ width, dark phenol coloration and medium brush hair length.

Only two varieties viz., Tapovan and MACS 6222 were similar in seed morphological characters. All other varieties under study were differed from each other at least for one seed character and could be helpful for the

identification of wheat variety from the seed lot. Similar observations and grouping of varieties based on seed morphological characters were made by (7) and (8).

References

- Anonymous 2020. Third Advance Estimates of Production of Food grains for 2019-20 as on 15.5.2020. Directorate of Economics and Statistics, DAC and FW, Ministry of Agriculture and Farmers Welfare, Govt. of India
- Shewry, P.R. and Hey, S.J. 2015. The contribution of wheat to human diet and health. *Food Energy Secur.* , 4: 178–202.
- Sarwar, M.H., Sarwar, M.F., Sarwar, M., Qadri, N.A. and Moghal, S. 2014. The importance of cereals (Poaceae: Gramineae) nutrition in human health: A review. *J. Cereals Oilseeds*, 4: 32–35.
- <http://plantaauthority.gov.in/pdf/GBread%20Wheat.pdf>
- Gupta Arun, Charan Singh, Vineet Kumar, Sushila Kundu, Vinod Tiwari and G.P. Singh. 2017. Indian Wheat Varieties at a Glance, Vol. II. ICAR-Indian Institute of Wheat and Barley Research, Karnal-132001 India.
- Cochran, W.G. and Cox, G.M. (1957). Experimental Designs. *John Wiley and Sons, Inc.* Chapman and Hall Limited, London.
- Patel, J.B., J.D. Ukani, C.A. Babariya and P.S. Ramani. (2016). Characterization of wheat varieties (*Triticum* spp.) through seed morphology. *Journal of Applied and Natural Science* 8 (1): 464-468 (2016).
- Naseem, M.; Dutta, M.; Shah, Shachi and Kumar, P. (2007). Characterization of buckwheat cultivars using morphological, chemical, physiological and biochemical parameters. Proc. 10th International Sympo. Buckwheat, G.B. Pant University of Agriculture & Technology, Hill Campus, Ranichauri, Tehri Garhwal, Uttarakhand, India.



Impact of Pre-Harvest Application of Plant Bio-Regulators and Micronutrient on Fruit Retention, Yield and Quality of Mango (*Mangifera Indica* L.)

Anushi, V.K. Tripathi, Vineet Awasthi and G. Naga Yashasvi

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

Email : drvkttripathicsa@gmail.com

Abstract

To investigate the effect of pre-harvest application of GA₃, Naphthalene acetic acid and zinc sulphate on fruit retention, yield and quality of Mango cv. Dashehari, an experiment was carried out in the Garden, Department of Fruit Science, C. S. Azad University of Agriculture and Technology, Kanpur (U.P.) during the cropping season 2021. The experiment was laid out in Randomized Block Design (RBD) with three replication and ten treatments viz., GA₃ @ 20 ppm (T₁), GA₃ @ 40 ppm (T₂), GA₃ @ 60 ppm (T₃), NAA @ 20 ppm (T₄), NAA @ 30 ppm (T₅), NAA @ 40 ppm (T₆), ZnSO₄ @ 0.5% (T₇), ZnSO₄ @ 1.0% (T₈), ZnSO₄ @ 1.5% (T₉) including a control or water spray (T₁₀). Spraying of plant bio-regulators and micronutrient was done at pea stage of fruits set on 1st March, 2021. From the results obtained during present experimentation, it is reported that pre-harvest spraying of GA₃ at 20 ppm results significant decrease in fruit drop (83.37%) with increase in fruit retention (16.63 %) and number of fruits per panicle (6.03). Plants sprayed with the GA₃ at 40 ppm results significantly more fruit yield (50.13 kg/tree) of fruits having more polar (9.66 cm) and equatorial diameter (7.96 cm), more pulp (72.55%) with decrease in peel (17.96%) and stone per cent (09.49 %). Increased fruit weight (242.88 g), volume (258.02 cc), specific gravity (1.08 g/cc), pulp: stone ratio (5.22), total soluble solids (18.86 °Brix), total sugars (17.89 %), ascorbic acid (37.91 mg/100g) were also found with the pre-harvest spraying of GA₃ at 60 ppm, whereas titratable acidity (0.51 %) contents in the fruits were drastically reduced under this treatment.

Key words : Mango, dashehari, gibberellic acid, NAA, zinc sulphate, fruit drop, fruit retention, yield and quality.

Introduction

The mango (*Mangifera indica* L.) is one of the most prominent and delicious fruit of the tropical countries and hold a premier position amongst the commercial fruits, grown in India and it is also known as king of fruits. It is indigenous to north-east India and north Myanmar in the foot-hills of the Himalaya and is said to have originated in the Indo-Burma region and belongs to family Anacardiaceae. Mango fruits are rich source of vitamin-A and fairly good source of vitamin-C. Its fruits are considered as excellent table fruit but a variety of products can be prepared from both immature green and ripe fruits. The green mature fruits are used extensively by food processing industry to prepare a wide variety of products such as dried slices, mango powder, pickles and chutneys. Ripe fruits are utilized in preparing squash, nectar, jam, jelly, cereals flakes, custard powder, baby food, toffee, etc. In Ayurveda, dried mango flowers are used to cure dysentery, diarrhea and inflammation of the urinary tract.

The foliar application of plant bio-regulators and micronutrients has an important role in improving fruit set, productivity and quality of fruits. Foliar application is based on the principle that the nutrients are quickly absorbed by natural opening of the leaves and transported to different parts of the plant to fulfil the

functional requirement of nutrition. Plant bio-regulators and micronutrient such as GA₃, NAA and zinc plays an important role in increasing fruits set, fruit yield and quality. Naphthalene acetic acid (NAA) is also very helpful in the induction of flowering, prevent shedding of flower buds, flowers and unripe fruits, increase fruit size and also increase the yield and quality of many fruits, whereas GA₃ application is found more effective in maximizing fruit retention percentage of fruits per panicle with increase in fruit size and fruit weight in mango and in many other fruits crops. Zinc is a constituent of some enzymes, indole acetic acid in plants and essential for CO₂ evolution, utilization of carbohydrate, phosphorus metabolism and synthesis of proteins. The intensity of damage caused by fruit dropping can also be minimized by the foliar application of plant bio-regulators and micro-nutrients. It also helps in improving yield and fruit quality parameters in mango and other fruits.

Materials and Methods

The present experiment was carried out on 11 years old plants of Mango cv. Dashehari, an experiment was carried out in the Garden, Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) during the cropping season 2021. The experiment was laid out in Randomized Block Design (RBD) with three replication and ten treatments viz., GA₃ @ 20 ppm (T₁),

Table-1 : Impact of pre-harvest application of GA₃, Naphthalene acetic acid and zinc sulphate on fruit drop, fruit retention and Number of fruits per panicle in Mango cv. Dashehari.

Treatments	Fruit drop (%)	Fruit retention (%)	Number of fruits per panicle
GA ₃ @ 20 ppm	83.37	16.63	6.03
GA ₃ @ 40 ppm	90.49	09.51	4.53
GA ₃ @ 60 ppm	86.18	13.82	4.32
NAA @ 20 ppm	87.17	12.83	5.08
NAA @ 30 ppm	86.57	13.43	5.26
NAA @ 40 ppm	85.20	14.80	5.56
ZnSO ₄ @ 0.5%	91.47	08.53	5.24
ZnSO ₄ @ 1.0%	84.29	15.71	5.52
ZnSO ₄ @ 1.5%	89.40	10.61	5.79
Control (water spray only)	92.35	07.65	3.26
S. E. m ±	1.18	0.59	0.63
CD at 5%	3.55	1.79	1.82

Table-2 : Impact of pre-harvest application of GA₃, Naphthalene acetic acid and zinc sulphate on physical parameters of fruits in Mango cv. Dashehari.

Treatments	Polar diameter of fruits (cm)	Equatorial diameter of fruits (cm)	Average fruit weight (g)	Fruit volume (cc)	Specific gravity (g/cc)	Pulp (%)	Peel (%)	Fruit stone (%)	Pulp /stone ratio
GA ₃ @ 20 ppm	9.03	7.88	232.63	239.93	1.04	64.11	22.33	13.56	4.72
GA ₃ @ 40 ppm	9.66	7.96	237.42	256.44	1.07	72.55	17.96	09.49	4.64
GA ₃ @ 60 ppm	8.56	7.59	242.88	258.02	1.08	66.28	21.03	12.69	5.22
NAA @ 20 ppm	8.50	7.56	213.56	220.16	1.02	63.05	22.60	14.35	4.39
NAA @ 30 ppm	8.93	7.85	220.96	222.97	1.03	64.13	22.54	13.33	4.81
NAA @ 40 ppm	9.37	7.92	236.98	248.61	1.06	69.76	17.73	12.51	5.57
ZnSO ₄ @ 0.5%	8.36	7.32	208.96	210.52	1.00	63.92	22.20	13.88	4.60
ZnSO ₄ @ 1.0%	8.91	7.83	221.07	236.57	1.03	70.66	18.09	11.25	6.28
ZnSO ₄ @ 1.5%	8.78	7.66	210.72	215.89	1.01	64.39	22.72	12.89	4.99
Control (water spray only)	8.06	6.95	202.96	201.91	0.98	58.26	23.41	18.33	3.17
S. E. m ±	0.54	0.57	1.09	1.29	0.03	0.95	0.73	0.83	0.56
CD at 5%	1.11	1.32	3.27	3.86	0.06	2.85	2.19	2.49	1.20

GA₃ @ 40 ppm (T₂), GA₃ @ 60 ppm (T₃), NAA @ 20 ppm (T₄), NAA @ 30 ppm (T₅), NAA @ 40 ppm (T₆), ZnSO₄ @ 0.5% (T₇), ZnSO₄ @ 1.0% (T₈), ZnSO₄ @ 1.5% (T₉) including a control or water spray (T₁₀). Spraying of plant bio-regulators and micronutrient was done at pea stage of fruits set on 1st March, 2021.

The observations were recorded on per cent fruit drop, per cent fruit retention and number of fruits per panicles. The physical parameters of fruits viz., fruit size (polar and equatorial diameter), weight, fruit volume (cc), pulp, peel and stone per cent, pulp: stone ratio, specific gravity, fruit yield and chemical parameters i.e., total soluble solids (TSS), total sugars, ascorbic acid (vitamin C) and titratable acidity contents were studied after harvest as per method suggested in (A.O.A.C., 1980).

Results and Discussion

Fruits drop and retention per cent : During present experimental period it is observed that significant increase in fruit retention with reduced fruit drop was recorded by

the use of plant bio-regulators and micro-nutrient (Table-1). The maximum fruit retention (16.63%) and minimum fruit drop per cent (83.37 %) were found with the pre-harvest application of GA₃ @ 20 ppm, followed by ZnSO₄ @ 1.0% (15.71% and 84.29%, respectively). However, the minimum fruit retention (7.65%) and maximum fruit drop per cent (92.35%) was recorded in control, where no plant bio-regulators and micronutrient were used. This increase in fruit retention and reduction in fruit drop per cent might be due to the suppression of ABA biosynthesis and increase in the endogenous level of auxin and other metabolites in the plant. Therefore, an exogenous application of gibberellins and auxin might have improved fruit retention and reduced drop per cent.

The present findings are in accordance with Singh *et al.* (2017), Kumar *et al.* (2018a) in mango, and Tripathi *et al.* (2018) in Aonla and Tripathi *et al.* (2019) in mango. Parauha and Pandey (2019) reported that the foliar spray of GA₃ 30 ppm + KNO₃ at 2% showed more fruit retention percentage at harvest stage (1.94%). Maurya *et al.*,

Table-3 : Impact of pre-harvest application of GA₃, Naphthalene acetic acid and zinc sulphate on chemical parameters of fruits in Mango cv. Dashehari.

Treatments	T.S.S. (°Brix)	Total sugar (%)	Titrateable acidity (%)	Ascorbic acid (mg/100g pulp)
GA ₃ @ 20 ppm	16.32	15.17	0.59	35.40
GA ₃ @ 40 ppm	16.90	15.63	0.56	37.44
GA ₃ @ 60 ppm	18.86	17.89	0.51	37.91
NAA @ 20 ppm	16.22	15.28	0.63	34.26
NAA @ 30 ppm	16.68	15.43	0.60	35.21
NAA @ 40 ppm	17.70	16.44	0.58	36.97
ZnSO ₄ @ 0.5%	16.14	15.20	0.61	34.51
ZnSO ₄ @ 1.0%	17.07	16.12	0.55	35.17
ZnSO ₄ @ 1.5%	16.44	15.48	0.57	36.91
Control (water spray only)	15.68	13.66	0.67	28.52
S. E. m ±	0.98	0.66	0.01	0.85
CD at 5%	1.92	1.99	0.03	2.56

(2020) also reported that pre-harvest spraying of GA₃ at 25 ppm results significant decrease in fruit drop (85.77%) with an increase in fruit retention (14.23 %).

Number of fruits per panicle : Significantly higher number of fruits per panicle (6.03) was obtained from the plants which were treated with GA₃ at 20 ppm followed by NAA at 20 ppm (5.08) treated plants (Table-1). This increased number of fruits per panicle may be the results of higher fruit retention and less drop with GA₃ at 20 ppm treatment. The results are in conformity with the findings of Singh *et al.* (2017) and Kumar *et al.* (2018b) in mango.

Fruit yield : The pre-harvest application of GA₃ @ 40 ppm followed by NAA @ 40 ppm were found to be best to enhance fruit yield of 50.13 kg/tree and 46.92 kg/tree, respectively, whereas the minimum fruit yield (kg/tree) was recorded under control which produced 30.36 kg of fruit per tree (Fig.-1). The enhancement in fruit yield due to foliar feeding of plant bio-regulators and micronutrient by plant leaves might be attributed to more luxuriant vegetative growth to the initial stage, which later on results synthesis of more metabolites for developing fruits. The importance of these plant bio-regulators and micronutrient in improving the physiological activities, which increase fruit retention per cent, polar diameter, equatorial diameter along with average weight of fruits is directly associated with increase in fruit yield during present experimental period. The result of present findings are in accordance with Tripathi and Shukla (2008), Singh and Tripathi (2010) in strawberry, who reported higher fruit yield with the application of GA₃ at 100 ppm and Badal and Tripathi (2021a), who also found higher yield with NAA 75 ppm spray in guava. More or less similar results were also reported by Tripathi *et al.*, (2018), Bhadauria *et al.*, (2018) in aonla, Lal *et al.*, (2015) in kinnow, Kumar *et al.*, (2018b), Tripathi *et al.*, (2019), Maurya *et al.* (2020) in mango and Verma *et al.*, (2021) in strawberry.

Fruit Size : The maximum polar (9.66 cm) and equatorial diameter (7.96 cm) of fruits were recorded with pre-harvest application of GA₃ 40 ppm, whereas minimum polar (8.06 cm) and equatorial diameter (6.95 cm) was recorded in fruit produced from the plants kept under control (Table 2). The reasons for increase in fruit size with spraying of plant bio-regulators and micronutrient may be because of the efficient accumulation of metabolites in initial stage of developing fruits due to luxuriance shoot growth. Spraying of plant bio-regulators and micronutrient might have regulated the cell-wall permeability and increased absorption, thereby allowing more water mobility in fruits resulting in enlargement of fruit size. These results are in close conformity with the findings of Singh *et al.*, (2017) also found increase in fruit size with pre-harvest application of GA₃ at 50 ppm in mango cv. Amarpali and Badal and Tripathi (2021b), who also found increased fruit size with NAA 75 ppm spray in guava. The results are in line with the findings of Kumar *et al.*, (2018b) in mango, Singh and Tripathi (2010), Tripathi and Shukla (2010) in strawberry, Tripathi *et al.*, (2018), Maurya *et al.*, (2020) in mango and Verma *et al.*, (2021) in strawberry.

Weight, volume and specific gravity of fruit : Fruit weight, volume and specific gravity was significantly influenced by the foliar application of plant bio-regulators and micronutrient. The significantly higher weight (242.88 g), volume (258.02 g/cc) and specific gravity (1.08 g/cc) of fruit was recorded in the fruits produced from the plants treated with GA₃ 60 ppm, while the minimum weight (202.96 g), volume (201.91 g/cc) and specific gravity (0.98 g/cc) of fruit was recorded under control (Table 2). Weight, volume and specific gravity of fruits get reduced with the reduction in the concentration of plant bio-regulators and micronutrient in all treatments. Gibberellic acid and zinc are directly or indirectly involved in the photosynthesis in the plants and then they were translocated to the fruits during their

growth and development, which increase the reserved food material in the fruits and ultimately increase weight and volume of fruits. This increase in weight and size with reduction in stone weight of fruit, results an increase in specific gravity of fruits. These results have got the support of Singh *et al.* (2017), Bhadauria *et al.* (2018) in aonla. Maurya *et al.*, (2020) in mango also found increased fruit weight at GA₃ @ 75 ppm followed by NAA @ 60 ppm.

Pulp, peel and stone per cent : Observations recorded on pulp, peel and stone per cent clearly indicate that pre-harvest application of GA₃ @ 40 ppm resulted significant increase in pulp per cent (72.55%) and reduction of peel (17.96%) and stone per cent (9.49%) in mango fruits. The minimum pulp per cent (58.26%) and maximum peel (23.41%) and stone per cent (18.33%) was recorded in fruits kept under control. This increase in pulp per cent may be due to more absorption of water, plant bio-regulators and micronutrient which ultimately increase the volume of inter-cellular spaces in the pulp. These results are in accordance with the findings of Tripathi *et al.*, (2018), who recorded higher pulp in aonla cv. NA 7 with the spraying GA₃ @ 50 ppm and also with Bhadauria *et al.*, (2018) who found increased pulp and reduced stone percentage in Aonla cv. NA 7 with the spraying with GA₃ @ 100 ppm. These results are in line with the reports of Kumar *et al.*, (2018b) and Tripathi *et al.*, (2019), Maurya *et al.*, (2020) in mango and Verma *et al.*, (2021) in strawberry.

Pulp/stone ratio : Pre-harvest application of ZnSO₄ @ 1.0% (6.28) resulted significant increase in pulp/stone ratio followed by NAA @ 40 ppm (5.57), whereas minimum pulp/stone ratio (3.17) was recorded under control. This increase in pulp/stone ratio might be due to increase in pulp per cent, volume of inter-cellular spaces in the pulp and decrease in stone per cent. These results have got the support with the findings of Tripathi *et al.*, (2018), Bhadauria *et al.*, (2018) in aonla, Kumar *et al.*, (2018) and Tripathi *et al.*, (2019) in mango. This improvement in pulp: stone ratio might be due to more accumulation of food substances in elongated cell and intercellular space of mesocarp by Maurya *et al.*, (2020) in mango.

Total soluble solids and total sugars : The maximum amount of total soluble solids (TSS) and total sugar content in fruits were found which were produced from the trees sprayed with GA₃ @ 60 ppm (18.86 °Brix and 17.89%, respectively) followed by NAA @ 40ppm (17.70 °Brix and 16.44%, respectively), while minimum total soluble solids and total sugar contents (15.68 °Brix and 13.66%, respectively) were recorded in fruits which were produced from the plants kept under control. This increase

in total soluble solids content of fruits may be due to the fact that plant growth regulators and micronutrient positively affect the photosynthesis rate which ultimately leads to the accumulation of photosynthates (carbohydrates) resulting increase in TSS content of mango fruits. The adequate amount of borax and NAA improve the auxin content that acted as catalyst in oxidation process. GA₃ indirectly influence many enzyme systems in plants, out of these the role of gibberellins in activation of amylase enzyme is well known which are responsible for the conversion of starch into sugar thus improve the TSS and total sugars contents in fruits. Gibberellins are known to play a crucial role in the sugar metabolism of plants. These results have got the support with the findings of Dubey *et al.*, (2017) in strawberry, Shukla *et al.*, (2011), Tiwari *et al.*, (2017), Bhadauria *et al.*, (2018) in aonla. Tripathi *et al.*, (2019) also reported increased TSS and total sugars content in mango with the application of GA₃ 50 ppm + NAA 40 ppm. Maurya *et al.*, (2020) also reported the increased of TSS and total sugar in mango at spray of GA₃ 75 ppm + NAA 40 ppm and Badal and Tripathi (2021b), who also found increased TSS and total sugars with NAA 75 ppm spray in guava.

Titrateable acidity : The minimum titrateable acidity per cent was found in fruits which were produced from the plants treated with GA₃ @ 60 ppm (0.51%), whereas the maximum titrateable acidity per cent (0.67%) was recorded in fruits which were kept under control. Titrateable acidity content of fruits was found less with the foliar application of plant bio-regulators and micronutrient, which might be due to an increase in translocation of photosynthates (carbohydrates) and more metabolic conversion of acids to sugars by the revers reaction of glycolytic path way which is utilized in various physiological activities. Another reason for reduction in acidity per cent might be the early ripening of fruits which was induced by the plant bio-regulators and micronutrient spray due to which degradation of acids might have occurred. These results are in accordance to the reports of Tripathi *et al.*, (2019) who reported increased TSS and total sugar content in mango with the application of GA₃ 50 ppm + NAA 40 ppm. Results obtained during present experimental period are also in line with the findings of Dubey *et al.*, (2017) in strawberry, Shukla *et al.*, (2011), Tiwari *et al.*, (2017), Tripathi *et al.*, (2018), Bhadauria *et al.*, (2018) in aonla and Verma *et al.*, (2021) in strawberry.

Ascorbic acid : Significantly higher quantity of ascorbic acid (37.91 mg) was recorded in fruits which were produced from the plants treated with GA₃ @ 40 ppm, followed by 37.44 mg in GA₃ @ 60 ppm treated plants, whereas lower amount of ascorbic acid (28.52 mg) content was recorded in fruits which were produced from the plants kept under control. This increase in ascorbic

acid content with gibberellic acid application might be due to uninterrupted synthesis of its precursor like glucose-6-phosphate during conversion of starch into various sugars and low rate of oxidation. These results have got the support with the findings of Dubey *et al.*, (2017) in strawberry, Shukla *et al.*, (2011), Bhadauria *et al.*, (2018) in aonla, Tripathi *et al.*, (2019), Maurya *et al.*, (2020) in mango and Verma *et al.*, (2021) in strawberry.

References

1. A.O.A.C. (1980). Official method of analysis. Association of Official Analytical Chemists (12th edn.), Washington. D.C.
2. Badal, D.S. and Tripathi, V.K. (2021a). Influence of foliar feeding of naa and boron on growth, flowering, fruiting, and yield of winter season guava (*Psidium guajava* L.) cv. L-49. Biological Forum—An International Journal, 13 (3):387-391.
3. Badal, D.S. and Tripathi, V.K. (2021b). Effect of foliar application of NAA and Boron on physico-chemical parameters of winter season guava (*Psidium guajava* L.) cv. Lucknow-49. The Pharma Innovation Journal, 10 (9): 928-932.
4. Bhadauria, A.S., Tripathi, V.K., Singh, A. and Gupta, S. (2018). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. Progressive Research-An International Journal, 13 (3): 216-219.
5. Dubey, Vishal, Meena, M.L. and Tripathi, V.K. (2017). Effect of plant bio-regulators and micronutrient on vegetative growth, yield and quality of strawberry cv. Chandler. Progressive Research-An International Journal, 12 (3): 330-332.
6. Kumar, R., Tripathi, V.K., Tomar, S. and Chaudhary, M. (2018b). Effect of best plant bio-regulators and micronutrient for achieving higher yield and quality of mango (*Mangifera indica* L.) fruits cv. Amrapali. Journal of Plant Development Sciences, 1 (11): 599-604.
7. Kumar, R., Tripathi, V.K., Tomar, S., Chaudhary, M. and Jeevan, R. (2018a). Effect of best plant bio-regulators and micronutrient for getting higher fruit setting in mango (*Mangifera indica* L.) cv. Amrapali. Journal of Plant Development Sciences, 10 (11): 701-705.
8. Lal, D., Tripathi, V.K., Kumar, S. and Nayyer, M.A. (2015). Effect of pre-harvest application of gibberellic acid, NAA, and calcium nitrate on fruit drop, maturity and storage quality of Kinnow Mandarin. Res. Environ. Life Sci., 8 (4) 561-564.
9. Maurya, P.K., Tripathi, V.K. and Gupta, S. (2020). Effect of pre-harvest application of GA3, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali. Journal of Pharmacognosy and Phytochemistry, 9 (6): 2123-2127.
10. Parauha, S. and Pandey, S.K. (2019). Influence of plant growth regulators and nutrients on fruit retention, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali. Journal of Pharmacognosy and Phytochemistry, 8 (2): 550-555.
11. Shukla, H.S., Kumar, V. and Tripathi, V.K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits 'Banarasi'. Acta Horticulturae, 890, 375-380.
12. Singh, T., Tripathi, V.K. and Tiwari, P. (2017). Influence of pre-harvest application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of mango. Progressive Research-An International Journal, 12 (Special-IV): 2640-2644.
13. Singh, V. K. and Tripathi, V. K. (2010). Efficacy of GA3, boric acid and zinc sulphate on growth, flowering, yield and quality of strawberry cv. Chandler. Progressive Agriculture, 10 (2): 345-348.
14. Tiwari, P., Tripathi, V. K. and Singh, A. (2017). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. Progressive Research-An International Journal, 12 (Special-IV): 2565-2568.
15. Tripathi, V.K. and Shukla, P.K. (2008). Influence of plant bio-regulators and micronutrients on flowering and yield of strawberry cv. Chandler. Annals of Horticulture, 1 (1): 45-48.
16. Tripathi, V.K. and Shukla, P.K. (2010). Influence of plant bio-regulators, boric acid and zinc sulphate on yield and fruit characters of strawberry cv. Chandler. Progressive Horticulture, 42 (2): 186-188.
17. Tripathi, V.K., Pandey, S. S., Kumar, A., Dubey, V. and Tiwari, P. (2018). Influence of foliar application of gibberellic acid, calcium and boron on fruit drop, yield and quality attributes of aonla (*Emblia officinalis*) cv. NA7. Indian Journal of Agricultural Sciences, 88 (11): 1784–8.
18. Tripathi, V.K., Singh, A., Bhadauria, A. S. and Gupta, S. (2019). Influence of GA3 and naphthalene acetic acid alone and in combination on fruit drop, yield and quality of mango cv. Amrapali. Progressive Research-An International Journal, 14 (1): 10-13.
19. Verma S., Dwivedi, A.K. and Tripathi, V.K. (2021). Effect of gibberellic acid and boron on growth, yield and yield attributory traits in strawberry (*Fragaria x ananassa* Duch.) under North Gangetic Plains. Biological Forum—An International Journal, 13 (3): 262-267.



Per se Performance in Dual Purpose Sorghum [*Sorghum bicolor* (L.) Moench]

B.L. Meena^{1*}, P.B. Singh², B.R. Ranwah² and S.P. Das³

¹ICAR-DRMR, Bharatpur Rajasthan-321303, India

²MPUAT, Rajasthan College of Agriculture, Udaipur Rajasthan -313001, India

³ICAR-RC for NEH Region Tripura Centre, Lembucherra

*Corresponding authors Email : blmeena.icar@gmail.com

Abstract

The experimental material was generated by line x tester In L x T mating design 10 male sterile lines viz., ICSA 29003 (L₁), ICSA 29004 (L₂), ICSA 29006 (L₃), ICSA 29010 (L₄), ICSA 29011 (L₅), ICSA 29012 (L₆), ICSA 29013 (L₇), ICSA 29014 (L₈), ICSA 29015 (L₉) and ICSA 29016 (L₁₀) were crossed with 3 restorer testers viz., SPV 245 (T₁), SPV 1430 (T₂) and SPV 1822 (T₃) in factorial fashion during kharif 2014. The experimental material of line x tester, thus, consisting of 30 F₁s, 10 MS lines, three restorer testers and three checks viz. CSV 23, CSV 27, and CSH 25 were evaluated in RBD with three replication during kharif 2015 in the four environments. Four environments were created adopting by spacing viz., 22.5 x 5 cm (E₁), 30 x 10 cm (E₂), 45 x 10 cm (E₃) and 60 x 10 cm (E₄). The analysis of variance for experimental design in individual environment revealed significant differences among genotypes for most of the characters in most of the environments. The Bartlett test revealed homogeneous error variance for plant height and ear head length only. The pooled analysis revealed significant differences between the environments and genotypes for both the characters. The mean values of genotypes in different environments revealed that environment E₁ was tested for grain yield, dry fodder yield, green fodder yield and protein content in grain, E₃ for protein in fodder and seed index and E₄ for harvest index where majority of genotypes expressed well. The mean values of ear head length were equally higher in E₃ and E₄.

Key words : *Sorghum bicolor*, per se performance, parent selection, line x tester, hybrid breeding.

Introduction

Sorghum is a very important multi use crop providing food, feed, fodder, forage, fuel etc. It is an energy efficient C₄ plant but, mainly cultivated on marginal soil under rain fed condition with low inputs. Considerable progress has been made in developing improved cultivars of grain type. In recent past the importance of dual purpose was realized with a wider acceptance of such genotypes.

In Rajasthan it is cultivated mainly for dual purpose i.e., food and fodder with major emphasis on fodder. Earlier only varieties were popular. But, a well known fact is that the hybrids are having more yield potential than the varieties. Looking to the growth of seed industries and availability of male sterility in this crop hybrids having bright future and yet also equal in number of released varieties.

For improving yield potential of varieties and hybrids, selection of proper parents is very important. This can only be done by knowing the genetic worth of the parental lines; because many times the high yielding parents may not combine well to give desirable segregants/ hybrids. Potential of cross can be judged by heterosis. Sorghum is predominantly self-pollinated crop endowed with a wide range of genetic variability due to its wide range of adaption and free gene exchange among various races.

Careful selection of parents for hybridization is a key of success in any breeding programme. The usefulness of parents may be obtained from their *per se* performance,

Materials and Methods

The experimental material comprised of 10 male sterile lines viz., ICSA 29003 (L₁), ICSA 29004 (L₂), ICSA 29006 (L₃), ICSA 29010 (L₄), ICSA 29011 (L₅), ICSA 29012 (L₆), ICSA 29013 (L₇), ICSA 29014 (L₈), ICSA 29015 (L₉) and ICSA 29016 (L₁₀), three restorer testers viz., SPV 245 (T₁), SPV 1430 (T₂) and SPV 1822 (T₃) and three checks viz. CSV 23, CSV 27, and CSH 25. These 10 lines and three testers were crossed in factorial fashion to obtain the 30 hybrids. The crossing programme was attempted at Udaipur during kharif 2014 and at Warangal during rabi 2014-15.

Experimental Design : In this experiment total 46 genotypes (10 lines, 3 testers, 30 crosses and 3 checks) were grown in a randomized block design with three replications in four different environments during *kharif* 2015 at Instructional farm, Rajasthan College of Agriculture, Udaipur (Rajasthan). Each genotype was sown in a single row plot of 2 meter length maintaining a separate crop geometry (spacing) for each environments. The row to row and plant to plant spacing was 22.5 cm x 5 cm, 30 cm x 10 cm, 45 cm x 10 cm and 60 cm x 10 cm in E₁, E₂, E₃ and E₄, respectively.

Table-1 : Mean square for different characters in individual environment.

S.No.	Characters	Env	Rep	Genotype	Checks	P Vs Chk	Parents	Tester	Lines	L Vs T	P Vs C	Crosses	Tester	Lines	L X T	Error
			[2]	[45]	[2]	[1]	[12]	[2]	[9]	[1]	[1]	[29]	[2]	[9]	[18]	[90]
1	Days to maturity	1	3.98	52.30	1.00	48.08**	88.47**	18.11**	111.19**	24.70**	162.24**	38.68**	18.34**	23.07**	48.74**	2.62
		2	2.89	46.51	0.44	42.78**	81.30**	16.33**	102.55**	20.01**	153.39**	33.04**	39.70**	19.44**	39.11**	1.66
		3	0.90	44.15	1.33	45.24**	76.92**	8.78**	97.29**	29.89**	109.86**	32.45**	42.34**	21.36**	36.90**	1.62
		4	1.62	43.18	2.33	43.39**	77.08**	21.78**	95.65**	20.53**	164.41**	29.12**	17.21**	19.38**	35.32**	1.61
2	Plant height	1	228.38	4664.01**	5502.78**	7116.72**	5575.03**	5875.11**	582.23**	7790.05**	19602.69**	3829.78**	21578.80**	3368.44**	2088.34**	244.59
		2	367.75	4622.98**	2000.44**	20733.39**	1592.25**	2890.11**	837.29**	5791.12**	34104.20**	4964.34**	37406.34**	4636.55**	1523.57**	199.05
		3	1213.36**	2775.89*	1119.44**	15204.18**	1417.53**	1058.33*	1242.02**	3715.58**	37223.73**	2246.41**	15802.50**	523.61*	1601.57**	244.42
		4	1767.07**	4656.56**	4381.00**	30724.92**	2012.15**	4999.00**	1026.33**	4910.78**	38078.42**	4342.94**	26938.84**	1495.11**	3256.19**	329.84
3	Green fodder yield	1	1613.83	101741.42**	71415.11**	199062.19**	142641.08**	9216.33*	183051.48**	45796.92**	37.91	86105.58**	126505.54**	91646.25**	78846.36**	2013.91
		2	456.96	72389.61*	5140.11*	404832.18**	53678.03**	26850.33**	23243.63**	381243.08**	72638.53**	75741.33**	404461.48**	68137.56**	43018.75**	1117.98
		3	80.92	22701.12**	29206.33**	956.33	30842.35**	3814.78*	25020.87**	137290.83**	17983.43**	19578.89**	72515.88**	22224.17**	12374.36**	1171.12
		4	3483.25	28495.85**	49284.78**	59073.85**	13472.35**	23713.44**	9134.24**	32033.23**	39687.14**	32715.42**	38902.81**	42038.61**	27366.34**	2109.41
4	Dry fodder yield	1	17.07	9575.48**	14802.78**	22051.62**	6866.19**	5584.00**	7877.41**	329.61	1234.86**	10222.36**	4421.01**	7012.23**	12472.02**	122.78
		2	245.42	19555.94**	7159.11**	51838.78**	17175.53**	3073.78**	8013.19**	127840.09**	17213.42**	20862.36**	131459.38**	12450.87**	12779.55**	323.84
		3	179.01	4576.05	261.44	14135.01**	5163.40**	490.78	5950.70**	7422.91**	5959.24**	4412.35**	9663.68**	2616.82**	4726.63**	278.96
		4	83.96	3219.74**	2989.00**	15079.04**	2492.90**	1026.33**	2926.54**	1523.27**	6878.04**	3179.63**	2049.38**	4888.25**	2450.90**	125.49
5	Ear head length	1	8.90	15.66*	21.78*	63.95**	8.42	19.44*	6.91	0.02	37.14**	16.70**	9.38	26.92**	12.40**	5.26
		2	0.66	19.43**	44.78**	17.12	16.47**	30.11**	15.24**	0.22	41.91**	18.68**	70.63**	14.70**	14.89**	5.44
		3	3.14	26.87**	55.11**	5.67	32.97**	67.00**	25.00**	36.62**	19.52*	23.56**	5.91	30.30**	22.15**	3.61
		4	30.49**	18.93**	57.33**	6.58	26.77**	34.78**	26.50**	13.14	49.49**	12.63**	45.30**	17.71**	6.46	5.98
6	Seed index	1	0.31**	0.20**	0.30**	0.06	0.27**	0.74**	0.18**	0.16**	0.35**	0.17**	0.04	0.19**	0.17**	0.02
		2	0.03*	0.59**	0.13**	4.41**	0.55**	0.83**	0.55**	0.02	0.17**	0.52**	0.89**	0.32**	0.57**	0.01
		3	0.12	0.61**	0.48**	2.67**	0.33**	0.40**	0.35**	0.05	2.28**	0.65**	0.89**	1.04**	0.43**	0.06
		4	0.04**	0.46**	0.33**	1.08**	0.34**	0.60**	0.32**	0.01	2.61**	0.46**	0.43**	0.54**	0.42**	0.01
7	Harvest index	1	0.30	12.72	0.88	192.53**	6.25	2.89	7.42	2.41	12.70	10.37	32.92	9.73	8.19	11.80
		2	6.05	8.18	7.66	1.58	8.96	3.24	10.16	9.55	0.46	8.40	3.59	5.59	10.35	6.79
		3	21.20	134.33**	90.78**	63.35	121.25**	171.38**	111.56**	108.21*	0.00	149.51**	119.97**	229.20**	112.95**	16.49
		4	22.49	40.41	3.67	52.22**	68.98**	3.74	82.48**	78.01**	25.85	31.86**	74.08**	49.64**	18.28**	7.57
8	Grain yield	1	74.62**	461.03**	280.44**	1199.72**	457.80**	252.11**	553.64**	6.62	254.61**	464.81**	150.10**	468.08**	498.15**	14.56
		2	106.44**	1274.01**	411.11**	4959.51**	707.15**	187.44**	523.61**	3398.32**	3088.38**	1448.96**	8072.43**	1266.35**	804.36**	19.75
		3	3.62	367.96**	835.44**	1252.12**	223.58**	42.33**	277.20**	103.51**	1520.08**	350.45**	1496.70**	359.36**	218.64**	6.38
		4	2.11	411.15**	53.44**	1532.93**	410.45**	995.44**	65.94**	2341.05**	742.28**	404.81**	339.70**	133.73**	547.59**	4.39
9	Protein content in grain	1	0.85**	5.12**	3.43**	17.06**	6.91**	0.14	9.09**	0.82*	18.02**	3.95**	0.81**	3.92**	4.32**	0.16
		2	0.01	11.31**	2.78**	6.43**	14.24**	0.87**	15.21**	32.27**	21.34**	10.70**	7.01**	21.36**	5.79**	0.06
		3	0.37	8.42**	4.48**	10.72**	9.75**	2.20**	6.92**	50.36**	6.82**	8.27**	4.29**	11.67**	7.02**	0.31
		4	0.01	9.15**	6.37**	10.46**	14.49**	1.73**	14.98**	35.63**	21.93**	6.92**	0.83**	13.23**	4.44**	0.01
10	Protein content in fodder	1	0.07	3.68**	1.24**	9.52**	1.59**	0.22*	1.84**	2.04**	1.77**	4.65**	1.51**	1.52**	6.56**	0.02
		2	0.07**	3.40**	1.53**	3.95**	3.03**	0.97**	3.77**	0.98**	5.06**	3.69**	4.74**	4.86**	2.99**	0.01
		3	0.01	3.13**	1.37**	2.84**	2.97**	0.87**	3.65**	0.98**	4.02**	3.35**	4.85**	4.39**	2.67**	0.01
		4	1.60**	3.14**	1.79**	3.88**	2.80**	0.47**	3.45**	1.56**	4.87**	3.37**	4.99**	4.65**	2.55**	0.01

*, ** Significant at 5 and 1 percent level of significance.

Traits under Investigation : The observations were recorded on five competitive plants selected at random for each genotype in each replication for four traits viz., plant height, ear head length,. The observations for days to maturity, green fodder yield, dry fodder yield, , seed index, harvest index, grain yield, protein content in grain and protein content in fodder were recorded on plot basis.

Statistical Analysis : Plot means of all the characters were subjected to various statistical analysis except stay greenness. The statistical analysis followed for different experiments were as follows :

Analysis of variance : The plot means of each character were subjected to analysis of variance for individual environment as well as over the environment where error variance in different environment were homogeneous using least square technique of Fisher (1932).

Analysis of variance for individual environment : ANOVA for individual environment is presented in Table-3. In this table looking to the materials used the genotypic variation was further partitioned as mentioned in the table.

The linear model of analysis of variance for individual environment was as under :

$$Y_{ij} = \mu + G_i + R_j + \epsilon_{ij}$$

Where,

Y_{ij} = Value of i^{th} genotype in j^{th} replication,

μ = Population mean,

G_i = An effect of i^{th} genotype which were further partitioned in Parents, Checks, Crosses, Lines, Testers and Line x Tester

R_j = An effect of j^{th} replication and

ϵ_{ij} = An uncontrolled variation associated with i^{th} genotype and j^{th} replication.

The mean, general mean, standard error, critical difference and coefficient of variation were calculated as :

$$\text{Mean } (\bar{X}_i) = \frac{1}{r} \sum_{j=1}^r X_{ij}$$

$$\text{General Mean } (\bar{X}) = \frac{1}{rg} \sum_{i=1}^g \sum_{j=1}^r X_{ij}$$

If mean square due to genotype was significant then CD was calculated as follow :

CD = SE (Diff.) $T_{[(r-1)(g-1)]}$ at 5% or 1% level of significance

$$CV \% = \frac{\sqrt{MSE}}{\bar{X}} \times 100$$

Where,

$\bar{X}_i$ = mean of the i^{th} genotype

$\bar{X}$ = mean over genotypes and replications

$\bar{X}_{ij}$ = value of i^{th} genotypes in j^{th} replication

r, g = number of replications and genotypes, respectively

$$SE (\text{Diff.}) = \frac{\sqrt{2MSE}}{r}$$

MSE = Error mean square (M_{14}) from table 3.2 and

Analysis of variance over environments : The structure of pooled ANOVA is given in Table-3. The statistical model for pooled analysis of variance was as under :

$$Y_{ijk} = \mu + G_i + R_j + E_k + GE_{jk} + \epsilon_{ijk}$$

Where,

Y_{ijk} = Yield of the i^{th} genotype in j^{th} replication of k^{th} environment,

μ = General mean,

G_i = An effect of i^{th} genotype where genotypes were further partitioned into checks, parents, hybrids, parent v/s checks and parents vs hybrids. Parents were further partitioned between testers, lines and testers' v/s lines. Hybrids were partitioned into effects of testers (GCA tester), effects of lines (GCA line) and their interactions line x tester (SCA).

R_j = An effect of j^{th} replication,

E_k = An effect of k^{th} environment,

$(GE)_{jk}$ = An interaction effect of i^{th} genotype with k^{th} environment. This effect was further partitioned into the interaction of environment with checks, parents (testers, lines and testers v/s lines) parents v/s checks, parents v/s hybrids and hybrids (GCA tester, GCA line and SCA)

ϵ_{ijk} = An uncontrolled variation associated with i^{th} genotype in j^{th} replication and k^{th} environment.

Bartlett's test : Before doing the pool analysis of variance homogeneity of error variance was tested using the Bartlett test. Pool analysis was performed only when error variance was homogeneous in different environments.

$$\text{Corrected } \chi^2 = \frac{1}{CF}$$

Where

$$\chi^2 = \frac{1}{3} \left(\sum_{i=1}^I df_i \log_e EMSP - \frac{1}{I} \left(\sum_{i=1}^I df_i \log_e EMS_i \right) \right)$$

$$CF = 1 - \frac{1}{3(I-1)} - \frac{1}{\sum_{i=1}^I df_i} - \frac{1}{\sum_{i=1}^I df_i}$$

df_i = Error degrees of freedom in i^{th} environment

I = Number of environments

EMSP = Pool error mean square, and

EMS_i = Error mean square in i^{th} environment.

Critical Difference (CD) : In case of significant mean square due to genotypes the CD was calculated as follows.

To compare between means of any two genotypes in two different environments or within environment

$$CD \sqrt{\frac{2M_{27}}{r}} t_{[s(g-1)(r-1)]} \text{ at 5\% and 1\% level of significance}$$

To compare between means of any two genotypes over environments

$$CD \sqrt{\frac{2M_{27}}{sr}} t_{[s(g-1)(r-1)]} \text{ at 5\% and 1\% level of significance}$$

To compare means of two environments

$$CD \sqrt{\frac{2M_{27}}{gr}} t_{[s(g-1)(r-1)]} \text{ at 5\% and 1\% level of significance}$$

M_{27} = Error mean square from pooled analysis

Results and Discussion

Analysis of variance for experimental design and mean values : The analysis of variance for experimental design in individual environment (Table-1) revealed significant differences among genotypes for all the characters in all the four environments except for days to maturity in all the four environments, dry fodder yield in E_3 and harvest index in E_1 , E_2 and E_4 . Partitioning of genotypic variance into parents, crosses and parents v/s crosses revealed that for all the characters under study there were significant difference in all the environments except mean squares due to ear head length in E_1 and harvest index in E_1 and E_2 , mean squares due to parents v/s crosses for green fodder yield in E_1 , and harvest index in all the four environments and mean squares due to crosses for harvest index in E_1 and E_2 .

The Bartlett test (Table-2) revealed that error variance was homogeneous for plant height and ear head length only. Therefore pooled analysis was carried out for these two characters only.

Table-2 : Test of homogeneity of error mean square (Bartlett test).

S. No.	Character	Bartlett value [3]
1.	Days to maturity	8.26*
2.	Plant height	5.96
3.	Green fodder yield	15.46**
4.	Dry fodder yield	34.82**
5.	Ear head length	6.23
6.	Seed index	153.55**
7.	Harvest index	23.07**
8.	Grain yield	62.52**
9.	Protein content in grain	200.69**
10.	Protein content in fodder	36.01**

*, ** Significant at 5 and 1 percent level of significance, [] Degrees of freedom.

The pooled analysis revealed significant differences between the environments for both the characters. The mean squares due to genotypes including parents,

crosses and parents vs. crosses were also significant for both the characters. Mean squares due to genotypes x environments interactions were significant for both the characters. The cross x environments and parents x environments was significant for both the characters. The parent vs cross x environments was significant for plant height only. The interaction of checks, parent vs. checks, tester, tester vs lines, parent vs crosses with environment were non significant for ear head length (Table-3).

The analysis of variances revealed non-significant difference between the genotypes in all the environments and the error variance was not homogeneous in environments. The average days to maturity were 101.80, 101.93, 102.01 and 102.01 days in E_1 , E_2 , E_3 and E_4 , respectively (Table-5).

Analysis of variance over the environment revealed significance difference between checks, parents and crosses. Interactions of parents and crosses with environments were also significant. The average plant height in E_1 , E_2 , E_3 , E_4 and pool was 188.90, 191.54, 174.28, 180.47 and 183.80 cm, respectively. Among the checks CSV 23 recorded maximum plant height in E_1 (250 cm) and pool (224.25) and CSV 27 in E_2 (240.67 cm), E_3 (213.33 cm) and E_4 (224.25). None of the parents had plant height more than best check.

Crosses $L_3 \times T_3$ (293.33 cm), $L_5 \times T_3$ (284.00 cm) and $L_7 \times T_3$ (270.00 cm) in E_2 , $L_3 \times T_3$ (251.00 cm) and $L_7 \times T_3$ (242.25 cm) in pool were significantly superior than the best check (Appendix II). Different between genotypes was significant in all the four environments and error variance was not homogeneous. The average green fodder yield in E_1 , E_2 , E_3 and E_4 was 541.76, 381.86, 385.21 and 327.67 q, respectively. Among the checks CSV 23 exhibited maximum green fodder yield in E_1 (869.00 q) and E_4 (515.67 q) and CSV 27 in E_2 (600.00 q) and E_3 (511.00 q). Among the parents T_1 in E_3 (536.00 q) and L_8 (548.00 q) in E_3 were significantly superior than the best check. Crosses $L_5 \times T_3$ (788.33 q) and $L_{10} \times T_3$ (713.33 q) in E_2 were significantly superior to their respective best check (Table 5).

Different between genotypes was significant in E_1 , E_2 and E_4 environments and error variance was not homogeneous. The average dry fodder yield in E_1 , E_2 , E_3 and E_4 was 185.95, 164.92, 162.78 and 129.25 q, respectively. Among the checks CSV 23 exhibited maximum dry fodder yield in E_1 (312.33 q) and E_2 (278.33 q) and CSH 25 in E_4 (182.00 q). None of the parents had dry fodder yield more than best check. Crosses $L_2 \times T_3$ (329.67 q) and $L_6 \times T_3$ (390.00 q) in E_2 were significantly superior to their respective best check (Table-5).

Analysis of variance over the environment revealed

Table-3 : Mean square over the environment for plant height and ear head length.

S. No.	Source	df	Plant height	Ear head length
1.	Environment	3	8631.70**	148.40**
2.	Rep./Env	8	894.14**	10.80*
3.	Genotype	45	11407.00**	42.91**
	Check	2	7361.40**	160.19**
	P vs Chk	1	69417.00**	72.93**
	Parent	12	5505.50**	51.04**
	Tester	2	13099.00**	136.69**
	Line	9	4037.30**	35.39**
	T v/s L	1	3532.60**	20.53**
	P v/s C	1	127000.00**	144.26**
	Cross	29	9816.50**	28.74**
	Tester	2	98585.00**	60.43**
	Line	9	3819.90**	45.46**
	L x T	18	2951.70**	16.87**
4.	G x E	135	1770.90**	12.66**
	Check x E	6	1880.80**	6.27
	Chk Vs P x E	3	1454.10**	6.79
	P x E	36	1697.10**	11.20**
	T x E	6	574.45*	4.88
	L x E	27	1443.50**	12.75**
	T v/s L x E	3	6225.00**	9.82
	P v/s C x E	3	668.12*	1.27
	Cross x E	87	1855.60**	14.27**
	T x E	6	1047.20**	23.60**
	L x E	27	2067.90**	14.72**
	L x T x E	54	1839.30**	13.01**
5.	Pooled Error	360	254.47	5.07

*, ** Significant at 5 and 1 percent level of significance.

significance difference in checks, parents and crosses. Interactions of parents and crosses with environments were also significant. The average ear head length in E₁, E₂, E₃, E₄ and pool was 32.67, 33.00, 34.67, 34.67 and 33.74 cm, respectively. Among checks CSH 25 recorded maximum ear head length in E₁, E₂, E₃, E₄ and pool being 32.67, 33.00, 34.67, 34.67 and 33.75 cm long, respectively. Among parents only T₂ (36.00 cm) in E₃ was found significantly superior than best check. Cross L₂ x T₁ (35.67 cm) in E₃ was significantly superior to their best check (Table-6).

Analysis of variance revealed significant difference between genotype in all the four environment but, error variance was not homogeneous. The average seed index in E₁, E₂, E₃ and E₄ was 3.08, 2.96, 3.63 and 3.20 g, respectively. Among the checks CSH 25 exhibited maximum seed index in E₁ (3.44 g), E₂ (3.75 g) and E₄ (3.43 g) and CSV 27 in E₃ (4.39 g). Among the parents T₃ in E₁ was significantly superior than best check. Crosses L₃ x T₁, L₃ x T₂ and L₅ x T₃ in E₄ were having mean values more than the best check (Table 6). Different between genotypes was significant in E₃ environments only and error variance was not homogeneous. The average harvest index in E₁, E₂, E₃ and E₄ was 37.68, 37.62, 41.20 and 42.84 per cent, respectively. Among the checks CSV

Table-4 : Correlation between line and F₁ per se for different testers.

S.No.	Character	Env	T ₁	T ₂	T ₃
1.	Days to maturity	1	0.10	-0.32	0.45
		2	0.16	-0.47	0.49*
		3	-0.03	-0.43	0.49*
		4	-0.07	-0.30	0.37
2.	Plant height	1	-0.56**	-0.35	-0.27
		2	0.65**	0.39	0.51*
		3	-0.05	0.66**	-0.07
		4	0.13	0.53*	-0.27
		Pool	-0.18	0.49*	0.19
3.	Green fodder yield	1	0.26	-0.20	0.01
		2	-0.11	0.26	-0.29
		3	-0.08	-0.10	0.11
		4	0.28	0.51*	0.05
4.	Dry fodder yield	1	0.10	0.25	-0.14
		2	-0.10	-0.25	0.55*
		3	-0.00	-0.17	0.23
		4	-0.29	0.28	0.09
5.	Ear head length	1	-0.04	0.11	-0.28
		2	0.16	0.21	0.50*
		3	0.49*	-0.06	-0.01
		4	0.17	0.61**	0.38
		Pool	0.08	0.31	0.24
6.	Seed index	1	-0.19	-0.57**	0.37
		2	-0.09	0.36	-0.05
		3	0.22	-0.42	0.08
		4	0.61**	0.21	0.48*
7.	Harvest index	1	0.25	0.15	0.18
		2	-0.32	0.07	0.46
		3	0.41	0.74**	-0.26
		4	0.11	-0.08	-0.31
8.	Grain yield	1	0.38	0.14	0.12
		2	-0.32	-0.06	0.02
		3	0.54*	0.35	-0.16
		4	-0.37	-0.08	0.24
9.	Protein content in grain	1	0.39	0.39	0.53*
		2	0.60**	0.47	0.58**
		3	0.63**	0.02	0.58**
		4	0.72**	0.75**	0.29
10.	Protein content in fodder	1	-0.06	-0.01	0.10
		2	-0.53*	-0.20	-0.32
		3	-0.50*	-0.28	-0.33
		4	-0.56**	-0.29	-0.36

*, **Significant at 1 and 5 per cent level of significance, respectively.

23 exhibited maximum harvest index in E₃ (44.28%). Among the parents L₆ in E₃ was significantly superior than best check. cross L₁₀ x T₁ (54.95) was significantly superior to the best check CSV 23 in E₃. Difference between genotypes was significant in E₁, E₂, E₃ and E₄ environments and error variance was not homogeneous. The average grain yield in E₁, E₂, E₃ and E₄ was 44.14, 39.16, 40.75 and 32.76 q, respectively. Among the checks CSV 23 exhibited maximum grain yield in E₁ (63.67 q), E₂ (67.67 q) and E₃ (66.67 q) and CSH 25 in E₄ (47.67 q). None of the parents had grain yield more than best check. Crosses L₁ x T₃ (106.00 q), L₂ x T₃ (78.00 q), L₆ x T₃ (81.33 q) and L₆ x T₁ and L₇ x T₁ (55.33 q) in E₂ were significantly superior than the respective best check (Table-7).

Table-5 : Mean values for DFY, Days to maturity and GFY.

S.No.	Genotype	Dry fodder yield				Days to maturity				Green fodder yield			
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
1.	T1	222.00	240.00	161.00	121.67	104.00	104.67	103.33	105.33	529.33	621.67	536.00	385.00
2.	T2	154.00	282.67	185.33	112.33	99.33	100.00	100.00	100.00	451.67	471.33	469.00	248.00
3.	T3	142.00	220.00	180.00	148.00	103.00	102.33	102.33	102.00	422.00	447.00	523.67	414.67
4.	L1	128.67	92.00	111.67	161.00	101.67	101.00	101.00	102.00	377.67	259.33	232.33	282.33
5.	L2	119.33	89.33	99.00	85.33	97.33	98.00	98.00	98.33	246.00	261.00	291.33	329.33
6.	L3	171.33	99.00	117.00	93.00	93.33	94.33	94.33	94.00	612.67	300.33	355.33	318.33
7.	L4	269.67	93.00	95.33	86.67	102.67	102.00	101.67	102.00	780.00	227.67	306.33	255.67
8.	L5	154.00	97.00	109.00	128.00	100.67	100.67	101.33	101.67	318.33	228.00	326.00	248.00
9.	L6	122.00	241.67	183.67	77.33	103.33	103.67	103.67	104.00	363.00	494.33	380.00	300.00
10.	L7	206.67	155.67	204.33	94.67	110.00	109.33	109.67	110.33	799.67	328.00	474.00	163.00
11.	L8	179.67	110.33	149.00	144.00	110.67	110.67	110.67	110.67	859.33	272.33	548.00	363.33
12.	L9	201.00	71.33	141.67	154.00	110.00	109.67	109.67	109.67	318.67	254.67	370.33	255.67
13.	L10	243.33	67.33	216.33	101.00	110.33	111.00	109.67	109.00	814.67	161.00	403.67	296.33
14.	L1 x T1	267.00	81.33	168.00	152.67	101.00	100.33	100.33	102.67	765.33	202.67	321.00	403.67
15.	L2 x T1	127.33	78.00	126.67	154.33	97.33	97.33	98.00	98.33	340.67	205.67	345.67	344.33
16.	L3 x T1	83.00	79.67	196.33	149.33	104.00	105.00	106.67	104.33	726.00	192.00	311.00	344.33
17.	L4 x T1	177.33	114.33	155.33	177.67	103.33	103.33	103.67	103.67	689.00	236.33	331.00	400.00
18.	L5 x T1	261.33	198.67	209.67	112.00	96.67	98.00	98.00	98.00	477.00	433.33	516.67	359.33
19.	L6 x T1	167.00	89.67	126.33	151.00	99.67	99.67	100.00	100.33	326.00	238.67	266.67	359.33
20.	L7 x T1	110.33	128.33	146.00	140.67	99.67	100.67	101.33	100.33	333.33	397.33	380.33	233.00
21.	L8 x T1	228.33	107.33	178.33	80.33	96.33	99.00	98.33	97.67	718.67	283.33	316.33	321.33
22.	L9 x T1	303.67	94.67	154.67	148.33	105.33	105.00	104.67	104.00	864.33	233.33	390.00	264.67
23.	L10 x T1	256.00	126.67	204.33	82.33	105.33	104.67	105.00	105.00	800.00	283.67	368.67	203.67
24.	L1 x T2	233.00	96.67	179.33	175.33	106.00	106.33	105.67	105.67	567.33	355.33	375.00	463.00
25.	L2 x T2	216.67	110.67	180.67	152.67	104.33	104.33	105.00	104.33	619.00	247.00	464.00	381.67
26.	L3 x T2	211.67	163.67	129.33	147.67	99.67	101.00	102.00	100.00	606.00	408.33	350.67	181.33
27.	L4 x T2	242.00	105.00	90.00	97.00	103.67	104.67	104.00	104.33	372.67	291.67	266.33	192.67
28.	L5 x T2	72.67	128.67	129.67	108.67	104.67	105.00	104.00	102.67	307.33	400.00	316.33	367.00
29.	L6 x T2	148.33	134.67	161.33	102.00	103.33	103.33	104.00	104.00	563.00	416.67	267.33	300.00
30.	L7 x T2	165.00	130.67	149.33	69.00	98.67	99.67	99.67	99.00	377.67	410.33	335.67	177.67
31.	L8 x T2	124.67	217.67	149.00	110.00	103.67	103.33	103.67	102.67	383.00	589.00	380.00	507.33
32.	L9 x T2	201.67	171.67	211.00	118.00	103.67	103.00	104.00	103.67	396.33	325.67	360.00	292.67
33.	L10 x T2	199.33	286.00	84.33	144.33	92.33	93.33	94.00	93.67	597.00	357.00	286.33	200.67
34.	L1 x T3	205.00	171.00	235.00	175.67	96.67	97.00	97.33	97.67	789.67	403.33	459.33	418.33
35.	L2 x T3	207.33	329.67	152.67	187.33	98.33	97.67	97.67	97.67	496.33	390.00	513.67	527.67
36.	L3 x T3	210.67	311.67	171.67	147.67	102.67	102.33	102.33	103.00	634.67	750.00	494.33	381.33
37.	L4 x T3	134.00	150.33	151.33	151.33	96.00	97.00	97.33	97.33	425.00	466.00	414.67	383.33
38.	L5 x T3	186.67	284.67	214.33	157.00	99.00	98.67	97.67	98.33	511.33	788.33	432.67	468.67
39.	L6 x T3	128.67	390.00	207.33	81.00	99.00	97.67	99.00	100.00	363.00	387.33	261.00	179.33
40.	L7 x T3	209.00	215.33	200.00	100.00	99.67	98.67	98.67	98.67	689.00	562.67	475.00	396.33
41.	L8 x T3	150.67	186.33	193.00	122.00	103.67	102.67	102.67	102.67	332.00	283.00	513.67	359.67
42.	L9 x T3	89.00	109.67	100.33	105.00	106.33	105.33	105.00	105.33	348.00	283.33	301.33	181.00
43.	L10 x T3	224.00	252.67	196.33	154.33	103.67	104.00	104.67	104.33	523.67	713.33	451.00	459.33
44.	CSV 23	312.33	278.33	203.67	177.00	100.33	101.00	101.67	100.67	869.00	583.00	313.67	515.67
45.	CSV 27	207.33	181.00	185.00	125.00	101.33	101.67	100.33	101.00	574.33	600.00	511.00	385.33
46.	CSH 25	179.00	222.33	194.00	182.00	101.33	101.00	101.00	102.33	642.33	521.33	413.33	259.33
	GM	185.9	164.92	162.78	129.25	101.80	101.93	102.01	102.01	541.76	381.86	385.21	327.67
	PM	177.97	143.03	150.26	115.92	103.56	103.64	103.49	103.77	530.23	332.82	401.23	296.90
	F1 M	184.71	168.18	165.06	131.82	101.12	101.27	101.48	101.31	531.41	384.49	375.52	335.09
	Chk M	232.89	227.22	194.22	161.33	101.00	101.22	101.00	101.33	695.22	568.11	412.67	386.78
	Se	6.40	10.39	9.64	6.47	0.94	0.74	0.73	0.73	25.91	19.30	19.76	26.52
	CD5%	17.97	29.19	NS	18.17	NS	NS	NS	NS	72.80	54.24	55.51	74.50
	CV	5.96	10.91	10.26	8.67	1.59	1.26	1.25	1.24	8.28	8.76	8.88	14.02

Table-6 : Mean values for plant height, Ear head length and green fodder yield.

S.No.	Genotype	Plant height					Ear head length				Seed index			
		E1	E2	E3	E4	Pool	E1	E2	E3	E4	E1	E2	E3	E4
1.	T1	108.67	154.33	153.33	141.67	139.50	24.00	24.00	27.00	27.67	2.74	3.49	3.75	3.47
2.	T2	128.67	191.33	155.00	156.67	157.92	29.00	30.33	36.00	34.00	2.93	2.48	3.06	2.65
3.	T3	193.33	216.00	186.67	218.67	203.67	27.33	27.33	29.00	28.67	3.68	2.72	3.19	2.73
4.	L1	218.33	127.33	115.00	119.33	145.00	25.33	29.00	27.67	31.67	3.08	3.19	3.01	3.20
5.	L2	161.33	172.33	143.33	169.00	161.50	27.67	30.67	33.67	34.67	2.69	2.75	3.74	2.71
6.	L3	138.33	153.67	137.00	143.33	143.08	28.33	27.33	27.67	29.00	3.45	3.47	3.85	3.39
7.	L4	143.33	138.33	108.33	120.67	127.67	27.33	23.33	23.00	27.33	2.61	2.20	3.19	2.64
8.	L5	133.33	171.67	150.00	153.67	152.17	24.00	29.00	29.67	30.00	3.01	2.71	3.79	3.21
9.	L6	151.67	159.00	159.67	146.33	154.17	27.00	28.00	30.33	27.33	2.89	3.19	3.80	3.01
10.	L7	245.00	185.33	180.00	161.67	193.00	27.00	24.67	25.33	27.00	2.94	2.51	3.23	3.00
11.	L8	238.00	160.00	140.00	171.67	177.42	26.33	29.00	27.67	30.00	2.88	2.81	3.34	2.98
12.	L9	181.67	161.00	145.00	133.00	155.17	26.00	27.33	29.33	25.00	2.89	3.29	2.99	3.29
13.	L10	160.00	154.33	140.00	138.33	148.17	29.33	25.67	29.33	25.33	3.24	2.33	3.28	2.35
14.	L1 x T1	150.00	143.67	153.33	161.67	152.17	25.00	26.33	25.00	28.00	3.18	3.16	4.16	3.37
15.	L2 x T1	150.00	246.67	173.33	184.33	188.58	25.00	27.33	35.67	32.33	2.82	2.68	4.24	3.03
16.	L3 x T1	225.00	168.33	183.33	151.67	182.08	28.67	22.33	26.33	29.00	2.66	2.73	4.76	3.92
17.	L4 x T1	210.00	148.33	198.33	201.00	189.42	28.33	25.67	29.00	34.00	3.03	2.92	3.67	3.34
18.	L5 x T1	195.00	210.00	191.67	218.67	203.83	30.00	30.33	32.67	32.67	3.45	3.63	3.17	3.73
19.	L6 x T1	194.67	205.67	171.67	178.33	187.58	30.00	26.33	27.67	33.33	3.55	3.58	3.42	3.33
20.	L7 x T1	178.33	178.67	178.33	185.00	180.08	27.33	29.67	30.00	31.67	3.04	2.94	3.53	3.07
21.	L8 x T1	160.33	171.33	171.67	169.67	168.25	28.33	28.33	27.33	31.00	3.39	2.89	3.20	2.81
22.	L9 x T1	183.00	172.67	146.67	171.67	168.50	26.33	28.00	31.33	27.67	2.97	2.88	3.26	2.94
23.	L10 x T1	255.00	195.00	208.33	172.33	207.67	28.00	26.00	27.33	29.33	3.15	3.33	4.01	2.69
24.	L1 x T2	141.33	162.00	150.00	148.67	150.50	28.33	30.00	31.00	31.33	2.98	2.48	3.57	3.03
25.	L2 x T2	166.67	196.00	158.33	166.67	171.92	28.00	31.67	31.67	33.67	3.30	3.41	3.49	2.75
26.	L3 x T2	198.33	172.33	140.00	131.33	160.50	29.67	34.67	28.00	29.00	2.70	3.42	3.51	3.86
27.	L4 x T2	146.33	153.00	130.00	137.67	141.75	27.00	28.33	30.33	30.67	2.97	2.23	3.79	3.01
28.	L5 x T2	199.33	190.33	186.67	225.67	200.50	25.67	31.33	31.00	32.00	3.19	2.36	3.32	2.81
29.	L6 x T2	196.33	189.67	170.00	162.33	179.58	29.33	25.33	32.33	31.33	3.16	2.52	3.30	3.22
30.	L7 x T2	182.67	161.67	183.33	166.33	173.50	35.67	30.67	32.33	29.67	3.41	2.51	2.96	3.19
31.	L8 x T2	168.33	171.33	178.33	191.67	177.42	29.00	30.67	32.67	34.00	2.93	3.36	3.32	3.43
32.	L9 x T2	155.00	170.67	203.33	173.33	175.58	27.67	28.33	24.67	31.00	3.23	2.56	4.13	3.29
33.	L10 x T2	175.00	195.00	151.67	150.67	168.08	26.00	30.00	25.67	30.33	2.91	2.56	3.59	3.45
34.	L1 x T3	193.33	226.67	228.33	250.33	224.67	29.67	30.00	31.33	29.33	3.06	3.55	4.30	3.54
35.	L2 x T3	235.00	253.67	206.67	173.67	217.25	26.00	31.33	31.00	28.33	3.25	3.23	3.91	3.67
36.	L3 x T3	253.33	293.33	208.33	249.00	251.00	30.33	26.33	32.33	29.00	3.26	3.24	4.44	3.74
37.	L4 x T3	253.67	185.67	203.33	250.00	223.17	26.00	29.00	27.00	30.67	2.67	2.98	4.43	3.46
38.	L5 x T3	241.67	284.00	190.00	174.33	222.50	28.33	30.00	28.67	30.67	3.13	3.40	4.00	3.80
39.	L6 x T3	248.33	255.00	240.00	179.00	230.58	29.67	28.00	30.33	29.33	2.93	2.64	3.14	2.51
40.	L7 x T3	250.00	270.00	205.00	244.00	242.25	30.67	26.33	34.67	29.67	3.54	2.70	3.13	3.57
41.	L8 x T3	210.00	237.33	216.67	252.67	229.17	27.33	30.33	29.67	30.33	3.22	2.44	3.80	3.67
42.	L9 x T3	205.00	195.00	175.00	185.67	190.17	24.67	26.00	26.33	26.00	3.25	2.47	3.29	3.52
43.	L10 x T3	165.00	208.33	223.33	270.33	216.75	23.67	29.33	29.00	26.67	3.18	3.23	3.87	2.71
44.	CSV 23	250.00	224.00	190.00	233.00	224.25	27.33	28.33	28.00	29.33	2.99	3.75	3.60	3.64
45.	CSV 27	175.00	240.67	213.33	244.00	218.25	29.33	25.33	26.67	26.00	2.84	3.39	4.39	2.99
46.	CSH 25	176.67	190.00	175.00	173.00	178.67	32.67	33.00	34.67	34.67	3.44	3.75	4.03	3.43
	GM	188.90	191.54	174.28	180.47	183.80	27.78	28.27	29.51	29.99	3.08	2.96	3.63	3.20
	PM	169.36	164.97	147.18	151.85	158.34	26.82	27.36	28.90	29.05	3.00	2.86	3.40	2.97
	F1 M	196.20	200.38	184.17	189.26	192.50	27.99	28.60	29.74	30.40	3.12	2.93	3.69	3.28
	Check M	200.56	218.22	192.78	216.67	207.06	29.78	28.89	29.78	30.00	3.09	3.63	4.01	3.36
	Se	9.03	8.15	9.03	10.49	4.61	1.32	1.35	1.10	1.41	0.08	0.06	0.15	0.04
	CD5%	25.37	22.89	25.36	29.46	12.82	3.72	3.78	3.08	3.97	0.23	0.17	0.41	0.12
	CV	8.28	7.37	8.97	10.06	8.68	8.26	8.25	6.44	8.15	4.69	3.49	6.95	2.22

Table-7 : Mean values for protein content in grain and protein content in fodder.

S.No.	Genotype	Protein content in grain				Protein content in fodder				Grain yield			
		E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
1.	T1	12.08	12.56	11.99	11.60	7.58	8.24	8.07	7.70	49.67	56.33	36.00	29.33
2.	T2	12.50	13.24	13.38	12.83	7.10	7.11	7.00	6.93	31.33	45.33	35.67	35.00
3.	T3	12.23	12.17	13.56	12.99	7.13	7.59	7.53	7.46	40.67	41.00	42.33	63.33
4.	L1	14.42	14.64	12.42	15.69	9.11	7.78	7.89	7.93	28.00	19.33	21.33	30.00
5.	L2	15.15	13.54	11.65	11.03	8.65	8.24	8.11	8.02	23.33	19.33	35.00	26.00
6.	L3	15.22	11.31	11.40	10.94	7.65	7.76	7.76	7.77	39.33	20.00	40.67	22.00
7.	L4	11.31	8.35	9.31	9.23	8.25	8.13	8.02	7.96	54.33	19.00	22.67	30.00
8.	L5	11.72	8.80	8.28	8.20	8.20	6.64	6.74	6.73	38.67	16.33	39.00	24.00
9.	L6	11.55	8.77	8.74	8.22	7.62	9.84	9.80	9.66	22.67	46.33	52.67	21.67
10.	L7	10.46	9.64	10.74	9.46	6.32	5.75	5.73	5.64	46.33	27.67	32.00	19.00
11.	L8	11.93	9.17	9.11	8.77	7.42	8.35	8.28	8.10	54.00	52.67	41.33	29.33
12.	L9	11.26	12.04	11.99	11.26	7.25	8.86	8.95	8.75	47.00	18.33	27.33	16.33
13.	L10	13.11	8.72	9.17	9.23	7.68	7.79	7.84	7.79	61.67	15.00	29.33	23.33
14.	L1 x T1	12.17	13.15	13.21	12.56	8.34	8.49	8.42	8.22	50.33	35.67	36.33	37.33
15.	L2 x T1	11.79	11.44	11.32	10.74	7.53	8.32	8.25	8.16	26.00	18.00	62.33	18.00
16.	L3 x T1	12.92	13.36	12.18	12.81	7.53	8.21	8.20	8.07	65.33	51.67	42.67	16.33
17.	L4 x T1	10.17	9.22	9.30	8.78	5.92	7.73	7.90	7.77	49.00	23.00	47.33	29.33
18.	L5 x T1	12.31	9.81	9.68	8.18	8.11	6.98	6.95	6.91	60.33	41.67	52.33	36.33
19.	L6 x T1	11.19	8.52	7.99	7.81	6.84	5.67	6.01	5.58	29.00	21.67	67.67	62.00
20.	L7 x T1	12.72	9.44	9.37	9.15	8.40	8.84	8.82	8.77	23.00	27.33	54.67	55.33
21.	L8 x T1	12.02	8.44	8.41	8.27	8.57	8.61	8.75	8.67	52.67	27.67	40.00	27.00
22.	L9 x T1	10.59	10.25	10.11	9.65	6.13	7.62	7.64	7.48	52.67	22.00	42.33	38.33
23.	L10 x T1	13.19	12.60	12.07	11.73	9.27	7.28	7.32	7.23	50.67	37.67	52.33	20.00
24.	L1 x T2	14.16	14.95	14.84	13.91	8.05	7.40	7.30	7.24	51.00	29.00	28.67	29.00
25.	L2 x T2	11.20	9.42	9.54	9.18	6.32	7.31	7.33	7.22	54.33	21.67	31.33	49.33
26.	L3 x T2	11.24	10.30	9.26	8.99	8.26	7.80	7.76	7.70	54.67	41.00	23.33	31.00
27.	L4 x T2	11.47	9.78	10.06	9.55	7.52	8.69	8.61	8.18	53.33	26.00	36.00	16.00
28.	L5 x T2	10.14	7.36	10.88	8.42	5.82	6.38	6.43	6.32	15.33	31.33	48.33	19.33
29.	L6 x T2	11.33	8.90	13.24	9.23	7.71	7.10	7.01	7.02	37.00	25.33	40.67	31.67
30.	L7 x T2	10.38	9.72	9.62	9.59	6.13	8.19	8.13	8.07	37.67	30.67	42.33	16.00
31.	L8 x T2	12.08	8.26	8.35	8.37	8.23	8.45	8.29	8.12	54.33	40.00	45.67	31.00
32.	L9 x T2	11.81	8.85	9.74	9.71	8.82	5.88	5.98	5.87	50.00	21.67	36.33	36.33
33.	L10 x T2	12.25	12.92	12.44	11.83	7.39	7.72	7.87	7.73	46.33	61.33	24.33	41.33
34.	L1 x T3	11.34	9.65	9.79	9.39	6.18	5.52	5.55	5.43	51.67	106.00	51.67	38.33
35.	L2 x T3	15.36	12.40	11.72	10.83	9.87	8.65	8.64	8.44	39.67	78.00	49.00	43.67
36.	L3 x T3	11.48	12.28	12.29	11.68	5.35	8.46	8.31	8.20	47.00	73.00	27.67	33.00
37.	L4 x T3	12.06	8.65	9.04	8.97	9.72	5.45	5.56	5.42	36.67	30.67	40.00	46.33
38.	L5 x T3	10.91	8.53	8.45	8.19	6.85	6.32	6.38	6.23	46.67	69.67	41.67	38.33
39.	L6 x T3	10.71	9.75	9.77	9.43	5.88	5.73	5.78	5.66	31.67	81.33	36.33	18.67
40.	L7 x T3	11.67	9.19	9.77	9.09	8.66	8.73	8.73	8.59	51.00	48.33	52.67	37.33
41.	L8 x T3	10.97	7.80	9.77	9.70	5.89	5.88	6.04	5.87	37.00	45.67	54.33	35.33
42.	L9 x T3	10.37	9.41	9.94	9.73	6.63	8.25	8.31	8.07	20.33	17.00	35.33	42.33
43.	L10 x T3	11.60	8.98	9.88	9.44	7.12	6.92	6.93	6.83	56.33	51.00	31.33	34.67
44.	CSV 23	10.49	9.33	9.15	8.86	6.15	7.90	7.94	7.77	63.67	67.67	66.67	41.33
45.	CSV 27	10.29	9.70	8.83	8.53	6.20	6.51	6.61	6.22	54.33	44.33	34.33	39.67
46.	CSH 25	12.24	11.15	11.09	11.20	7.29	6.94	7.06	7.00	44.33	57.67	43.33	47.67
	GM	11.90	10.36	10.50	10.06	7.45	7.52	7.53	7.40	44.14	39.16	40.75	32.76
	PM	12.53	11.00	10.90	10.73	7.69	7.85	7.82	7.73	41.31	30.51	35.03	28.41
	F1 M	11.72	10.11	10.40	9.83	7.43	7.42	7.44	7.30	44.37	41.17	42.50	33.63
	Check M	11.01	10.06	9.69	9.53	6.55	7.12	7.20	7.00	54.11	56.56	48.11	42.89
	Se	0.23	0.15	0.32	0.06	0.09	0.06	0.06	0.05	2.20	2.57	1.46	1.21
	CD5%	0.64	0.41	0.90	0.18	0.25	0.17	0.18	0.14	6.19	7.21	4.10	3.40
	CV	3.31	2.43	5.31	1.08	2.09	1.39	1.45	1.14	8.65	11.35	6.20	6.40

Difference between genotypes was significant in all the four environments but error variance was not homogeneous. The average protein content in grain in E₁, E₂, E₃ and E₄ was 11.90, 10.36, 10.50 and 10.06 per cent, respectively. Among the checks CSH 25 exhibited maximum protein content in grain in all the four environments *i.e.* 12.24, 11.15, 11.09 and 11.20 per cent in E₁, E₂, E₃ and E₄, respectively.

Among the parents L₁ in all four environment; T₂ and T₃ in E₂, E₃ and E₄; T₁ and L₉ in E₁ were significantly superior to the best check CSH 25.

Crosses L₃ x T₁, L₁₀ x T₁ and L₁ x T₂ in all the four environments; L₁₀ x T₂ in E₂, E₃ and E₄; L₆ x T₂ in E₃ and L₁ x T₁ in E₂ and E₄ were significantly superior than the best check CSH 25 (Table 7). Difference between genotypes was significant in all the four environments but error variance was not homogeneous. Among the checks CSV 23 exhibited maximum protein content in fodder in E₂ (7.90 %), E₃ (7.94 %), E₄ (7.77 %) and CSH 25 in E₁ (7.29 %). The average protein content in fodder in E₁, E₂, E₃ and E₄ were 7.45, 7.52, 7.53 and 7.40 per cent, respectively. Among the parents L₂, L₄, L₆ and L₈ having mean values more than best check in all the four environments. The mean value of T₁ in E₁, E₂ and E₃; L₉ in E₂, E₃ and E₄; L₁ and L₁₀ in E₁ and E₄; L₃ and L₅ in E₁ were significantly superior than the best check. Crosses L₁ x T₁, L₂ x T₁, L₃ x T₁, L₇ x T₁, L₈ x T₁, L₄ x T₂, L₈ x T₂, L₂ x T₃ and L₇ x T₃ in all the four environments; L₇ x T₂, L₃ x T₃ and L₉ x T₃ in E₂, E₃ and E₄ and L₅ x T₁, L₁₀ x T₁, L₁ x T₂, L₃ x T₂, L₆ x T₂, L₉ x T₂, L₁₀ x T₂ and L₄ x T₃ in E₁, were significantly superior than the best check (Table-7).

The correlation between *per se* performance of lines and their crosses with tester T₁ was significant positive for plant height and protein content in grain in E₂, days to 50% flowering, dry fodder yield, ear head length, number of seeds per primary, grain yield and protein content in grain in E₃ and seed index and protein content in grain in E₄. The correlation between *per se* performance of lines and their crosses with tester T₂ was significant positive for plant height in E₃, E₄ and pool and harvest index and for protein content in grain in E₃. The correlation between *per se* performance of lines and their crosses with tester T₃ was significant and positive for seed index and protein content in grain in E₁, days to maturity, plant height, green fodder yield, dry fodder yield, ear head length and protein content in grain in E₂, days to 50% flowering and days to maturity in E₃ and seed index and protein content in grain in E₄ (Table-4).

The analysis of variance for experimental design in individual environment revealed significant differences between genotypes for all the characters in all the four

environments except for days to 50 % flowering in E₁ and E₃, days to maturity in all the four environments, dry fodder yield in E₃, number of primaries per plant in E₃, number of seeds per primary in E₁ and E₄, and harvest index in E₁, E₂ and E₄. This indicated significant variation between genotypes for all the characters in all the environments except above. Partitioning of genotypic variance into parents, crosses and parents vs crosses revealed that for all the characters under study there were significant difference between parents in all the environments except for days to 50 % flowering in E₁ and E₃, ear head length in E₁ and harvest index in E₁ and E₂. Difference between crosses was also significant for all the characters in all the environments except for harvest index in E₁ and E₂. Difference between parents and crosses was also significant in most of the cross which indicates existence of average heterosis for these characters in different environments.

The error variance was homogeneous for plant height and ear head length therefore; pooled analysis was carried out only for these two characters. The differences between genotypes, parents, cross and parents vs crosses were significant for both the characters over the environments. This indicates variation among parents and crosses and existence of average heterosis for these two characters. The significance of G x E interaction for both the characters indicated that different genotypes influenced by the environment differentially. Non-significant parents vs cross x environment interaction mean square indicated that the difference between mean of parents and hybrids was constant and in same direction for ear head length. Significance of this mean squares for plant height indicated differential response of parents and crosses in different environments.

The mean values of genotypes in different environments revealed that environment E₁ was best for grain yield, dry fodder yield, green fodder yield, protein content in grain and number of seeds per primary, E₃ for protein content in fodder and seed index and E₄ for number of primaries per plant and harvest index where majority of genotypes expressed their best performance. The mean values of ear head length were equally higher in E₃ and E₄. The earliest flowering was observed in E₄ where as maturity in E₁. Among the checks CSV 23 had maximum mean values for grain yield and dry fodder yield in all the four environments, green fodder yield in E₁ and E₄, number of seeds per primary in E₂, E₃ and E₄, harvest index in E₁, E₃ and E₄ and protein content in fodder in E₂ and E₃. CSH 25 had minimum mean for days to 50% flowering and maximum mean values for ear head length and protein content in grain in all the four environments, seed index in E₁, E₂ and E₄ and number of primary per

plant in E₁ and E₄. And CSV 27 had maximum mean only for plant height in E₂, E₃ and E₄. Therefore these genotypes were considered best check for different characters in respective environments.

Parents significantly out crossed the limit of best check were T₃ in E₄ for grain yield, T₁ and L₈ in E₃ for green fodder yield, L₁ in all the four environments, L₂ and L₃ in E₂, E₃ and E₄, L₂ and L₃ in E₁ and L₉ and L₁₀ in E₂ for protein content in grain. This indicates that only these parent having higher per se performance than best check for these characters in given environments. The crosses having significantly higher mean value than best check were were L₁ x T₃, L₂ x T₃ and L₆ x T₃ in E₂, L₆ x T₁ and L₇ x T₁ in E₄ for grain yield; L₂ x T₃ and L₆ x T₃ in E₂ for dry fodder yield; L₅ x T₃ and L₁₀ x T₃ in E₂ for green fodder yield; L₃ x L₁, L₁₀ x L₁ and L₁ x T₂ in all the four environments, L₁₀ x T₂ and L₃ x T₃ in E₂, E₃ and E₄, L₁ x T₁ in E₂ and E₄, L₂ x T₃ in E₁, L₂ x T₃ in E₂ L₅ x T₂ in E₃ for protein content in grain; L₃ x T₃, L₇ x T₃ in E₂ and pool and L₅ x T₃ in E₂ for plant height; L₈ x T₂ in E₁, E₂ and E₃, L₈ x T₁ in E₁ and E₃, L₈ x T₃ in E₄, L₈ x T₁, L₄ x T₂ and L₇ x T₂ in E₁, L₁ x T₁, L₂ x T₁, L₄ x T₁, L₅ x T₁, L₆ x T₁, L₇ x T₁, L₉ x T₁, L₂ x T₂, L₄ x T₂, L₅ x T₂, L₆ x T₂, L₇ x T₂, L₁₀ x T₂, L₄ x T₃, L₆ x T₃, L₇ x T₃ and L₈ x T₃ in E₃ for days to flowering. Therefore these crosses may be identified as superior crosses for these characters.

The correlation between *per se* performance of lines and their crosses with different testers did not have any specific trend for any character in different environments or in different testers except protein content in grain where correlation was positive and significant in most of the cases. This indicate that protein content in grain in crosses can be predicted on the basis of protein content in lines similar finding were also reported by Meena *et al* (2020), Meena *et al* (2018), Singhania, D. L. (1980), Thanky *et al.* (1981) Khidse *et al.* (1982), Giriraj and Goud (1982) and Sakhare *et al.* (1992)

The difference between mean of parents and mean of F₁'s was significant for all the characters in all the environments except harvest index in all the environments and green fodder yield and number of primaries per plant in E₁. This suggested significant deviation of F₁ means from parental means. Mean of the F₁'s was significantly decreased for days to 50 % flowering, days to maturity, protein content in grain and protein content in fodder in all the four environments whereas, for number of primaries per plant in E₁, green fodder yield in E₃ and number of seeds per primary in E₄. For plant height, grain yield, dry fodder yield, ear head length, number of primaries per plant, number of seeds per primary, seed index the F₁ mean was higher than

parental mean except for green fodder yield in E₃, number of primaries per plant in E₁ and number of seeds per primary in E₄. Increase in F₁ mean was also observed for protein content in fodder in E₁. This indicates presence of average heterosis for these characters in above environments. Such average heterosis was also observed by Khapre *et al.* (2000), Umakanth *et al.* (2006), Kulkarni *et al.* (2007), Rani *et al.* (2008), Salini *et al.* (2008), Sumalini *et al.* (2009), Murty *et al.* (2010), Sajjanar *et al.* (2011), Thakare *et al.* (2011) and Hariprasanna *et al.* (2012) for different characters.

References

- Allard, R.W. (1960) Principles of Plant Breeding. John Wiley and Sons Inc., New York. 485.
- Fisher, R.A. (1932). *The Genetical Theory of Natural Selection*. Clarendon, Oxford.
- Giriraj, K and Goud, J.V. (1982). Genetics of yield and panicle components in grain sorghum. *Crop Improvement*, 9 (2): 111-114.
- Khidse, S. R.; Bhole, N. L. And Borikar, S. T. (1982). Combining ability for leaf water deficit and grain yield in rabi sorghum. *Indian J. Genet.* 42: 82-86.
- Kulakarni, V., Salimath, P.M and Patil, M.S. (2006). Combining ability analysis in rabi sorghum [*Sorghum bicolor* (L.) Moench]. *Crop Research.*, 32 (3): 455-458.
- Murty, U.R. (1985). The concept of vybrid III. Stability of grain, biological and fodder yield of purelines, vybrids and hybrids in *Sorghum bicolor* (L.) Moench. *Cereal Res. Communication*, 13: 169-176.
- Meena BL, Ranwah BR, Das SP, Meena HS, Meena SK, Kumari R *et al.* Assessment of Economic Heterosis in Dual Purpose Sorghum [*Sorghum bicolor* (L.) Moench]. *Int. J. Curr. Microbiol. App. Sci.* 2018; 7(7): 3196-3205.
- BL Meena and BR Ranwah (2020) General and specific combining ability in dual purpose sorghum [*Sorghum bicolor* (L.) Moench]. *Journal of Pharmacognosy and Phytochemistry* 2020; 9(5): 384-391
- Sakhare, R.S., Maheshwari, J.J and Ghorpade, P.B. (1992). Combining ability studies in grain sorghum. *Journal of Soils and Crops*. 2 (1): 17-20.
- Salini, K., Satyanarayana Rao, V., Ramana, J.V and Srinivasa Rao, V. (2008). Line x tester analysis in dual purpose sorghum [*Sorghum bicolor* (L.) Moench]. *The Andhra Agricultural Journal*. 55 (2): 166-174.
- Singhania, D. L. (1980). Heterosis and combining ability studies in grain sorghum. *Indian J. Genet.*, 40: 463-471.
- Thanky, H.H.; Desai, K.B. and Tikka, S.B.S. (1981). Hetsrosis and combining ability in grain sorghum. *GAU Res. J.*, 6 (2): 65-71.
- Umakanth, A.V., Rao, S.S and Kuriakose S.V. (2006). Heterosis in landrace hybrids of post rainy sorghum (*Sorghum bicolor* (L.) Moench). *Indian Journal of Agricultural Research*, 40(2): 147-150.



Identification of Statistical Weights for the Components of the Hunger Index

Arshi Khan* and P.V. Ubale

Department of Statistics, G.S. College of Arts, Commerce and Science, Khamgaon

*Corresponding author : arshi29khan@gmail.com

Abstract

There are many faces of hunger such as loss of energy, lack of interest, increased vulnerability to disease, shortfalls in nutritional status and premature death. Global Hunger Index is a tool that measures hunger globally, by region, and by country. Principal component analysis provides a convenient way of assigning proper weights to the components to form a composite hunger index. The results indicated the highest weight (0.29) for the percentage of stunted children in India followed by percentage of population undernourished (0.25), child mortality (0.24) and percentage of wasted children (0.22). This also suggests the percent contribution of these components is 29%, 25%, 24% and 22%, respectively. Along with the healthy diet improved, processed, complementary foods as well as dairy products and supplements of iron and calcium should be incorporated in the mother's diet.

Key words : *Hunger index, undernourishment, stunting, wasting, child mortality, principal component analysis.*

Introduction

World is facing, one of the many terrible problems which is threatening the existence of human being, a cruel hunger. There are many faces of hunger such as loss of energy, lack of interest, increased vulnerability to disease, shortfalls in nutritional status and premature death.

The development agenda has a factor of brawling with under nutrition and hunger. Poverty reduction being in which, food security and nutrition are been stalked, plays a vital role. Connecting this hunger and malnutrition are not withstand the process required for the targets and even if the portion of hungry people bisects by 2015 under the millennium development goal, the adequacy of people suffering from hunger will be nearly 580 million according to the recent predictions .

Adults who were malnourished as children are less physically and intellectually productive, have lower educational attainment and lifetime earnings and are affected by higher levels of chronic illness and disability . The collaborative efforts of the Government of India and the World Bank in nutrition in 1980 reviewed the effectiveness, efficiency and impact of public spending on nutrition in India, as well as suggesting means for improvement. The report analysed the three main causes for malnutrition i.e. inadequate food intakes, disease and pernicious caring practices. Steps and improvements concerning malnutrition have been taken seriously by the Government, through target food supplementation, micro-nutrient programmes, and food subsidy programmes. The report submitted that these policies and programmes have limited impact on nutrition among the poor, due to ineffective targeting, implementation, and

coverage and a higher level of sustained political commitment is required for India to succeed on the subject of malnutrition. This will definitely require structural actions at the national, state, and local levels in sectors such as agriculture, industry, water, and sanitation . Studied the nutritional situation in India and found that it depends on the measures of undernutrition consulted. FAO estimates based on the national availability of food and its distribution across households suggests that about one quarter of Indian household have a habitual insufficient calorie intake.

Global Hunger Index : It is a tool that measures hunger globally, by region, and by country. The GHI is calculated annually, and its results published in a report issued in October each year.

The GHI was shaped in 2006 initially published by the International Food Policy Research Institute (IFPRI). Welthungerhilfe in 2007, the Irish NGO Concern Worldwide also became a co-publisher. In 2018, the GHI was a joint project of Welthungerhilfe and Concern Worldwide, with IFPRI stepping aside from its involvement in the report.

The 2018 Global Hunger Index (GHI) report, the 13th in the annual progression, presents a multidimensional measure of national, regional, and global hunger by assigning a numerical score based on several aspects of hunger. It then ranks countries by GHI score and compares current scores with past results. It also showed that in many countries and in terms of the global average, hunger and under nutrition have declined since 2000; in some parts of the world, however, hunger and under nutrition persist or have even worsened. Since 2010, 16

countries have seen no change or an increase in their GHI levels (Table-1).

GHI is comprised of four components (5)

(1) Percentage of population undernourished (PUN).

(2) Percentage of Stunted children under 5 years of age.

(3) Percentage of Wasted children under 5 years of age.

(4) Mortality rate of children under 5 years of age.

Percentage of population undernourished (PUN) :

According to Food and Agriculture Organization (FAO), percentage of population undernourished is defined as “the probability that a randomly selected individual from the reference population is found to consume less than his/her calorie requirement for an active and healthy life”. It is written as :

$$PoU = \int_{x_{MDER}} f(x) dx$$

Where; $f(x)$ = probability density function of per capita calorie consumption.

$MDER$ = Minimum dietary energy requirement.

As per the estimates, in ‘The State of Food Security and Nutrition in the World’, report, 189.2 million people are undernourished in India. By this measure 14% of the population is undernourished in India. Also, 51.4% of women in reproductive age between 15 to 49 years are anemic.

The percentage of population undernourished can be calculated using the methodology as suggested by FAO, but the state-wise data required for calculation of prevalence of under nourishment was available for the year 2011-12. Hence, the percentage of population undernourished was calculated from the available data of 2011-12 for 19 states of India published in research article authored by Dr. Vikas Rawal and for remaining states the national average of 17.9 for the year 2011-12 was used (6, 7).

Percentage of Stunted children (CST) : When a child has a low height for his/her age he/she is called stunted child, it is usually due to underfeeding, starvation and recurrent infections. The World Health Organization classifies children who are stunted as those, whose height is lower than average for their age and at least two standard deviations below the WHO’s Child Growth Standards Median. Children who are suffering from developmental retardation as a consequence of deprived diets or recurrent infections tend to be at higher probability for illness and death (UNICEF). Nutritional deficiencies for longer period of time causes Stunting that results in

deferred mental development, poor school performance and abridged intellectual capacity. This consecutively affects economic efficiency at national level. Women of short physique are at higher risk for obstetric difficulties because of a smaller pelvis. These women are at greater risk of delivering an infant with low birth weight; this becomes a great cause to the intergenerational cycle of stunting. These infants with low birth weight or immature intrauterine status probably become smaller as adults. A stunted child may also have an inferior immune system, brain utility and organ development. Performing below average in these areas may also restrict their future productivity and threaten the health of their future children.

But there are dealings by which we can take preventive measures against stunting, particularly in the first 1,000 days between pregnancy and a child’s second birthday. For stunted children, some effects can be reduced and even inverted.

Percentage of children aged < 5 years stunted for age = (number of children aged 0–59 months whose z-score falls below -2 standard deviations from the median height-for-age of the WHO Child Growth Standards/total number of children aged 0–59 months who were measured) x 100.

Percent of Wasted children (CWA) : According to UNICEF the term “wasting” refers to a situation where a child has failed to attain adequate weight for height (W/H). Weight-for height is normally used as an indicator of recent nutritional status. Wasting may be the result of malnourishment or severe disease. Wasting says something about the process by which weakening disease causes muscle and fat tissue to “waste” away. Wasting is sometimes mentioned as “acute malnutrition” because it is had belief that events of wasting have a short period of time. Wasting can be caused by a very low energy consumption (e.g. by starvation), losses of substances that provides nourishment essential for the maintenance of active life due to infection, or a mix of low consumption

and high loss. Infections and conditions connected with wasting cover tuberculosis, chronic diarrhoea, AIDS and higher mesenteric artery syndrome.

There are 51 million wasted children in the world. India alone houses 20 million - that’s half of the world’s severely wasted children. Since 2005 in India, severe wasting in children declined from six per cent to five per cent, while wasting levels remained stagnant (19.8 per cent in 2006, 17.3 per cent in 2018) (NFHS 3 2005-06, CNNS 2016-18).

About 21 percent of children under age 5 are wasted

Table-1 : Global Hunger Index (GHI) rankings for India.

Year	GHI Values	Ranking / Out of Countries
2003	25.73	96/119
2007	25.03	94/119
2008	23.70	66/88
2009	23.9	65/84
2010	32.0	67/84
2011	23.7	67/81
2012	22.9	65/79
2013	21.3	63/78
2014	17.8	55/76
2015	29	80/104
2016	28.5	97/118
2017	31.4	100/119
2018	31.21	103/119
2019	30.3	102/117

Source : GHI annual reports, IFPRI).

(International Institute for Population Sciences, National Family Health Survey (NFHS)-4 2015-16). The national average also hides the greater burden and prevalence among certain geographic areas and population groups. Children from tribal communities have an especially high prevalence of wasting at 21.5 per cent. Severely wasted children are more likely to die because their resistance to infections is weakened by a lack of nutrients. Those who survive may go on to suffer poor growth and development and fail to thrive (UNICEF).

WFH as % of median reference value is calculated this way :

Weight for height

$$= \frac{\text{Weight of a given child}}{\text{Median weight for a given child of that height}} \times 100$$

Cut off points may vary, but <80% (close to -2 Z-score) is often used.

The proportion of children under the age of 5 having low weight for their height reflecting acute under nutrition-2 standard deviation of the WHO child growth standard median.

The recommended reporting system of height for age (H/A) and weight for height (W/H) is in terms of Z-scores — a statistical measure of the distance from the median expressed as a proportion of the standard deviation. The most common cutoff point is -2 Z-score, i.e., two standard deviations below the median values of the international reference. This is the cutoff risk level used to differentiate malnourished children from those adequately nourished. Children whose H/A and W/H scores fall below this point are therefore considered, stunted and wasted, respectively.

Table-2 : State wise values of components of GHI.

S.No.	States / UTs.	PUN	CST	CWA	CM
1.	A & N Islands	17.90	23.3	18.9	1.30
2.	Andhra Pradesh	28.13	31.4	17.2	4.08
3.	Arunachal Pradesh	17.90	29.4	17.3	3.28
4.	Assam	40.78	36.4	17.0	5.66
5.	Bihar	31.09	48.3	20.8	5.81
6.	Chhattisgarh	38.21	37.6	23.1	6.42
7.	Daman & Diu	17.90	23.4	24.1	3.40
8.	D & N Haveli	17.90	41.7	27.6	4.20
9.	Delhi NCT	17.90	32.3	17.1	4.20
10.	Goa	17.90	20.1	21.9	1.29
11.	Gujarat	44.22	38.5	26.4	4.35
12.	Haryana	28.09	34.0	21.2	4.11
13.	Himachal Pradesh	16.31	26.3	13.7	3.76
14.	Jammu & Kashmir	22.84	27.4	12.1	3.76
15.	Jharkhand	39.19	45.3	29.0	5.45
16.	Karnataka	43.69	36.2	26.1	3.22
17.	Kerala	17.90	19.7	15.7	0.71
18.	Lakshadweep	17.90	27.0	13.8	3.00
19.	Madhya Pradesh	38.15	42.0	25.8	6.49
20.	Maharashtra	36.97	34.4	25.6	2.91
21.	Manipur	17.90	28.9	6.8	2.59
22.	Meghalaya	17.90	43.8	15.3	3.97
23.	Mizoram	17.90	28.0	6.1	4.59
24.	Nagaland	17.90	28.6	11.2	3.73
25.	Odisha	34.96	34.1	20.4	4.86
26.	Punjab	28.41	25.7	15.6	3.32
27.	Puducherry	17.90	23.7	23.6	3.22
28.	Rajasthan	29.53	39.1	23.0	5.07
29.	Sikkim	17.90	29.6	14.2	3.22
30.	Tamil Nadu	48.74	27.1	19.7	2.69
31.	Telangana	17.90	28.1	18	3.36
32.	Tripura	17.90	24.3	16.8	3.26
33.	Uttarakhand	18.34	33.5	19.5	7.81
34.	Uttar Pradesh	34.45	46.3	17.9	4.67
35.	West Bengal	38.38	32.5	20.3	3.18

Percent Child Mortality (CM) : Child mortality is defined as the number of deaths of children under five years of age in a given year per one thousand children in this age group. The age constraints, however, may vary among different reports. Some researchers might consider only children between the ages of one and four years, while others might include infant mortality. Infant mortality rate cannot fully account for the effects of weakening nutritional status. Every researcher has an authority of defining child mortality prior its employment in a report before making comparisons with other indicators.

Child mortality rate is calculated as :

$$\text{Child mortality rate} = \frac{\text{no. of deaths under 5 years}}{\text{total no. of live birth}} \times 1000$$

All the 4 components were selected to monitor severity the hunger situation of India. The percentage of people who are food and energy deficient refers to entire population. Wasting, stunting, and child mortality and

these components deals with children under 5 years. This ensures that both the situation, conditions of the population as a whole and that of children particularly physiologically venerable section of a population is captured.

However, instead of per thousand child mortality values percent values are used during the present study for child mortality. The statewide data pertaining to all the above components is given in table-2.

Materials and Methods

Estimation of weights using Principal Component Analysis : The method of Principal Components provides a convenient way of assigning proper weights to the components to form a composite index. Principal Component Analysis (PCA) has traditionally been used to transform a large set of variables into a smaller set of uncorrelated variables that account for most of the variation in the original set of variables.

The method of principal component analysis is used by various researchers for index development; some studies have used the method for deriving a suitable weighting pattern. For example, have analyzed social sector development in the major states of India with the help of suitable composite indices constructed using the method of principal components. Studies like (9) and (10) have also used the method of principal components for constructing suitable 152 indices for analyzing intra-state disparities in levels of socio-economic development.

Thus principal component analysis provides optimal weights that capture the largest fractions of the variance of the original variable based on the data available. The weight of indicator can be obtained from the following formula (11) :

$$\text{Weight of variable } x = \frac{\text{factor score of variable } x}{\text{sum of all scores}}$$

Principal component analysis was performed using the SPSS software trail version 20.

Results of Principal Component Analysis.

Correlations	Stunted	Wasted	Mortality	PUN
Stunted	1			
Wasted	0.414*	1		
Child Mortality	0.685**	0.229	1	
PUN	0.505**	0.513**	0.321	1
Anti-image Matrices	Stunted	Wasted	Mortality	PUN
Stunted	0.625a			
Wasted	-0.206	0.713a		
Child Mortality	-0.639	0.072	0.601a	
PUN	-0.294	-0.385	0.010	0.726a

* & ** Correlation is significant at the 0.05 level & 0.01 level respectively, (2-tailed) a-indicates sample adequacy.

The above table represents the correlation between

the components. The correlation between stunted & wasted, stunted & child mortality, stunted & undernourished population and wasted & undernourished population is significant with correlation coefficient 0.414, 0.685, 0.505 and 0.513, respectively. Whereas, the correlation between wasted & child mortality and child mortality and undernourished population is non-significant with correlation coefficient 0.229 and 0.321. It can be inferred that percentage of population that is undernourished has weak correlation with child mortality implicating that poor nutrition in children leads to long term deficiencies and diseases in the population and could cause death in extreme situation. However, sampling adequacy is calculated on the basis of anti-image of correlation matrix.

Kaiser-Meyer-Olkin Measure

$$= (0.625+0.713+0.601+0.726)/4$$

$$= 0.66.$$

This showed that the sample data used for the present study is fairly adequate and further statistical tools can be applied on this data.

Factor	Eignvalue	% variance	Cumulated percentage
Factor	2.35	58.71	58.71
Final statistics	Communality	Factor score	Derived weight
Stunted	0.757	0.371	0.29
Wasted	0.466	0.291	0.22
Mortality	0.546	0.315	0.24
Undernourishment	0.579	0.324	0.25

Results and Discussion

PCA weights calculated based on data from 35 States of India showed that, the percentage of children who are stunted in India have higher weight of 0.29 and that of wasted is 0.22. The weights for child mortality under 5 years of age and the percentage of population undernourished 0.24 and 0.25 respectively. It can be concluded that the percent contribution of stunted children, undernourished population, child mortality and wasted children are 29%, 25%, 24% and 22%, respectively.

Stunting is a symptom for adverse environmental, both maternal and child health factors, including improper sanitation, restriction of intrauterine growth, micronutrient deficiencies, and inappropriate infant and young child eating habits. Current international recommendations for achieving a 20% reduction in stunting and a 61% reduction in severe wasting include delivery of a set of nutrition-specific interventions at 90% coverage level.

There are number of factors that influence stunting other than those mentioned in nutrition-specific

interventions. Antenatal care, decreased open defecation, low fertility, agriculture, clean water and sanitation, women's education and empowerment, and optimum availability of quality food have been the key factors in reducing stunting, while income growth and political system played a facilitating role.

The formulation of the hunger index is based on four components viz; Prevalence of undernourishment in the total population, stunted children under five years of age, wasted children under five of age, and mortality rate of children under five years of age. It is very important to closely monitor these components.

The problem of stunting, wasting and child mortality in children under five years of age can be prevented by ensuring that the healthy, appropriate and nutritious food is available at an affordable price to every child for consumption to achieve his or her full potential. Infants should be closely monitored for the first 1000 days of birth and essential services should be provided for pregnant and lactating women to ensure the health of the baby and the mother. Along with the healthy diet improved, processed, complementary foods as well as dairy products and supplements of iron and calcium should be incorporated in the mother's diet. Rapid and exclusive breastfeeding to new born baby, trained and experienced staff with antenatal, birth and postnatal care skills, access to nutritious foods, Family knowledge of symptoms that are harmful to a child's health, access to clean water, sanitation and vaccination can prevent most of the diseases that could cause death.

Conclusions

Results of the principle component analysis indicated the highest weight (0.29) for the percentage of stunted children in India followed by percentage of population undernourished (0.25), child mortality (0.24) and percentage of wasted children (0.22). This also suggests the percent contribution of these components is 29%, 25%, 24% and 22%, respectively. Considering the percent contributions of the components, the policies needs to be framed. The percentage of stunted children contributes to about 30% in Hunger Index for India and needs immediate attention followed by percentage of population

undernourished, child mortality and percentage of wasted children.

References

1. FAOSTAT, F. A. O. (2006). FAO statistical databases. *Rome: Food and Agriculture Organization of the United Nations.*
2. UNICEF. (1998). The state of the world's children: Focus on nutrition. *New York: UNICEF.*
3. Measham, A. R., & Chatterjee, M. (1999). *Wasting away: The crisis of malnutrition in India.* The World Bank. Retrieved from elibrary.worldbank.org
4. Svedberg, P. (2008). Why malnutrition in shining India persists. *4th Conference on Growth and Development.*
5. Wiesmann, Doris, Biesalski, H., von Grebmer, K., and Bernstein, J. (2015). Methodological review and revision of the global hunger index. *Available at SSRN 2673491.*
6. Rawal, V., Bansal, V., & Bansal, P. (2019). Prevalence of undernourishment in Indian States Explorations based on NSS 68th round data. *Economic and Political Weekly*, 54(15), 35–45.
7. Mohd, A., Seema, K., Amlendu, S., and Dubey, K. (2020). *Data Gap Analysis , Indicator Selection and Index Development: A Case for Developing Economies.*
8. Prabhu, K. S., & Chatterjee, S. (1993). *Social sector expenditures and human development: A study of Indian states.* Department of Economic Analysis and Policy, Reserve Bank of India.
9. Prabhu, K.S and Sarker, P.C (1992), "Identification of Levels of Development: Case of Maharashtra", *Economic and political Weekly*, September 5, 1992.
10. Shaban, Abdul and Bhole, L.M (1999), "Development and Disparities in Maharashtra: A Spatio-Temporal Analysis", *Indian Journal of Regional Science*, Vol.XXXI, No.I.
11. Wiesmann, D, Weingärtner, L., & Schöninger, I. (2006). *The challenge of hunger: Global Hunger Index: Facts, determinants, and trends.* Retrieved from <https://books.google.com/books?hl=en&lr=&id=40bN91xgGi8C&oi=fnd&pg=PA6&dq=hunger+index+of+india&ots=Tu8NqEdnIE&sig=miksVZBQ14yVful5HTCP5ur0rrc>
12. Bhutta, Z.A., Das, J.K., Rizvi, A., Gaffey, M.F., Walker, N., Horton, S., ... Group, T. L.N. I.R. (2013). Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *The Lancet*, 382(9890), 452–477.
13. Smith, L., and Haddad, L. (2014). Reducing Child Undernutrition: Past Drivers and Priorities for the Post-MDG Era. *IDS Working Papers*, 2014(441), 1–47.



Impact of *Azotobacter* and Vermicompost on Growth, Flowering, Yield and Quality Traits of Strawberry

Vineet Awasthi, V.K. Tripathi, G. Naga Yashasvi and Anushi

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur-208 002

Email : drvkttripathicsa@gmail.com

Abstract

An experiment was carried out during 2019-20 to study the impact of *Azotobacter* and vermicompost on growth, flowering, yield and quality traits of strawberry. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and vermicompost (20 and 25 t/ha) and their combinations along with one control, replicated thrice in randomized block design on strawberry cv. Chandler. Five kg of FYM was applied as a basal dose in all the treatments including control. All the doses of *Azotobacter* and vermicompost were applied at the time of planting in the field. From the results it was reported that the combined application of vermicompost at 25 t/ha + *Azotobacter* at 7 kg/ha significantly increased the height of plant (19.12 cm), number of leaves (63.22), crowns (6.96) and runners (5.86) per plant, whereas maximum number of flowers (65.17), fruits set (38.35) per plant with increased duration of harvesting (68.92 days) and minimum number of days taken to produce first flower (56.12 days) and fruit set (6.28 days) with significantly more yield (235.14 g/plant). Plants fertilized with vermicompost at 25 t/ha + *Azotobacter* at 7 kg/ha also produced the berries with maximum length (5.06 cm), width (3.20 cm), weight (9.02 g), volume (6.07 cc), TSS (10.17°Brix), total sugars (9.35%), ascorbic acid (56.32 mg/100g edible portion) with minimum titratable acidity (0.51%) in comparison to other treatments under plains of central Uttar Pradesh.

Key words : Strawberry, vermicompost, *azotobacter*, flowering, growth, flowering, yield, quality.

Introduction

The modern cultivated strawberry is a hybrid between two American octaploid species *Fragaria chilonensis* and *Fragaria virginiana*, belonging to family Rosaceae and was developed in France during seventeenth century. It is an octaploid in nature with $2n=8x=56$ chromosome number, is a valuable food in the diet of millions of people around the world and gives high return within shortest time than other berry fruits. Its fruits are very nutritious with distinct pleasant aroma and flavour and are consumed as dessert or processed as jam, syrup and ice-cream, etc.

Now-a-days intensive crop cultivation results with the huge application of chemical fertilizers which are not only in short supply but also expensive and pollute the environment, soil and water too. *Azotobacter*, phosphate solubilizing bacteria and vermicompost are main bio-fertilizers and organic manure used for horticultural crops. These bio-fertilizers having micro-organisms which are either free living in soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of plants. They also produce hormones, vitamins and other growth factors required for the growth and development of plants. Therefore, keeping in view, the importance of fruits and the enormous rate of *Azotobacter* and vermicompost an experiment was planned to infer concrete information on the impact of these in respect of vegetative growth, fruiting, yield and quality parameters of strawberry.

Materials and Methods

One year old runners of strawberry cv. Chandler were planted at 30x30 cm spacing on 8-10 cm raised beds of 60x60 cm dimension in the Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.), India on 14th October, 2019. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and vermicompost (20 and 25 t/ha) and their combinations along with one control, replicated thrice in randomized block design. Five kg of FYM was applied as a basal dose in all the treatments including control. All the doses of *Azotobacter* and vermicompost were applied at the time of planting in the field. The data recorded on different parameters during experimentation period were analyzed.

Observations on plant height, number of leaves, crowns and runners per plant were recorded at the end of fruiting season, whereas days taken to produced first flower, fruit set and duration of harvesting were recorded as suggested by Kidmose *et al.*, (1996). Number of flowers and fruits per plant were counted at five days interval during entire cropping season. At each picking, data on berry weight and yield per plant were recorded. The length and width of ten randomly selected berries was measured with vernier caliper. These berries were also used for measuring volume by water displacement method. The TSS of berries was recorded with the help of hand refractometer. The titratable acidity, total sugars and

ascorbic acid contents were determined by the methods as suggested in A.O.A.C. (1980).

Results and Discussion

Height of plants and number of leaves : Height of plants and number of leaves per plant were increased significantly with the use of *Azotobacter* and vermicompost at different levels. The maximum height of plants (19.12 cm) and number of leaves (35.88) per plant were obtained with the application of *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha (Table 1). The height of plants and number of leaves per plant get reduced with the reduction in doses of *Azotobacter*, vermicompost and their combinations and they were minimum in plants kept under control. This increase in growth parameters might be due to the production of more chlorophyll content with inoculation of nitrogen fixers. The other reason for increased vegetative growth may be the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological nitrogen fixation. This increase in height of plants and number of leaves per plant with the application of *Azotobacter* and vermicompost during the course of investigation get the support of Gupta and Tripathi (2012), Tripathi et al., (2015), Tripathi et al., (2016), Tripathi et al., (2017) in strawberry, Patil and Shinde (2013) in banana and Tripathi et al., (2013) in Isabgol.

Number of runners and crowns : During the present investigation the number of runners and crowns per plant were significantly increased with the application of *Azotobacter* and vermicompost at different levels. The maximum number of runners (6.96) and crowns (5.86) per plant were produced in the plants fertilized with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha, whereas the minimum number of runners (2.83) and crowns (2.24) were produced under control treatment. These findings are in complete agreement with that of Tripathi et al., (2015), who narrated highest runners per plant in strawberry with *Azotobacter* at 7 kg/ha + vermicompost at 25 t/ha. Increase number of crown and runners per plant might be due to increased growth of plant in the form of height and number of leaves, which accumulated more photosynthates and thereby increased runners and crown per plant. These investigation get the support of Gupta and Tripathi (2012), Tripathi et al., (2017) in strawberry and Patil and Shinde (2013) in banana.

Days taken to produce first flower and days taken to fruit set : The minimum number of days taken to produce first flower (56.12 days) and days taken to fruit set (6.28 days) were recorded in the plants which were fertilized with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha (Table-1). However, the maximum number of days (74.22

days) taken to produce first flower days taken to fruit set (8.52 days) were recorded in plants kept under control i.e., unfertilized plants. This phenomenon may be on account of prolonged growth of plant in the presence of *Azotobacter* and vermicompost. These results have got the support of the findings of Tripathi et al., (2010), Tripathi et al., (2015), Tripathi et al., (2017), Singh et al., (2019) in strawberry and Patil and Shinde (2013) in banana.

Number of flowers and number of fruits set : Further it was also observed during this investigation that the maximum number of flowers (65.17) and number of fruits set (38.35) per plant was recorded in *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha, whereas, the minimum number of flowers (30.52) per plant and number of fruits set (18.33) were observed in the untreated control plant. It may possibly be due to the fact that *Azotobacter* and vermicompost application accelerated the development of inflorescence, leaf number in autumn, which are positively correlated with the number of flowers and fruits in the following spring. Increased number of flowers might have also resulted because of increase in number of crowns per plant. These results are in conformity with the finding of Gupta and Tripathi (2012), who noted that increase in *Azotobacter* and vermicompost fertilization resulted in increased number of flowers per plant and higher fruit set in strawberry. *Azotobacter* is expected to hasten plant development, hence the increase in berries set during the present studies is due to commutative effect of *Azotobacter* and vermicompost.

Duration of harvesting : During the present investigation the maximum duration of harvesting (68.92 days) was observed when the plants were treated with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha, whereas, the minimum duration of harvesting (52.37 days) was observed in the untreated control plant. Similar results were also recorded by Tripathi et al., (2010), Singh and Singh (2009), Kumar et al., (2020) in strawberry, who got advanced duration of harvesting (earliness) by approximately one month which obviously extended the period of harvesting.

Yield : During the present investigation the maximum yield per plant (235.14 g) was recorded in the plant fertilized with vermicompost 25 tonnes/ha + *Azotobacter* 7 kg/ha followed by 225.53 g from the application of *Azotobacter* 7 kg/ha + vermicompost 20 tonnes/ha, whereas the minimum yield per plant (92.11 g) was recorded from the untreated plants kept under control (Fig.-1). These findings are in line with the findings of Wonge et al., (1998), Tripathi et al., (2010), Gupta and Tripathi (2012), Singh et al., (2019), Srivastav et al., (2019) in strawberry. Tripathi et al., (2015), also recorded higher yield with *Azotobacter* and vermicompost

Table-1 : Influence of different levels of *Azotobacter* and vermicompost on vegetative growth and flowering of strawberry cv. Chandler.

Treatment	Plant height (cm)	Number of leaves/plant	Number of crowns/plant	Number of runners / plant	Days taken to produce first flower	Number of flowers / plant	Days taken to fruit set	Number of fruits set/plant	Duration of harvesting (days)
Vermicompost 20 tonnes/ha	14.30	51.76	3.25	4.05	62.47	40.34	7.55	21.77	61.27
Vermicompost 25 tonnes/ha	15.19	54.44	3.62	4.11	63.73	43.25	8.18	24.70	63.81
<i>Azotobacter</i> 6 kg/ha	16.33	57.28	4.07	4.16	63.43	47.42	7.62	27.15	64.71
<i>Azotobacter</i> 7 kg/ha	17.00	59.32	4.38	4.23	61.76	49.89	7.23	28.53	66.31
Vermicompost 20 tonnes/ha + <i>Azotobacter</i> 6 kg/ha	18.15	59.84	5.27	4.37	60.96	53.77	7.16	30.91	66.86
Vermicompost 25 tonnes/ha + <i>Azotobacter</i> 6 kg/ha	19.05	62.21	6.19	5.57	60.86	59.77	6.54	36.99	67.82
Vermicompost 20 tonnes/ha + <i>Azotobacter</i> 7 kg/ha	18.85	61.38	5.85	4.82	59.27	57.03	6.95	35.30	67.19
Vermicompost 25 tonnes/ha + <i>Azotobacter</i> 7 kg/ha	19.12	63.22	6.96	5.86	56.12	65.17	6.28	38.35	68.92
Control (untreated)	13.63	35.88	2.83	2.24	74.22	30.52	8.52	18.33	52.37
S.E.	1.26	1.92	0.21	0.24	1.83	1.54	0.41	1.77	2.02
CD at 5% level	3.83	5.84	0.64	0.72	5.55	4.68	1.25	5.36	6.13

Table-2 : Influence of different levels of *Azotobacter* and vermicompost on yield and quality of strawberry fruit cv. Chandler.

Treatment	Berry length (cm)	Berry width (cm)	Berry weight (g)	Berry volume (cc)	TSS (°Brix)	Titrateable acidity (%)	Total sugars (%)	Ascorbic acid (mg/ 100 edible portion)
Vermicompost 20 tonnes/ha	2.84	2.21	5.27	4.43	8.24	0.66	6.12	52.09
Vermicompost 25 tonnes/ha	3.16	2.37	6.39	5.20	8.41	0.64	6.66	52.54
<i>Azotobacter</i> 6 kg/ha	3.28	2.50	6.75	5.34	8.67	0.64	7.05	53.20
<i>Azotobacter</i> 7 kg/ha	3.48	2.78	7.02	5.52	8.85	0.63	7.86	53.86
Vermicompost 20 tonnes/ha + <i>Azotobacter</i> 6 kg/ha	3.72	2.81	7.39	5.66	8.94	0.61	8.31	54.34
Vermicompost 25 tonnes/ha + <i>Azotobacter</i> 6 kg/ha	4.16	2.87	8.33	5.82	9.30	0.57	8.68	54.90
Vermicompost 20 tonnes/ha + <i>Azotobacter</i> 7 kg/ha	4.28	2.96	8.49	5.99	9.90	0.53	9.23	55.82
Vermicompost 25 tonnes/ha + <i>Azotobacter</i> 7 kg/ha	5.06	3.20	9.02	6.07	10.17	0.51	9.35	56.32
Control (untreated)	2.38	1.41	4.39	3.48	7.01	0.70	6.48	46.31
S.E.+	0.13	0.31	0.49	0.50	0.56	0.04	0.61	1.57
CD at 5% level	0.40	0.93	1.49	1.52	1.71	0.11	1.84	4.77

application in strawberry. This increase in yield might be due to increased fruit set per plant, increased berry size as well as berry weight and may be due to the fact that nitrogen fixers and organic manures not only increased the availability of nitrogen to the plants but also increased their translocation from root to flower through plant foliage.

Physical Character of Fruits : In the present investigation the berry size (length and width), weight and volume were significantly increased by the use of *Azotobacter* and vermicompost. The maximum berry length (5.06 cm), width (3.20 cm) weight (9.02 g) and volume (6.07 cc) were recorded in the plants fertilized with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha (Table 2) followed by *Azotobacter* 7 kg/ha + vermicompost 20

tonnes/ha (4.28 cm, 2.96 cm, 8.49 g and 5.99 cc, respectively), whereas, the minimum berry length (2.38 cm), width (1.41 cm) weight (4.39 g) and volume (3.48 cc) were recorded under control. Similar results were obtained by Gupta and Tripathi (2012), Tripathi *et al.*, (2015), Tripathi *et al.*, (2016), Tripathi *et al.*, (2017), Kumar *et al.*, (2020) in strawberry and Patil and Shinde (2013) in banana.

This increase in berry size, weight and volume during the present investigation might be due to the increased photosynthetic ability of plants fertilized with *Azotobacter* + vermicompost, which in turn might have favoured and increased accumulation of dry matter. Fruit size, weight and volume are highly correlated with dry

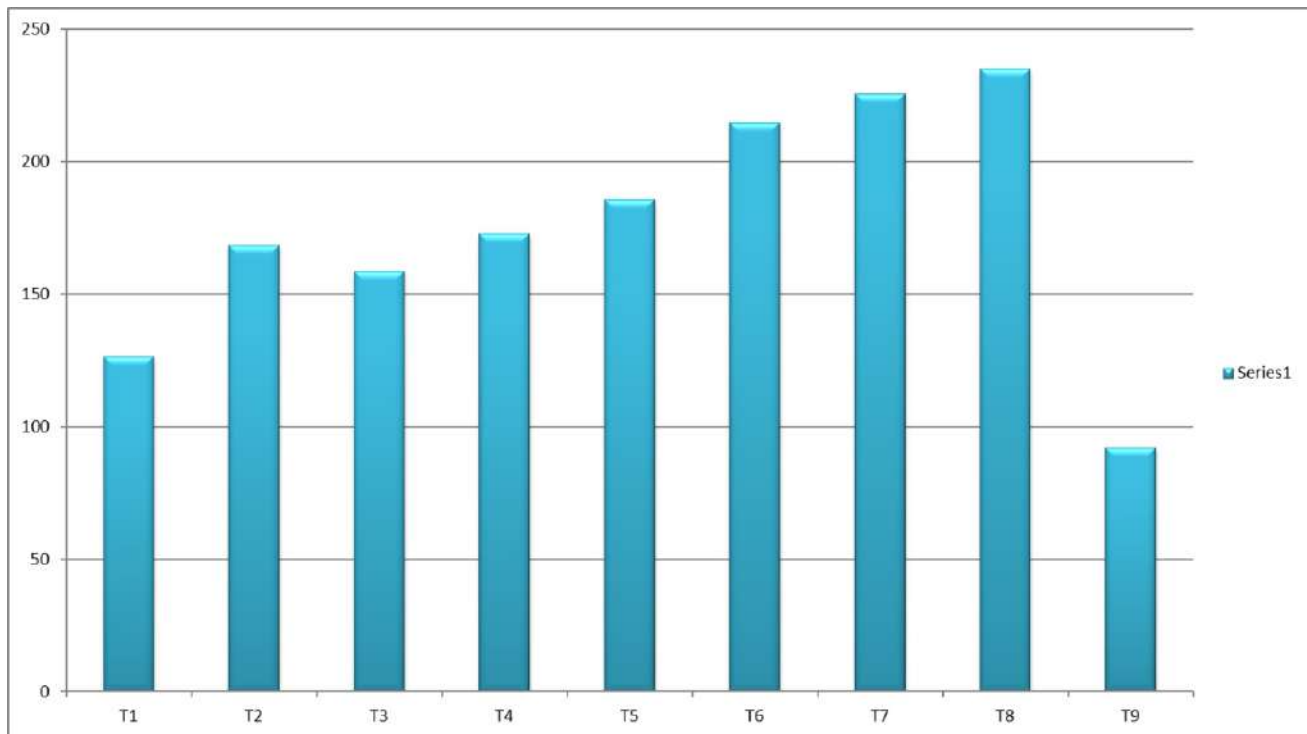


Fig.-1: Impact of *Azotobacter* and vermicompost on yield per plant (g).

matter content and balance level of hormone and nitrogen fixers are known for accumulation of dry matter and their translocation as well as favours synthesis of different growth regulators.

Chemical Character of Fruits : TSS and total sugars content of berries were significantly increased by different level of *Azotobacter* and vermicompost applications. The maximum TSS (10.17 °Brix) and total sugars (9.35%) contents were recorded in the berries produced from the plants fertilized with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha followed by *Azotobacter* 7 kg/ha + vermicompost 20 tonnes/ha (9.90 °Brix, 9.23%, respectively) and the minimum (7.01 °Brix, 6.48%, respectively) under control i.e., in unfertilized plants. Increase in TSS and total sugars contents with *Azotobacter* and vermicompost application may be attributed due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits. These findings are in agreement with the result of Patil and Shinde (2013) in banana, Tripathi *et al.*, (2016), Tripathi *et al.*, (2017) and Kumar *et al.*, (2020) in strawberry.

The maximum titratable acidity (0.70%) was recorded in the berries which were produced from the unfertilized plants (Table-2), whereas, the minimum acidity (0.51 %) was recorded with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha treated plants. The views were corroborated with the observations of Mishra and

Tripathi (2011), Gupta and Tripathi (2012), Tripathi *et al.*, (2015) and Tripathi *et al.*, (2017) in strawberry.

The maximum amount of ascorbic acid content (56.32 mg/ 100 edible portion) was recorded in berries produced from the plants fertilized with *Azotobacter* 7 kg/ha + vermicompost 25 tonnes/ha, closely followed by *Azotobacter* 7 kg/ha + vermicompost 20 tonnes/ha (55.82 mg/ 100 edible portion), whereas, the minimum amount of ascorbic acid content (46.31 mg/ 100 edible portion) was recorded in fruits produced from untreated (control) plants. The results also got the support with the findings of Gupta and Tripathi (2012), Tripathi *et al.*, (2016), Tripathi *et al.*, (2017) and Kumar *et al.*, (2020) in strawberry. The respective increase in ascorbic acid content might be due to the increased efficiency of microbial inoculants to fix atmospheric nitrogen, increase in availability of various nutrients and secretion of growth promoting substances which accelerates the physiological process like carbohydrates synthesis, *etc.*

References

1. A.O.A.C. (1980). *Official Methods of Analysis*. Association of Official Analytical Chemists, Washington, D.C., USA.
2. Gupta, A.K. and Tripathi, V.K. (2012). Efficacy of *Azotobacter* and vermicompost alone and in combination on vegetative growth, flowering and yield of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler. *Progressive Horticulture*, 44(2): 256-261.
3. Kidmose, U., Andersen, H. and Vang-Petersen, O. (1996). Yield and quality attributes of strawberry cultivars grown in Denmark 1990-1991. *Fruit Variety Journal*, 50: 160-67.

4. Kumar, S., Kundu, M. and Rakshit, R. (2020). Effect of bio-fertilizer on growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Camarosa. *Bulletin of Environment, Pharmacology and Life Sciences*, 9(2): 121-129.
5. Mishra, A.N. and Tripathi, V.K. (2011). Influence of Different Levels of Azotobacter, PSB Alone and in Combination on Vegetative Growth, Flowering, Yield and Quality of Strawberry cv. Chandler. *International Journal of Applied Agricultural Research*, 6(3): 203-210.
6. Patil, V.K. and Shinde, B.N. (2013). Studies on integrated nutrient management on growth and yield of banana cv. Ardhapuri (Musa AAA). *Journal of Horticulture and Forestry*, 5(9): 130-138.
7. Singh, A. and Singh, J.N. (2009). Effect of bio-fertilizers and bio-regulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. *Indian Journal of Horticulture*, 66: 220-24.
8. Singh, B., Kachwaya, D.S., Singh, J., Singh, G. and Singh, M. (2019). Effect of vermicompost and biofertilizers on soil health, flowering and yield of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler in central plain region of Punjab. *International Archive of Applied Sciences and Technology*, 11(3): 11-15.
9. Srivastav, A., Singh, R., Baksh, H., Singh, B.K., Pandey, R., Pal, V.K. and Maurya, L.K. (2019). Effect of organic manures and bio-fertilizers on floral and commercial yield characters of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler. *International Journal of Current Microbiology and Applied Sciences*, 8(2): 392-397.
10. Tripathi, V.K., Jain, A., Kumar, S., Dubey, V., and Kumar, A. (2017). Efficacy of biofertilizers and mulching on growth, yield and quality of strawberry. (*Fragaria x ananassa*) cv. Chandler. *Indian Journal of Agricultural Science*, 87(9): 1179-1183.
11. Tripathi, V.K., Kumar, S., and Gupta, A.K. (2015). Influence of Azotobacter and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. *Indian Journal of Horticulture*, 72 (2), 201-205.
12. Tripathi, V.K., Kumar, S., Katiyar, P.N. and Nayyar, A. (2013). Integrated nutrient management in Isabgol (*Plantago ovata* Forsk.). *Progressive Horticulture*, 45(2): 302-305.
13. Tripathi, V.K., Kumar, S., Kumar, K., Kumar, S. and Dubey, V. (2016). Influence of *Azotobacter*, *Azospirillum* and PSB on vegetative growth, flowering, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, 48(1): 48-52.
14. Tripathi, V.K., Kumar, N., Shukla, H.S. and Mishra, A.N. (2010). Influence of *Azotobacter*, *Azospirillum* and PSB on growth, yield and quality of strawberry cv. Chandler. In: *National Symposium on Conservation Horticulture* held at Dehradun during March, 21-23, 2010. pp-198-199.
15. Wange, S.S., Patil, M.T. and Singh, B.R. (1998). Cultivar x bio-fertilizer interaction study in strawberry. *Recent Horticulture*, 4: 43-49.



Production Potential and Economics of Rice (*Oryza sativa*) Based Cropping Systems under Organic Nutrient Management

Ratan Deep Soni¹, S.B. Agrawal², R.P. Sahu³, S.K. Singh⁴ and Poornima Malviya⁵

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur Madhya Pradesh-482004

Abstract

A field experiment was conducted to study the effect of organic nutrient management practices on productivity and economics of rice based cropping systems on clay loam soil in Kymore plateau and satpura hill zone of Madhya Pradesh. Average of two years data proved that ONM4 produced significantly highest yields of grain and straw (38.55 and 63.52 q/ha) and harvest Index of 36.52% and proved significantly superior over control but at par to ONM1 as well as ONM3. The rice berseem cropping system with ONM 4 produced higher yield of 35.11 q/ha over same cropping system with ONM5. Significantly higher rice grain equivalent yield of 64.43, 70.54 and 67.49q/ha was noted under rice-berseem cropping system during 1st, 2nd year and in pooled analysis respectively. Production efficiency was also found highest with rice-berseem cropping system (23.77 kg/ha/day). The highest REY of 67.86 Q/ha was recorded under ONM3. The cropping system rice-berseem with FYM+VC+NOC1/3rd of N from each recorded markedly highest REY (73.82q/ha).

Key words : Cropping system, organic nutrient management practice, production potential, economics.

Introduction

The production of food grains was achieved with the introduction of high yielding varieties and use of higher levels of agro inputs particularly fertilizers and plant protection chemicals. However, it has now been realized that the increase in production was gain at the cost of soil health which is not be a sustainable (Prasad 2005) Apart from this, rice-wheat cropping system is a dominant in the country and widely adopted. However, this intensive system over a period of time has shown a declining trend in yield even with the optimum use of fertilizers and deterioration in soil productivity has been observed (Bhandari *et al.* 2002).

Department of Agronomy, Jabalpur : Hence, for restoration of productivity, there is an urgent need to look forward to an alternate of chemical fertilizers. On the other hand, organic farming is a good option for maintaining soil health (Ramesh *et al.* 2009). Organic sources such as FYM, Vermicompost, Neem oil cake conjunction with green manure crops were found to substitute of nitrogen requirement in rice wheat cropping system. Ganajaxi and Math (2008). The cropping systems with the inclusion of legume fodder may result in high crop productivity and returns per unit area. The present experiment was therefore conducted with the object to study the effect of organic nutrient management practices on the productivity and economics of rice based cropping systems in Kymore Plateau and Satpura hill zone of Madhya Pradesh.

Materials and Methods

Field experiment was carried out during 2007-08 to

2008-09 at Krishi Nagar research farm of Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur on clay loam soil. The soil of experimental field was neutral in reaction (pH 7.2), normal in EC (0.48-1 dsm), medium in organic carbon (0.68%) medium in available nitrogen (252.0 kg-1ha) phosphorus (11.8 kg/ha) and Potassium (273.0 kg/ha). The bulk density of soil was 1.35 Mg-3m³. The experiment was conducted with ten treatment combinations consisted of two cropping systems. (C1: green manuring rice – wheat, C2: green manuring rice – berseem fodder and seed both) as main plot treatments and five organic nutrient management practices (ONM1: Farm yard manure + Vermicompost (1/2 N through each), ONM2: Vermicompost + Neem oil cake (1/2 N through each) ONM3: Farm yard manure + Neem oil cake (1/2 N through each), ONM4: Farmyard manure + Neem oil cake + Vermicompost (1/3 N through each) and ONM5: No manure (Control) as sub plot treatments in a split plot design with three replications. Crop varieties were grown Pusa Basmati-1 of rice, in kharif, HD 4672 of durum wheat and Jawahar Berseem-1 of berseem during rabi season. Sun hemp crop variety K-7 was grown uniformly before rice crop in all plots except control. The 45 day old sun hemp crop was turn down as green manure before transplanting of rice during both the years. Rock phosphate was applied to rice in equivalent to phosphorus requirement of both kharif and rabi crops subtracting accumulated by biomass of green manure crop as well as organic inputs supplied to both crops. The nutrient composition of manures and neem oil cake are given in the Table-1.

Quantity of various manures applied based on

Table-1 : Major nutrient contents in different organic sources applied under study during 2007-08 and 2008-09.

Organic manure	Nutrients content (%)					
	N		P		K	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Green Manure (Sunhemp)	1.08	1.12	0.13	0.14	0.49	0.51
Farmyard Manure (FYM)	0.55	0.58	0.23	0.25	0.24	0.26
Vermicompost (VC)	1.68	1.70	0.62	0.63	0.85	0.90
Neem Oil Cake (NC)	4.52	4.52	1.12	1.12	1.40	1.40

Table-2 : Quantity of various manures applied based on recommended dose of N as per treatments to the crops during 2007-08 and 2008-09.

S. No.	Treatments	Quantity of organic manure (kg/ha) applied in rice and wheat crops					
		2007-08			2008-09		
		FYM	VC	NC	FYM	VC	NC
1.	FYM+VC (1/2+1/2 N from each) ONM ₁)	6000	1965	-	5520	1883	-
2.	VC+NC (1/2+1/2 N from each) ONM ₂	-	1965	730	-	1883	708
3.	FYM+NC (1/2+1/2 N from each) ONM ₃	6000	-	730	5520	-	708
4.	FYM+VC+NC (1/3+1/3+1/3N from each) ONM ₄	4000	1310	487	3690	1260	473
5.	Control-ONM ₅	-	-	-	-	-	-

Table-3 : Quantity of various manures applied based on recommended dose of N as per treatments in berseem crop during 2007-08 and 2008-09.

S.No.	Treatments	Quantity of organic manure (kg/ha) applied in berseem crop					
		2007-08			2008-09		
		FYM	VC	NC	FYM	VC	NC
1.	FYM+VC (1/2+1/2 N from each) ONM1	1818	595	-	1724	588	-
2.	VC+NC (1/2+1/2 N from each) ONM2	-	595	221	-	588	221
3.	FYM + NC (1/2+1/2 N from each) ONM3	1818	-	221	1724	-	221
4.	FYM +VC+NC (1/2+1/2 N from each) ONM4	1212	397	147	1149	392	147
5.	Control-ONM5	-	-	-	-	-	-

Table-4 : Recommended doses of NPK applied in crops under rice based cropping system through combinations of organic manures during 2007-08 and 2008-09.

S.No.	Crops	Recommended doses of Nutrients (Kg/ha)		
		N	P	K
1.	Rice	120	60	40
2.	Wheat	120	60	40
3.	Berseem	20	60	40

recommended dose of N as per treatments to the rice, wheat and berseem crop during 2007-08 and 2008-09 are given in Table-2 and 3.

The recommended doses of NPK applied in test crops under rice based cropping system through various combinations of organic during both the years (Table-4).

Various crops as per the cropping systems were sown in different seasons as per their recommended practices and seed rates. Rice crop was transplanted in the third week of July and harvested in the second week of November. The winter crops (wheat and berseem) were sown in the third week of November and harvested in the end of April. The rainfall received during the experimental period was 1063.6 and 1419.5 mm during 2007-08 and 2008-09, respectively. The total productivity

of the system was expressed in terms of rice equivalent yield.

Results and Discussion

Rice and rice equivalent yield : Yields of rice with respect to grain and straw as well as harvest index (Table-5) did not changed significantly due to cropping systems. On the other hand, parameters grain straw yields and HI significantly differ due to organic nutrient management. Average of two years data showed that ONM₄ produced significantly the highest yields of grain and straw (38.55 and 63.52 q/ha) and harvest index of 36.52% and proved significantly superior over control but at par to ONM₁ and ONM₃. Moreover, the rice-berseem cropping system with ONM₄ produced markedly higher

Table-5 : Grain and straw yields (q/ha) of rice as well as harvest index (%) as influenced by different cropping systems and organic nutrient management practices.

Treatments	Grain yield (q/ha)			Straw yield (q/ha)			Harvest index (%)		
	2007-08	2008-09	Period yield (g/ha)	2007-08	2008-09	Period	2007-08	2008-09	Period
Cropping systems (CS)									
CS1 Rice-Wheat	39.16	33.86	36.51	72.46	63.07	67.76	35.02	35.53	35.27
CS2 Rice-Berseem	39.74	33.51	36.62	72.40	62.44	67.42	34.82	35.12	34.97
SEM±	2.79	2.04	2.20	2.24	1.18	1.73	0.36	0.18	0.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic Nutrient Management Practices (ONM)									
ONM-1 (FYM+VC1/2+1/2)	32.64	34.04	33.34	60.00	64.13	62.00	35.23	34.67	34.96
ONM-2 (VC+NC1/2+1/2)	33.19	34.15	33.67	62.09	63.72	62.90	34.83	34.89	34.86
ONM-3 (FYM +NC1/2+1/2)	33.97	34.77	34.37	62.64	63.73	63.18	35.16	35.29	35.26
ONM-4 (FYM+NC1/2+1/2) Each	34.83	38.27	36.55	63.73	63.32	63.52	35.33	37.67	36.52
ONM-5 (Control)	24.56	27.21	25.88	47.80	58.82	53.31	33.94	31.63	32.68
SEM±	1.18	1.36	1.21	1.54	1.57	1.55	0.41	0.64	0.51
CD (P=0.05)	3.52	4.10	3.63	4.57	4.72	4.66	1.20	1.89	1.57

Table-6 : Rice equivalent yield (q/ha) as influenced by cropping systems and various organic nutrient management practices (2007-08, 2009-09 and pooled data).

Treatments	REY (q/ha)		
	2007-08	2008-09	Pooled
Cropping systems (CS)			
CS1 Rice-Wheat	56.89	56.74	56.82
CS2 Rice-Berseem	64.43	70.54	67.49
SEM±	2.41	2.21	1.83
CD (0.05%)	7.22	6.64	5.48
Organic Nutrient Management Practices (ONM)			
ONM 1	62.74	65.76	64.25
ONM 2	63.13	65.32	64.22
ONM 3	63.85	65.96	64.90
ONM 4	67.36	68.36	67.86
ONM 5 (Control)	46.23	52.84	49.53
SEM±	2.00	2.10	1.74
CD (0.05%)	5.99	6.30	5.20

grain yield (35.11 q/ha) over same cropping system with ONM₅ (control). The higher yields of rice under ONM₄ reflected due to organic sources provide nutrient in regular and static manner to crop which promote the growth and establishment of rice seedlings and have positive correlation with the plant growth and biomass production (Shekaran *et al.* 2010 Pardhan and Moharana 2017). The crop yields recorded under different cropping systems were computed for rice equivalent yield for both the years (Table-6). The significantly higher rice equivalent yield of 64.43, 70.54 and 67.49 q/ha was noted under rice-berseem cropping system during 1st, 2nd year and in pooled analysis, respectively. Further, the addition of nutrients through organic sources found to affect the REY and computed the highest value of 67.36 and 68.36 q/ha under ONM₄ during both the years, respectively and found at par to ONM₁, ONM₂ and ONM₃.

The CS₂ x ONM₄ (rice-berseem cropping system with FYM + VC + NOC 1/3rd of N from each) recorded

markedly higher REY (73.82 q/ha). Similarly the highest production efficiency of rice-berseem cropping system was recorded (23.77 kg/ha/day). The organic nutrient ONM₄ having production efficiency of (24.26 kg/ha/day) closely followed by 23.47 and 23.20 kg/ha/day in ONM₁ and ONM₃, respectively, which proved superior over ONM₅ and ONM₂ (Table-7).

Net Monetary Return (Rs/ha/year) : It is apparent from the data (Table-8) that Net Monetary Returns (NMR) under different cropping systems were differed numerically. The NMR was also more in terms of money (Rs. 63731/ha/year) under rice-berseem cropping system over rice-wheat cropping system which recorded Rs 448143/ha/year only. On the other hand organic nutrient management with FYM+VC+NOC in a combination recorded and get returns of Rs 61088/ha/year closely followed by ONM₁ (Rs. 60427/ha/year) and Rs. 59879/ha/year under ONM₃. While the lowest NMR of Rs 43625/ha/year was noted under control plot (ONM₅). It is

Table-7 : Production efficiency (Kg/ha/day) as influenced by cropping systems and various organic nutrient management practices during 2007-08, 2008-09 and pooled data.

Treatments	Production efficiency (kg/ha/day)		
	2007-08	2008-09	Pooled
Cropping systems			
CS1 Rice-Wheat	20.75	20.55	20.65
CS1 Rice-Berseem	22.98	24.57	23.77
SEM±	4.18	3.02	2.48
CD (0.05%)	12.50	9.06	7.40
Organic Nutrient management practice (ONM)			
ONM 1	23.63	23.31	23.47
ONM 2	22.78	23.16	22.97
ONM 3	23.03	23.38	23.20
ONM 4	24.30	24.23	24.26
ONM 5 (Control)	16.59	18.72	17.65
SEM±	0.38	0.52	0.40
CD (0.05%)	1.15	1.57	1.23

Table-8 : Average Net Monetary Return (Rs/ha/year) and Benefit cost Ratio under different cropping systems and organic nutrient management practices.

Net Monetary Returns (Rs/ha/year)						
Cropping Systems	Organic Nutrient Management					Mean
	ONM1	ONM2	ONM3	ONM4	ONM5	
Rice-Wheat (CS-1)	53686	45018	52396	47929	41693	48143
Rice-Berseem (CS-2)	67168	64322	67363	74247	45557	63731
Mean	60427	54670	59879	61088	43625	—

Benefit Cost Ratio						
Cropping Systems	Organic Nutrient Management					Mean
	ONM1	ONM2	ONM3	ONM4	ONM5	
Rice-Wheat (CS-1)	2.02	1.72	1.94	1.84	2.13	1.93
Rice-Berseem (CS-2)	2.15	2.07	2.14	2.25	1.81	2.08
Mean	2.08	1.89	2.04	2.04	1.97	—

due to the combinations of CS₂ x ONM₄, CS₂ x ONM₁ registered the NMR of Rs 74247, 67168 and 64322/ha/year, respectively. Whereas the lowest NMR of Rs 41693/ha/year was noted under rice-wheat cropping without any nutrient application. Similar results were recorded by upadhyay *et. al* (2011).

Benefit Cost Ratio (BCR) : Benefit cost ratio indicates about monetary returns per rupee invested as capital invested as capital by the grower in cultivation of crops under different systems and organic nutrient management. Overall highest BCR was computed (2.08) in the CS₂ (Rice-Berseem) whereas the CS₁ recorded the BCR of 1.93. The organic nutrient management in which various organics (FYM, VC and NOC) applied in different combinations delivered markable results in terms of economic benefits over control and ONM₂. The ONM₄, ONM₃ and ONM₁ proved almost numerically equally good for fetching return per rupee investment and recorded 2.04, 2.04 and 2.08, respectively. The combination of CS₂ x ONM₄ possessed the highest economic benefits of 2.25 followed by CS₂ x ONM₁ (2.15) and CS₂ x ONM₃ (2.14).

References

- Bhandari, AL; Ladha, JK; Pathak, H, Padre AT. Dawe, D. and Gupta RK (2002). Yield and soil nutrient changes in a long-term rice wheat rotation in India. *Soil Science society of America Journal* 66: 162-170
- Ganajaxi and K. K. Math (2008) Effect of organic and inorganic fertilizers on yield and aroma of scented rice in lowland situations. *International Journal of Agric. Sci.* 4 (1): 79-80.
- Pradhan Saswat and Moharana (2017). Study of growth parameters in organically grown rice-rice sequence. *J. of Eco-friendly Agriculture* 12 (2): 16-21.
- Prasad, R. (2005). Rice wheat cropping systems. *Advances in Agronomy* 86: 255-339.
- Samesh, P., Panwar, NR, Singh, AB and Rammana S (2009). Production potential, nutrient uptake soil fertility and economics of soybean (*Glycine max*) based cropping systems under organic, chemical and integrated nutrient management practices, *Indian Journal of Agronomy* 54(3): 278-83.
- Shekhran BG, Shamapaa and N. Krishna Murthy (2010). Effect on irrigation schedules on growth and yield of aerobic rice under varied levels of FYM in cauvery command area. *Indian Journal of Agronomy*. 55(1) : 35-39.
- Upadhyay, V.B., Vikas Jain, S.K. Vishwakarma and A.K. Kumhar (2011). Production potential, Soil health, water productivity and economics of rice (*oryza sativa*) based cropping systems under different nutrient sources. *Indian Journal of Agronomy* 56 (4): 18-22.



Triple Test Cross Analysis in Three Sorghum Crosses

B.L. Meena^{1*}, P.B. Singh², B.R. Ranwah² and S.P. Das³

¹ICAR-DRMR, Bharatpur Rajasthan-321303, India

²MPUAT, Rajasthan College of Agriculture, Udaipur Rajasthan-313001, India

³ICAR-RC for NEH Region Tripura Centre, Lembucherra

*Corresponding authors Email : blmeena.icar@gmail.com

Abstract

The experiment was having three sub experiments viz., cross SPV 245 x SPV 1430 (1), SPV245 x SPV 1822 (2) and SPV1430 X SPV 1822 (3). Test crosses for this experiment was obtained by crossing the 10 MS lines (ICSA 29003(L₁), ICSA 29004 (L₂), ICSA 29006 (L₃), ICSA 29010 (L₄), ICSA 29011(L₅), ICSA 29012 (L₆), ICSA 29013 (L₇), ICSA 29014 (L₈), ICSA 29015 (L₉) and ICSA 29016 (L₁₀)) with both the parents and their F₁s for all the three sets. In this way each sub experiment was having 30 hybrids. All the three sub experiments were conducted in RBD with three replications following the 45 cm between rows and 10 cm between plants spacing. In present investigation difference between testers in line in all the three sets of TTC were significant. The total and “j+l” type of epistasis were significant for all the characters in most of the sets. Whereas, “i” type epistasis was significant for 4, 3 and 8 characters in set SPV 245 x SPV 1430, SPV 245 x SPV 1822 and SPV 1430 x SPV 1822, respectively. This was on account of significance of epistasis in one or other lines. After dropping the epistatic lines the unbiased D and H were estimated. Both D and H were significant for all the characters except additive variance (D) for green fodder yield and seed index in set SPV 1430 x SPV 1822, days to maturity in set SPV 245 x SPV 1430 and ear head length in set SPV 245 x SPV 1822.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the most important crops in the world because of its adaptation to a wide range of ecological conditions, suitability for low input cultivation and diverse uses (Doggett, 1988). The crop is widely grown for food, feed, fodder, forage and fuel in the semi-arid tropics (SAT) of Asia, Africa, America and Australia. Sorghum is predominantly self-pollinated crop endowed with a wide range of genetic variability due to its wide range of adaption and free gene exchange among various races. Careful selection of parents for hybridization is a key of success in any breeding programme. The knowledge of nature of inheritance is essential for success of breeding programme. Triple test cross analysis for working out the nature of inheritance is most appropriate mating design for the type of genetic material used in present investigation and information to be derived. The information on the nature and magnitude of gene action is important in understanding the genetic potential of population and to decide the breeding procedure to be adopted in given population. A design which is a simple extension of design III of Comstock and Robinson (1956) has been proposed by Kearsey and Jinks (1968). This design, known as “triple test cross”, provides not only a precise test for epistasis but also gives unbiased estimates of additive (D) and dominance (H) components if epistasis is absent (Singh *et al*, 1976). Further, this approach is independent of both the gene frequencies and the mating system of the population to be

investigated was followed to detect the presence of epistasis. The procedure involves a set of lines, crossed to three T₁, T₂ and T₃, T₃ being the F₁ of T₁ x T₂. Ketata *et al*. (1976) suggested the use of different varieties instead of F₂ plants. Among the available mating designs triple test cross is the most efficient mating design provide information about epistasis. Triple test cross analysis in three sorghum crosses was designed to provide helpful genetic information in identifying genotypes with good agronomic performance and heritable qualities that will lead into formulating an appreciable and effective breeding programme to improved yield and good agronomic performance. The design has wide applicability as it can be used to investigate both segregating and non-segregating populations arising from different generations such as F₂, backcross and homozygous lines (Sofi *et al*, 2006). Genotypes were evaluated during kharif, 2014 and kharif, 2015 at Instructional Farm, Rajasthan college of Agriculture, Udaipur, India.

Materials and Methods

Experimental material : 10 lines were identified on the basis of nicking of flowering. Three testers were identified on the basis of availability of restorer gene and past performance. Checks CSV 23, CSV 27 and CSH 25 were national checks in coordinated trials.

In The experiment, the three testers viz., SPV 245 (A), SPV 1430 (B) and SPV 1822 (C) were crossed in all possible combination during kharif 2014 to obtained three

F₁s i.e. A x B, A x C and B x C at Udaipur. In the next season all 10 lines were crossed with three testers i.e. T₁, T₂ and F₁ (T₁ x T₂) of all the three cross (set) at Warangal. In this way 30 hybrids were obtained for each set (cross).

Experimental design : In the triple test cross analysis, the experiment was having three sub experiments viz., cross SPV 245 x SPV 1430 (1), SPV245 x SPV 1822 (2) and SPV1430 X SPV 1822 (3). Test crosses for this experiment was obtained by crossing the 10 MS lines (ICSA 29003(L₁), ICSA 29004 (L₂), ICSA 29006 (L₃), ICSA 29010 (L₄), ICSA 29011(L₅), ICSA 29012 (L₆), ICSA 29013 (L₇), ICSA 29014 (L₈), ICSA 29015 (L₉) and ICSA 29016 (L₁₀)) with both the parents and their F₁s for all the three sets. In this way each sub experiment was having 30 hybrids. All the three sub experiments were conducted in RBD with three replications following the 45 cm between rows and 10 cm between plants spacing.

Traits under investigation : Observations were recorded on following 13 characters. To record different observation five competitive plants in each plot were tagged at random. Days to 50 % flowering, days to maturity, plant height (cm), green fodder yield (q ha⁻¹), dry fodder yield (q ha⁻¹), ear head length (cm), number of primaries per plant, number of seeds per primaries, seed index, harvest index (%), grain yield (q ha⁻¹), Protein content in fodder (%) and rotein content in grain (%).

Statistical analysis : Plot means of all the characters were subjected to various statistical analysis. Triple test cross analysis was performed according to the method proposed by Ketata *et al.* (1976) for detecting epistasis which is essentially the same as that of Bauman (1959). This method employs a set of lines crossed to testers T₁, T₂ and T₃ where T₃ is the F₁ of T₁ x T₂.

Detection of epistasis : The procedure put forth by Kearsey and Jinks (1968) was followed to detect the presence of epistasis. The procedure involves a set of lines, crossed to three T₁, T₂ and T₃, T₃ being the F₁ of T₁ x T₂. Ketata *et al.* (1976) suggested the use of different varieties instead of F₂ plants. This test is based on following model.

$$L_{ik} = X_{i1k} + X_{i2k} - 2X_{i3k}$$

Where, L_{ik} is the epistasis in ith lines and kth block/condition, X_{i1k}, X_{i2k} and X_{i3k} are the value of cross between ith line and 1st, 2nd and 3rd tester in k the block/condition. This value was calculated for each line (variety) in each replication and over the replications.

Significance of epistasis for each line was tested by using t test as follows :

$$t_{[(g-1)(r-1)]} = \frac{\bar{X}}{SE}$$

Where,

$$\begin{aligned} & \bar{X} = \frac{\sum_{i=1}^t \sum_{j=1}^r \sum_{k=1}^2 L_{ijk}}{2L_3} \\ & SE = \sqrt{\frac{6MSE}{r}} \\ & MSE = \frac{\sum_{i=1}^t \sum_{j=1}^r x_{ij}^2 - \frac{(\sum_{i=1}^t \sum_{j=1}^r x_{ij})^2}{r} - \frac{(\sum_{j=1}^r \sum_{i=1}^t x_{ij})^2}{t} - \frac{(\sum_{i=1}^t \sum_{j=1}^r x_{ij})^2}{tr}}{tr} \end{aligned}$$

Where,

x_{ij} = Value of ith genotype in jth replication

r and t = Number of replications and genotype, respectively

$\bar{L}_1, \bar{L}_2$ and $\bar{L}_3$ = mean of cross between P₁ V_i, P₂ V_i and (P₁ P₂) V_i, respectively.

V_i = ith variety used as line in crossing programme.

Estimation of 'D' and 'H' Components : For unbiased estimation of D and H components i.e. in the absence of epistasis, only those lines were used for estimation of these components epistasis was absent.

D component : To estimate the additive variance (D) the sum of L_{1i} + L_{2i} was worked out for each variety in each replication and over the replications where epistasis was not significant.

Significance of additive variance (D) was tested using F test

$$^2s = (MS_2 - MS_3) / 2r$$

$$D = 8 \ ^2s$$

'H' component : To estimate the H components (dominance variance) differences between cross of ith lines and tester T₁ and T₂ were used. Only those values were conderd which were lacking the epistasis.

Significance of dominance variance (H) was tested using F test. The value of H was calculated as follows:

$$^2s = (MS_2 - MS_3) / 2r$$

$$H = 8 \ ^2s.$$

The negative value was considered zero.

The degree of dominance was calculated only for those characters where both D and H were present. Formula used for this was as follows :

$$\sqrt{H/D}$$

Direction of dominance : To determine the direction of dominance correlation between sums (S_i) and differences (D_i) was worked out.

Table-1 : ANOVA (MS) for different characters.

S. No.	Characters	Cross	Rep/Lines [20]	TC/Lines [20]	Error [40]
1.	Days to 50% flowering	1	19.86	51.36**	17.27
		2	13.99	46.42**	13.96
		3	5.52	85.29**	7.34
2.	Days to maturity	1	24.16**	11.46	6.76
		2	3.13	14.80**	2.37
		3	1.43	21.40**	1.70
3.	Plant height	1	118.92	892.26**	198.59
		2	286.93	1727.17**	229.82
		3	166.56	1548.36**	219.17
4.	Green fodder yield	1	1338.80	13649.30**	1808.45
		2	1767.38	39309.24**	1055.26
		3	1650.19	41575.79**	1138.16
5.	Dry fodder yield	1	599.46	3545.06**	326.91
		2	350.50	11047.60**	275.97
		3	265.20	12455.90**	319.15
6.	Ear head length	1	9.02	23.12**	6.26
		2	7.49	17.22*	8.52
		3	4.19	26.99**	7.66
7.	Number of primaries per plant	1	32.10	199.40**	42.83
		2	46.19*	180.19**	23.62
		3	15.34*	342.41**	44.73
8.	Number of seeds per primary	1	41.88	512.44**	35.94
		2	42.98	357.04**	64.29
		3	27.33	1233.33**	53.12
9.	Seed index	1	0.03	0.09**	0.03
		2	0.07	0.25**	0.05
		3	0.05	0.16*	0.07
10.	Harvest index	1	5.05	66.68**	8.86
		2	8.01	13.77	7.97
		3	18.17	220.47**	15.62
11.	Grain yield	1	33.31	969.44**	55.03
		2	73.74	1599.14**	66.93
		3	114.64	3610.04**	93.89
12.	Protein content in grain	1	0.02	7.06**	0.01
		2	0.23	10.15**	0.21
		3	0.03	9.64**	0.02
13.	Protein content in fodder	1	0.21**	2.69**	0.02
		2	0.07**	1.84**	0.03
		3	0.01	1.83**	0.01

[] Degrees of freedom, *, ** Significant at 5 and 1 per cent level of significance.

$$r_{SD} = \frac{\sum_{i=1}^l S_i D_i}{\sqrt{[\sum_{i=1}^l S_i^2 (\sum_{i=1}^l S_i)^{2/l} + \sum_{i=1}^l D_i^2 (\sum_{i=1}^l D_i)^{2/l}]}}$$

Significance was tested using 't' test

$$t_{(l-2)} = \frac{r}{\sqrt{\frac{1-r^2}{l-2}}}$$

The negative and significant value of 'r' suggested that increasing genes were dominant and vice-versa.

Where S_i and D_i is the sums and difference between crosses obtained by crossing i^{th} line with T_1 and T_2 testers.

And r and l are the number of replications and lines respectively.

Results and Discussion

Analysis of variance : The analysis of variance for different characters indicated significant differences between lines for all the characters in all the three crosses (SPV 245 x SPV 1430, SPV 245 X SPV 1822 and SPV 1430 x SPV 1822) except days to 50 % flowering in cross SPV 245 x SPV 1430 and harvest index in cross SPV 1430 x SPV 1822 (Table-1).

Cross / Set 1-SPV 245 x SPV1430 : The analysis of variance for detection of epistasis for thirteen characters is

Table-2 : ANOVA for epistasis and correlation between per se and direction of dominance.

S.No.	Charactar	Cross	i [1]	j+l [9]	Total [10]	i x B [2]	j+l x B [18]	TEpixB [20]	r [8]
1.	Days to 50% flowering	1	61.63	254.89	235.57	8.13	112.06	101.67	-0.17*
		2	907.50	156.91	231.97*	79.30	83.71	83.27	0.35*
		3	3328.53*	300.24**	603.07**	122.63	47.45	54.97	0.54*
2.	Days to maturity	1	0.83	38.98	35.17	2.13	43.84	39.67	-0.41*
		2	710.53	28.83*	97.00**	57.43	8.62	13.50	0.05*
		3	1190.70*	72.92**	184.70**	4.30	10.74	10.10	-0.13*
3.	Plant height	1	1104.13	2196.50	2087.27	1752.43	1137.25	1198.77	0.44*
		2	374.53	11746.61**	10609.40**	1158.63	795.82	832.10	-0.74*
		3	37949.63	6432.00**	9583.77**	2816.43	1694.91	1807.07	0.22*
4.	Green fodder yield	1	57203.33*	84524.52**	81792.40**	2326.93	16267.23	14873.20	-0.28*
		2	5713.20	358132.01**	322890.13**	2770.00	8309.59	7755.63	0.68
		3	617767.50*	144282.46**	191630.97**	2342.10	10690.29	9855.47	-0.32*
5.	Dry fodder yield	1	326.70	24648.11**	22215.97**	1220.70	2479.44	2353.57	-0.02*
		2	51750.53*	84321.27**	81064.20**	1619.43	1539.95	1547.90	-0.23*
		3	49369.63*	78720.60**	75785.50**	1538.23	1705.20	1688.50	0.21*
6.	Ear head length	1	104.53	83.35*	85.47*	18.43	26.69	25.87	-0.60*
		2	64.53*	31.35	34.67	1.63	59.34	53.57	0.48*
		3	1216.03*	129.74*	238.37**	52.03	46.29	46.87	0.30*
7.	Number of primaries per plant	1	842.70	1380.48**	1326.70**	153.30	290.19	276.50	0.28*
		2	276.03	1778.85**	1628.57**	119.63	205.00	196.47	0.05*
		3	229.63	1882.97**	1717.63**	266.13	277.47	276.33	0.59*
8.	Number of seeds per primary	1	4392.30*	3311.78**	3419.83**	132.40	169.10	165.43	0.43*
		2	367.50	2131.65**	1955.23**	529.60	507.64	509.83	-0.47*
		3	472.03	6543.00**	5935.90**	299.43	233.29	239.90	-0.65*
9.	Seed index	1	0.05	0.40*	0.37*	0.04	0.16	0.14	-0.40*
		2	0.39	1.85**	1.71**	0.62*	0.17	0.22	0.04*
		3	8.41	0.24	1.06	3.18	0.30	0.58	0.26*
10.	Harvest index	1	589.19	286.87**	317.10**	36.06	58.33	56.10	0.09*
		2	58.02	53.64	54.08	40.44	31.93	32.79	0.12*
		3	861.03	1283.06**	1240.86**	49.89	95.44	90.89	0.11*
11.	Grain yield	1	410.70	3237.29**	2954.63**	456.30	205.67	230.73	0.09*
		2	2881.20	14233.13**	13097.93**	310.00	368.59	362.73	0.33*
		3	6482.70*	23154.40**	21487.23**	87.30	606.67	554.73	-0.30*
12.	Protein content in grain	1	174.53**	67.46**	78.17**	0.02	0.06	0.06	-0.37*
		2	549.72*	48.13**	98.29**	1.72	2.38	2.32	-0.64*
		3	83.53**	70.72**	72.00**	0.17	0.14	0.15	0.29*
13.	Protein content in fodder	1	15.24**	26.20**	25.11**	0.01	0.12	0.11	-0.37*
		2	1.71	17.94**	16.32**	0.92**	0.12	0.20	-0.49*
		3	2.34*	17.05**	15.58**	0.01	0.06	0.05	-0.40*

[] Degrees of freedom, *, ** Significant at 5 and 1 per cent level of significance.

given in Table-2. Total epistasis was significant for green fodder yield, dry fodder yield, ear head length, number of primaries per plant, number of seeds per primary, seed index, harvest index, grain yield, protein content in grain and protein content in fodder. All these characters also had significance 'j + l' epistasis. where as 'i' is significant for green fodder yield, number of seeds per primary, protein content in grain and protein content in fodder (Table-2).

As for as epistasis in each line is concern L_1 was not having epistasis for any of the character. The L_6 had only

epistasis for grain yield and L_4 had for grain yield and number of seeds per primary. Rest of the lines having epistasis for three characters except L_2 which has epistasis for four characters. The magnitude of unbiased estimation of D and H did not have any specific trend in comparison to estimation from all the line. The D and H was increased in 6 and 7 characters, remain constant in 2 and 2 characters and decreased in 5 and 4 characters, respectively. It was remain same only in those characters where none of the lines was epistatic. The additive variance D and dominance variance H was significant for

Table-3 : Significance of epistasis in individual line in different sets.**Set-SPV 245 × SPV 1430 (1)**

Line	Days to 50% flowering	Days to maturity	Plant height	Green fodder yield	Dry fodder yield	Ear head length	Number of primaries per plant	Number of seeds per primary	Seed index	Harvest index	Grain yield	Protein content in grain	Protein content in fodder
L1													
L2	1				1		1	1					
L3								1		1	1		
L4								1			1		
L5									1			1	1
L6											1		
L7			1		1			1					
L8				1								1	1
L9								1				1	1
L10							1					1	1

Set-SPV 245 × SPV 1822 (2)

Line	Days to 50% flowering	Days to maturity	Plant height	Green fodder yield	Dry fodder yield	Ear head length	Number of primaries per plant	Number of seeds per primary	Seed index	Harvest index	Grain yield	Protein content in grain	Protein content in fodder
L1				1	1		1						
L2	1	1		1	1			1			1		
L3			1	1	1		1		1		1		
L4		1			1					1	1		
L5							1	1					1
L6		1						1					
L7		1							1				
L8													1
L9	1	1											1
L10	1	1											1

Set-SPV 1430 × SPV 1822 (3)

Line	Days to 50% flowering	Days to maturity	Plant height	Green fodder yield	Dry fodder yield	Ear head length	Number of primaries per plant	Number of seeds per primary	Seed index	Harvest index	Grain yield	Protein content in grain	Protein content in fodder
L1	1			1	1						1	1	
L2		1											
L3		1	1	1	1		1	1	1		1	1	
L4		1	1	1	1			1		1	1	1	1
L5	1	1	1	1	1		1		1				1
L6	1	1		1	1		1			1	1		
L7	1		1							1			
L8			1	1	1						1	1	1
L9	1	1	1					1					1
L10	1	1		1				1	1			1	1

1=Significance of epistasis.

all the characters except D in days to maturity and H in Days to 50% flowering and number of seeds per primary (Table-4).

Average degree of dominance $\sqrt{(H / D)}$ were greater than unity for grain yield (1.37), harvest index (1.36), days to maturity (1.22), plant height (1.17), seed index (1.16) and number of primaries per plant (1.14). For rest of the

characters it was less than unity. The direction of dominance was positive i.e. negative correlation differences sums and differences between L₁ and L₂ for days to 50 % flowering, days to maturity, green fodder yield, dry fodder yield, ear head length, seed index, protein content in grain and protein content in fodder where as direction of dominance was negative for plant

**Table-4 : Additive (D), dominance (H) and degree of dominance (DD).
Set- SPV 245 × SPV 1430 (1)**

S. No.	Charactar	D	H	DD
1.	Days to 50% flowering	212.74**	49.11	0.48
2.	Days to maturity	20.55	30.39*	1.22
3.	Plant height	3035.81**	4144.52**	1.17
4.	Green fodder yield	34381.15**	28840.07**	0.92
5.	Dry fodder yield	11895.67**	7993.33**	0.82
6.	Ear head length	41.02*	32.13*	0.89
7.	Number of primaries per plant	320.17*	417.83*	1.14
8.	Number of seeds per primary	1676.33**	283.27	0.41
9.	Seed index	0.25*	0.34**	1.16
10.	Harvest index	131.29**	242.83**	1.36
11.	Grain yield	2018.13**	3809.37**	1.37
12.	Protein content in grain	11.00**	3.75**	0.58
13.	Protein content in fodder	12.13**	4.09**	0.58

Set-SPV 245 × SPV 1822 (2)

S. No.	Charactar	D	H	DD
1.	Days to 50% flowering	367.81**	11.05	0.17
2.	Days to maturity	351.78**	0.00	0.00
3.	Plant height	3630.56**	4480.52**	1.11
4.	Green fodder yield	134389.68**	24622.13**	0.43
5.	Dry fodder yield	36693.33**	12177.78**	0.58
6.	Ear head length	7.10	59.42*	2.89
7.	Number of primaries per plant	1188.32**	246.73**	0.46
8.	Number of seeds per primary	2052.16**	762.63**	0.61
9.	Seed index	0.53*	0.63**	1.09
10.	Harvest index	127.72**	33.49	0.51
11.	Grain yield	8926.16**	2179.17**	0.49
12.	Protein content in grain	20.65**	10.87**	0.73
13.	Protein content in fodder	10.78**	3.67**	0.58

Set-SPV 1430 × SPV 1822 (3)

S. No.	Character	D	H	DD
1.	Days to 50% flowering	180.89**	0.00	0.00
2.	Days to maturity	236.00**	19.11*	0.28
3.	Plant height	4990.78**	552.56	0.33
4.	Green fodder yield	0.00	125463.56**	0.00
5.	Dry fodder yield	36144.78**	75153.44**	1.44
6.	Ear head length	22.70*	10.90	0.69
7.	Number of primaries per plant	1324.60**	691.78**	0.72
8.	Number of seeds per primary	6041.64**	2192.76**	0.60
9.	Seed index	0.16	0.32*	1.40
10.	Harvest index	399.93**	451.31**	1.06
11.	Grain yield	7983.53**	8097.93**	1.01
12.	Protein content in grain	8.65**	6.01**	0.83
13.	Protein content in fodder	10.36**	5.03**	0.70

height, number of primaries per plant, number of seeds per primary, harvest index and grain yield.

Cross / Set 2- SPV 245 x SPV 1822 : The analysis of variance for detection of epistasis for thirteen characters is given in Table-4. The effect of line in epistasis was significant in 33 combinations out of 130. All the lines were having epistasis for one or other characters. The numbers of characters ranged from 1 (L_3) to 6 (L_2 and L_3). For ear head length and protein content in grain none was having

significant epistasis. Whereas for plant height (L_3) and harvest index (L_4) only one line was having epistasis. In rest of the characters it ranged from 2 to 6. Magnitude of D and H increased in 7 and 5 characters, remain constant in 2 characters and decreased in 4 and 6 characters. Consistency was observed only in those characters where none of the line was epistatic (Table-4).

Total epistasis was significant for days to 50% flowering, days to maturity, plant height, green fodder

Table-5 : D and H components with and without epistatic lines.

S. No.	Character	Cross	Epistasis	No of epistatic lines	All lines			Without epistatic lines		
					D	H	H/D	D	H	H/D
1.	Days to 50% flowering	1	235.57	1	191.75**	78.21*	0.64	212.74**	110.90**	0.72
		2	231.97*	3	321.45**	93.04*	0.54	367.81**	81.56**	0.47
		3	603.07**	6	334.06**	191.27**	0.76	180.89**	14.28**	0.28
2.	Days to maturity	1	35.17	0	20.55	30.39*	1.22	20.55	41.72**	1.42
		2	97.00**	6	126.89**	25.50**	0.45	351.78**	9.94**	0.17
		3	184.70**	7	103.08**	29.33**	0.53	236.00**	37.33**	0.40
3.	Plant height	1	2087.27	1	2807.75**	3700.52**	1.15	3035.81**	4765.77**	1.25
		2	10609.40**	1	3163.16**	3863.04**	1.11	3630.56**	5629.59**	1.25
		3	9583.77**	6	4975.14**	920.77*	0.43	4990.78**	2085.50**	0.65
4.	Green fodder yield	1	81792.40**	1	40038.52**	27692.21**	0.83	34381.15**	44655.66**	1.14
		2	322890.13**	3	187193.45**	57100.71**	0.55	134389.68**	34047.52**	0.50
		3	191630.97**	7	154350.64**	117187.61**	0.87	0.00	136301.33**	0.00
5.	Dry fodder yield	1	22215.97**	2	12396.71**	9238.96**	0.86	11895.67**	10505.67**	0.94
		2	81064.20**	4	47004.10**	24548.07**	0.72	36693.33**	14635.42**	0.63
		3	75785.50**	6	27360.50**	33715.76**	1.11	36144.78**	77970.78**	1.47
6.	Ear head length	1	85.47*	0	41.02*	32.13*	0.89	41.02*	111.83**	1.65
		2	34.67	0	7.10	59.42*	2.89	7.10	85.57**	3.47
		3	238.37**	0	22.70*	10.90	0.69	22.70*	45.76**	1.42
7.	No of primaries/plant	1	1326.70**	2	400.98**	409.99**	1.01	320.17*	497.87**	1.25
		2	1628.57**	3	1600.68**	191.56**	0.35	1188.32**	301.06**	0.50
		3	1717.63**	3	1076.67**	961.64**	0.95	1324.60**	1089.16**	0.91
8.	No. of seeds/primary	1	3419.83**	5	1032.67**	1224.01**	1.09	1676.33**	435.80**	0.51
		2	1955.23**	3	1957.05**	818.27**	0.65	2052.16**	865.83**	0.65
		3	5935.90**	4	5104.09**	2576.03**	0.71	6041.64**	4782.60**	0.89
9.	Seed index	1	0.37*	1	0.27*	0.30**	1.04	0.25*	0.49**	1.39
		2	1.71**	2	0.55**	0.47**	0.93	0.53*	0.75**	1.19
		3	1.06	3	0.10	0.31**	1.72	0.16	0.39**	1.54
10.	Harvest index	1	317.10**	1	118.69**	215.63**	1.35	131.29**	286.09**	1.48
		2	54.08	1	114.29**	29.10	0.50	127.72**	81.43**	0.80
		3	1240.86**	3	783.75**	509.07**	0.81	399.93**	547.71**	1.17
11.	Grain yield	1	2954.63**	3	2180.00**	3669.99**	1.30	2018.13**	4193.32**	1.44
		2	13097.93**	3	6938.61**	2516.56**	0.60	8926.16**	2464.76**	0.53
		3	21487.23**	5	15337.33**	10361.63**	0.82	7983.53**	8377.13**	1.02
12.	Protein content in grain	1	78.17**	4	6.70**	2.99**	0.67	11.00**	4.44**	0.64
		2	98.29**	0	20.65**	10.87**	0.73	20.65**	12.99**	0.79
		3	72.00**	5	13.25**	21.13**	1.26	8.65**	13.46**	1.25
13.	Protein content infodder	1	25.11**	4	7.45**	3.28**	0.66	12.13**	4.99**	0.64
		2	16.32**	4	6.96**	2.69**	0.62	10.78**	4.24**	0.63
		3	15.58**	5	6.46**	2.96**	0.68	10.36**	5.56**	0.73

*, ** Significant at 5 and 1 percent level of significance, respectively.

yield, dry fodder yield, number of primaries per plant, number of seeds per primary, seed index, grain yield, protein content in grain and protein content in fodder. All these characters also had significant 'j + l' epistasis, except days to 50% flowering, where as 'i' is significant for dry fodder yield, ear head length and protein content in grain. The direction of dominance was positive *i.e.* negative correlation between sums and differences between L_1 and L_2 for dry fodder yield, number of seeds per primary, protein content in grain and protein content in fodder where as direction of dominance was negative for

days to 50% flowering, days to maturity, plant height, green fodder yield, ear head length, number of primaries per plant, seed index, harvest index and grain yield (Table-2).

Cross / Set 3 - SPV 1430 x SPV 1822 : The analysis of variance for detection of epistasis for thirteen characters is given in Table-2. Total epistasis was significant for days to 50 % flowering, days to maturity, plant height, green fodder yield, dry fodder yield, ear head length, number of primaries per plant, number of seeds per primary, harvest index, grain yield, protein content in grain and protein

content in fodder. All these characters also had significant of 'j + l' epistasis, where as 'i' was significant for days to 50 % flowering, days to maturity, green fodder yield, dry fodder yield, ear head length, grain yield, protein content in grain and protein content in fodder (Table-2).

In this cross out of 130 (10 lines x 13 characters) combinations 60 had significant epistasis. All the lines having significant epistasis for one or other characters. It was ranged from 1 (L_2) to 9 (L_3 and L_4) characters. Similarly, all the characters having significant epistasis in one or more lines except ear head length where epistasis was not significant for any of the lines. In rest of the characters epistatic lines were ranged from 3 (harvest index) to 7 (days to maturity and green fodder yield). After unbiased estimations of D and H. Their magnitude was increased in 7 and 3 characters, remain constant in 1 character and decreased in 5 and 9 characters. The unbiased estimate of D and H was significant for all the characters except D for Green fodder yield and seed index and H for days to flowering, plant height and ear head length (Table-4). The average degree of dominance $\sqrt{(H/D)}$ was more than unity for dry fodder yield (1.44), seed index (1.40), harvest index (1.06) and grain yield (1.01) whereas for rest of the characters it was less than unity. The direction of dominance was positive i.e. negative correlation differences sums and differences between L_1 and L_2 for days to maturity, green fodder yield, number of seeds per primary, grain yield and protein content in fodder where as direction of dominance was negative for days to 50 % flowering, plant height, dry fodder yield, ear head length, number of primaries per plant, seed index, harvest index and protein content in grain (Table-2).

In the presence of epistasis, the estimates D (additive variance) and H (dominance variance) are biased. To estimate unbiased D and H the triple test cross was used. The triple test cross analysis proposed by Ketataa (1976) provide unbiased estimation of D and H components. In present investigation difference between test crosses in lines were significant for all the characters in all the three set (SPV 245 x SPV 1430, SPV 245 X SPV 1822 and SPV 1430 x SPV 1822) except days to 50 % flowering in set SPV 245 x SPV 1430 and harvest index in set SPV 1430 x SPV 1822. This indicates presence of variability in test crosses in lines. In case of unbiased estimation, the magnitude of D and H may change in any direction accordingly the degree of dominance may also change. The cross SPV 245 x SPV 1430 (25) cross was least epistatic i.e. out of 130 combinations (10 lines x 13 characters) epistasis was significant in 25. As for as epistasis in each line concern it was absent for ear head length. The ear head length was followed by harvest index

(5), number of seeds per primary (6), number of primaries per plant (8), plant height (8) and protein content in grain (9). In these lines in three testers epistasis was present in less than 10 combinations. The lines depicted medium epistasis in cross SPV 1430 x SPV 1822 (60) followed by SPV 245 x SPV 1822 (33) and SPV 245 x SPV 1430 (25). Among the lines L_1 was not having epistasis for any of the character in cross SPV 245 x SPV 1430. It was followed by L_6 (SPV 245 x SPV 1430), L_2 (SPV 1430 x SPV 1822), L_8 (SPV 245 x SPV 1822), which were having epistasis for one character only in above mentioned crosses.

The total epistasis was significant for all the characters in all the three crosses except days to 50 % flowering in SPV 245 x SPV 1430 and plant height in SPV 245 x SPV 1430 ear head length in SPV 245 X SPV 1822, seed index in SPV 1430 x SPV 1822 and harvest index in SPV 245 X SPV 1822. In all these crosses the j + l type of epistasis was also significant. The additive x additive (i) epistasis was more frequent in set SPV 1430 x SPV 1822 where it significant for eight characters. In set SPV 245 x SPV 1430 and SPV 245 x SPV 1822 it was significant for 4 and 3 characters. It was significant in all the three sets for protein content in grain where in more than two sets for green fodder yield, dry fodder yield, ear head length and protein content in fodder. Only i type of epistasis was significant for ear head length in SPV 245 x SPV 1822 set. This indicates the present of epistasis and need to unbiased estimation of D and H components. The significance of epistatic effect further tested for each line, none of the line exhibited significant epistasis for ear head length. The other characters having less epistatic lines were harvest index, number of seeds per primary, number of primaries per plant, plant height and protein content in grain. In cross SPV 1430 x SPV 1822 maximum epistasis was observed considering different crosses and different characters, it was followed by SPV 245 X SPV 1822 and SPV 245 x SPV 1430. Among the lines L_1 was not having epistasis for any of the character in cross SPV 245 x SPV 1430 it was followed by L_6 in (PV 245 x SPV 1430, L_2 in SPV 1430 x SPV 1822 and L_8 in SPV 245 X SPV 1822 set which were having epistasis for one character only in above mentioned crosses.

After dropping the epistatic lines unbiased D and H were estimated. This indicates that epistasis may bias the D and H components in any direction and average degree of dominance may change accordingly (Table-5). The unbiased estimation revealed significance of D and H components for all the characters in all the three crosses except additive variance (D) for days to maturity in SPV 245 x SPV 1430, green fodder yield in SPV 1430 x SPV 1822 ear head length in SPV 245 X SPV 1822 and seed index in SPV 1430 x SPV 1822 sets. The total epistasis was also absent in all the above exceptional sets for

above characters. This indicates that significance of epistasis more biased the D in present investigation. The average degree of dominance for days to 50 % flowering, number of seeds per primary and protein content in fodder was less than one and for ear head length and seed index the degree of dominance was more than one. For rest of the characters it was varied from set to set.

These outcomes indicate that an eistatic component play an important role in governing all the characters studied in these sorghum crosses. Therefore, this component cannot be overlooked when one is articulating breeding plans to improve sorghum populations for economic traits. If the presence of epistasis is overlooked in sorghum population, one would not only lose information about epistasis but also the estimates of additive and dominance components would be biased as they are in the present crosses and, therefore, could be confusing. Further, the detection and estimation of epistasis would enable the breeder to determine the genetic cause of heterosis with greater confidence.

Acknowledgements

Indian Council of Agricultural Research (ICAR), is sincerely acknowledged for financial support of the study, International Crops Research Institute for Semi-Arid Tropics (ICRISAT) for providing lines (ms) for the study, Maharana Pratap University of Agriculture and Technology (MPUAT) is sincerely acknowledged for providing facility and support for the study.

References

1. Anonymous 2015. FAOSTAT, Food and Agriculture Organization of the United Nations Statistics Division, Rome.
2. Bauman, L.F., 1959. Evidence of non-allelic interaction in determining yield, ear height and kernel row number in corn. *Agron. J.*, 51: 531-534.
3. Comstock R.E., H.F. Robinson, 1952. Estimation of average dominance of genes. pp. 494-516. In: J.W. Gowen (Ed.), *Heterosis*. Ames USA, Iowa State College Press.
4. Doggett H, 1988. Sorghum. Longman Scientific & Technical, London. *Cereal Sci* 44: 236-251
5. Fisher, R.A. (1932). The Genetical Theory of Natural Selection. Clarendon, Oxford.
6. Kearsey, M.J. and Jinks J.L. (1968). A general method of detecting additive, dominance and epistatic variation for metrical traits. *Heredity*, 23: 403-409.
7. Ketata, H., E.L. Smith, L.K. Edwards and R.W. McNew. 1976. Detection of epistasis, additive and dominance variation in winter wheat. *Crop Sci.*, 16: 1-4.
8. Marwa M. El-Nahas (2015). Using Triple Test Cross Analysis to Estimates Genetic Components, Prediction and Genetic Correlation in Bread Wheat. *Int. J. Curr. Microbiol. App.Sci.* 4(11): 79-87.
9. Mallikarjun, K., E. Ganagappa, L. Vijaya Kumar, T. Basavaraja and Ramesh, S. 2017. Determination of Genetic Components through Triple Test Crosses in Okra [*Abelmoschus esculentus* (L) Moench]. *Int. J. Curr. Microbiol. App. Sci.* 6(9): 1991-1999.
10. Panda, P.K., and Singh, K.P. 2000. Modified triple test cross analysis for yield and yield components in okra [*Abelmoschus esculentus* (L) Moench]. *Indian J. Genet.*, 60: 569-571.
11. Saravanan, K., Sabesan, T., Senthil Kumar, N., Ganasan, J., 2005. Triple test cross analysis in bhendi [*Abelmoschus esculentus* (L) Moench]. *Indian J. Agric. Res.*, 39: 242-248.
12. Singh, J.P. (2016). Triple test cross analysis for yield and yield traits in tomato (*Lycopersicon esculentum* Miller). *Advance Research Journal of Crop Improvement*, 7(2) : 231-233.
13. Singh, S. and Singh R.B (1976). Triple test cross analysis in two wheat crosses. *Heredity*, 37(2): 173-177.
14. Smita Kumari, K.S. Chandel and Aanchal Chauhan. 2017. Triple Test Cross Analysis for Yield and Horticultural Traits in Brinjal (*Solanum melongena* L.). *Int. J. Curr. Microbiol. App. Sci.* 6(6): 2807-2812.
15. Sofi, P., Rather, A.G. and Venkatesh, S. (2006). Triple test cross analysis in maize (*Zea mays* L.). *Indian J. Crop Science*, 1(1-2): 191-193 (2006).



Influence of Foliar Application of Plant Bio-Regulators and Micronutrient on Fruit Retention, Yield and Quality Attributes of Mango

Jitendra Singh Yadav, R.K.S. Gautam, Ankit Singh Bhadauria and Prakash Pandey

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur, Uttar Pradesh

Email : jy46060@gmail.com

Abstract

To investigate foliar application of plant bio-regulators and micronutrient on fruit retention, yield and quality attributes of mango, an experiment was carried out in the Garden, Department of Fruit Science, C. S. Azad University of Agriculture and Technology, Kanpur (U.P.) during the cropping season 2021. The experiment was laid out in Randomized Block Design (RBD) with three replication and ten treatments viz., GA₃ @ 20 ppm (T₁), GA₃ @ 40 ppm (T₂), GA₃ @ 60 ppm (T₃), NAA @ 25 ppm (T₄), NAA @ 50 ppm (T₅), NAA @ 75 ppm (T₆), ZnSO₄ 0.2% (T₇), ZnSO₄ 0.4% (T₈), ZnSO₄ 0.6% (T₉) including a control or water spray (T₁₀). Spraying of plant growth regulators and micronutrient was done at pea stage of fruits. The Cultivar used was Amrapali. From the results obtained during present experimentation, it is reported that spraying of GA₃ 40 ppm significantly increases fruit yield (56.62 kg/tree), polar diameter (8.97cm), equatorial diameter (7.96 cm), whereas, foliar spraying of trees with GA₃ at 20ppm results significantly reduction in fruit drop (85.62%), with increase in fruit retention (14.38%) and number of fruits per panicle (5.98). Pre-harvest spraying of trees with GA₃ @ 60 ppm results significantly more ascorbic acid (37.10mg/100gm pulp) and total sugars (18.25%). Plants treated with NAA @ 50 ppm increases fruit weight (248.69 g), pulp percent (73.21%) fruit volume (238.00 cc) and minimum fruit stone percentage (11.43%) and NAA @ 75 ppm increases total soluble solids (19.57 °Brix), while the zinc sulphate @ 0.6% increases the specific gravity 1.07 of fruits.

Key words : Mango, GA₃, NAA, ZnSO₄, fruit drop, fruit retention, TSS, yield, quality.

Introduction

Mango is botanically known *Mangifera indica* L. belongs to the family *Anacardiaceae*. Mango is also known as “King of fruits” and “National Fruit of India.” It has delicious taste, excellent flavour and attractive fragrance. Besides Indian subcontinent, the mango is also found in several countries of the tropical and subtropical world. Mango is an evergreen tree bearing numerous branches. The inflorescence of mango is large panicles which are grown terminally. Mango is and andro-monoecious *i.e.*, inflorescence bears both hermaphrodite and staminate flowers. According to Arkroyd *et al.*, (1996), mango fruits provide 64-66 calories per 100g of fresh ripe fruits and fruit contains 73.0-86.7% moisture, 11.6-24.3% carbohydrates, 0.3-1.0% protein, 0.1-0.8% fat, 0.3-0.7% minerals, 650-25900 µg vitamin-A and 3-83 mg vitamin C per 100g fruit. Seed kernels also contain 9.50% protein, 8-12% fat, 79.20% starch, 2% mineral matter and 2% fibers. Mango fruit is considered as excellent fruit for table purpose. A various type of products can be prepared from both immature green and ripen fruits. Mango is one of the most extensively exploited fruits for food, juice, flavour, fragrance, colour making. Plant bio-regulators and micronutrient such as NAA, GA₃ and ZnSO₄ play a significant role in increasing fruits set, fruit yield and quality improvement. The role of Naphthalene Acetic Acid (NAA) in the control of vegetative and reproductive

development has been subject of studies of several workers. GA₃ application is found more effective in the increasing fruit set percentage per panicle with increase in fruit size and fruit weight in mango and improve yield in many other fruits crops. Zinc is required to obtain good fruit set and size. Zinc plays an important role in biosynthesis of hormones. It is one of the essential elements for the formation of chlorophyll and hence useful towards photosynthetic activity.

Materials and Methods

The present investigation was carried out on 23 years old plants of Mango cv. Amrapali located in the garden, Department of fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during 2021, in Randomized Block Design (RBD) and replicated thrice with ten treatments viz., GA₃ @ 20 ppm (T₁), GA₃ @ 40 ppm (T₂), GA₃ @ 60 ppm (T₃), NAA @ 25 ppm (T₄), NAA @ 50 ppm (T₅), NAA @ 75 ppm (T₆), ZnSO₄ 0.2% (T₇), ZnSO₄ 0.4% (T₈), ZnSO₄ 0.6% (T₉) including a control or water spray (T₁₀). Spraying of plant growth regulators and micronutrient were done at pea stage of fruits set. Data were recorded at 15th day's intervals after foliar application till harvesting. The observations were recorded on per cent fruit drop, per cent fruit retention and number of fruits per panicles. The physical characters of fruits viz., fruit size (polar and equatorial diameter), weight, fruit volume (cc), pulp and

stone per cent, specific gravity, fruit yield and the chemical characters *i.e.*, fruit total soluble solids (TSS), total sugars and ascorbic acid (vitamin C) content were studied after harvest as per method suggested in (A.O.A.C., 1980).

Results and Discussion

Fruits drop and retention per cent : During present investigation, it is observed that significant increase in fruit retention with reduced fruit drop was recorded by the use of plant bio-regulators and micro-nutrient (Table 1). The maximum fruit retention and minimum fruit drop per cent was recorded with the foliar application of GA₃ @ 20 ppm (14.38% and 85.62%, respectively) followed by NAA @ 75 ppm (12.65% and 87.35%, respectively). However, the minimum fruit retention and maximum fruit drop per cent (7.23% and 93.27%, respectively) was recorded in plants kept as control, where non amount of plant bio-regulators and micronutrient was used. This increase in fruit retention and reduction in fruit drop per cent might be due to the suppression of ABA biosynthesis and increase in the endogenous level of NAA and other metabolites in the plant. Therefore, an exogenous application of gibberellins and NAA might have improved fruit retention and reduced drop per cent. The present findings are in accordance with Vashistha *et al.*, (2010), Singh *et al.*, (2017), Kumar *et al.*, (2018b) in mango, Tripathi and Shukla (2010) in strawberry and Tripathi *et al.*, (2018) in aonla. Tripathi *et al.*, (2019), Maurya *et al.*, (2020) also reported maximum fruit retention and minimum fruit drop in mango cv. Amrapali with the combined application of GA₃ @ 50 ppm + NAA @ 40 ppm.

Number of fruits per panicle : Significantly higher number of fruits per panicle (5.98) was obtained from the plants which were treated with GA₃ at 20 ppm followed by NAA at 25 ppm (5.74) treated plants (Table-1). This increased number of fruits per panicle may be the results of higher fruit retention and less drop with GA₃ at 20 ppm treatment. The results are in conformity with the findings of Singh *et al.*, (2017), Kumar *et al.*, (2018b), Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango.

Fruit yield : The pre-harvest application of GA₃ @ 40 ppm followed by ZnSO₄ (0.6%) were found to be best to enhance fruit yield of 56.62 kg/tree and 54.21 kg/tree, respectively, whereas the minimum fruit yield (38.77 kg/tree) was recorded in plants kept under control (Fig.1). The enhancement in fruit yield due to foliar feeding of plant bio-regulators and micronutrient by plant leaves might be attributed to more luxuriant vegetative growth to the initial stage, which later on results synthesis of more metabolites for developing fruits. The result of present finding is in accordance with Tripathi and Shukla (2008), Singh and Tripathi (2010) in strawberry, who reported higher fruit

yield with the application of GA₃ at 100 ppm. More or less similar results were also reported by Tripathi *et al.*, (2018), Bhadauria *et al.*, (2018) in aonla, Kumar *et al.*, (2018a), Tripathi *et al.*, (2019), Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango and Badal and Tripathi (2021) in Guava.

Fruit Size : The maximum polar and equatorial diameter of fruits were recorded with the pre-harvest application of GA₃ 40 ppm (8.97 cm and 7.96 cm, respectively), whereas minimum polar and equatorial diameter (8.04 cm and 6.73 cm, respectively) of fruit was recorded in fruit produced from the plants kept under control (Table 2). The reasons for this increase in fruit size in polar and equatorial diameter with spraying of plant bio-regulators and micronutrient may be because of efficient accumulation of metabolites in initial stage of developing fruits. Spraying of plant bio-regulators and micronutrient might have regulated the cell-wall permeability and increased absorption, thereby allowing more water mobility in fruits resulting an enlargement of fruit size. These results are in close conformity with the findings of Singh *et al.*, (2017), who also found increase in fruit size with pre-harvest application of GA₃ at 50 ppm in mango cv. Amrapali. The results are in line with the findings of Kumar *et al.*, (2018a) in mango, Singh and Tripathi (2010), Tripathi and Shukla (2010) in strawberry, Tripathi *et al.*, (2018), Bhadauria *et al.*, (2018) in aonla, Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango.

Weight, volume and specific gravity of fruit : Fruit weight, volume and specific gravity were significantly influenced by the foliar application of plant bio-regulators and micronutrient. The significantly higher weight (248.69 g), volume (238.00 g/cc) and specific gravity (1.07 g/cc) of fruit was recorded in the fruits produced from the plants treated with GA₃ 50 ppm, while the minimum weight (182.29 g), volume (188.00 g/cc) and specific gravity (0.96 g/cc) of fruit was recorded under control (Table-2). Weight, volume and specific gravity of fruits gets reduced with the reduction in the concentration of plant bio-regulators and micronutrient in all treatments. Gibberellic acid and Zinc Sulphate are directly or indirectly involved in the photosynthesis in the plants and then they were translocated to the fruits during their growth and development, which increase the reserved food material in the fruits and ultimately increase weight and volume of fruits. This increase in weight and size with reduction in stone weight of fruit, results an increase in specific gravity of fruits. These results have got the support of Singh *et al.*, (2017), Bhadauria *et al.*, (2018) in aonla, Tripathi *et al.*, (2019), Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango.

Table-1 : Influence of foliar application of GA₃, Naphthalene acetic acid and Zinc Sulphate on fruit drop, fruit retention and number of fruits per panicle in Mango cv. Amrapali.

Treatments		Fruit drop (%)	Fruit retention (%)	Number of fruits per panicle
GA ₃ 20 ppm	(T ₁)	85.62	14.38	5.98
GA ₃ 40 ppm	(T ₂)	88.10	11.19	4.82
GA ₃ 60 ppm	(T ₃)	88.43	11.57	4.53
NAA 25 ppm	(T ₄)	89.95	10.05	5.74
NAA 50 ppm	(T ₅)	89.10	10.90	5.26
NAA 75 ppm	(T ₆)	87.35	12.65	4.95
ZnSO ₄ (0.2%)	(T ₇)	90.15	9.85	4.06
ZnSO ₄ (0.4%)	(T ₈)	88.42	11.58	4.50
ZnSO ₄ (0.6%)	(T ₉)	87.91	12.09	4.73
Control	(T ₁₀)	93.27	6.73	3.96
SEm±		0.72	0.38	0.24
CD at 5%		2.16	1.15	0.71

Table-2 : Influence of foliar application of GA₃, Naphthalene acetic acid and Zinc Sulphate on physical parameters of Mango cv. Amrapali fruits.

Treatments		Polar diameter of fruits (cm)	Equatorial diameter of fruits (cm)	Average fruit weight (g)	Pulp (%)	Fruit stone (%)	Fruit volume (cc)	Specific gravity (g/cc)
GA ₃ 20 ppm	(T ₁)	8.42	7.05	211.47	65.02	14.08	211.47	1.00
GA ₃ 40 ppm	(T ₂)	8.97	7.96	206.34	70.15	12.32	194.00	1.06
GA ₃ 60 ppm	(T ₃)	8.15	6.92	238.76	63.96	15.56	228.00	1.04
NAA 25 ppm	(T ₄)	8.26	6.89	227.52	66.08	15.02	223.00	1.02
NAA 50 ppm	(T ₅)	8.87	7.24	248.69	73.21	11.43	238.00	1.04
NAA 75 ppm	(T ₆)	8.81	7.10	242.43	71.32	13.85	230.00	1.05
ZnSO ₄ (0.2%)	(T ₇)	8.21	6.98	196.24	64.32	16.90	190.00	1.03
ZnSO ₄ (0.4%)	(T ₈)	8.68	7.03	202.58	66.92	14.26	191.00	1.06
ZnSO ₄ (0.6%)	(T ₉)	8.34	7.09	208.64	67.65	15.78	194.00	1.07
Control	(T ₁₀)	8.04	6.73	182.29	60.28	18.60	188.00	0.96
SEm±		0.04	0.60	2.53	0.91	0.29	2.06	0.01
CD at 5%		0.14	0.18	7.53	2.70	0.86	6.12	0.02

Pulp and stone per cent : Pre-harvest application of NAA @ 50 ppm resulted significant increase in pulp per cent (73.21%) and reduction of stone per cent (11.43%) in mango fruits. The minimum pulp per cent (60.28%) and maximum stone per cent (18.60%) was recorded in fruits harvested from the plants kept as control (Table 2). This increase in pulp per cent may be due to more absorption of water, plant bio-regulators and micronutrient which ultimately increase the volume of intercellular spaces in the pulp. These results are in accordance with the findings of Tripathi *et al.*, (2018), who recorded higher pulp in aonla cv. NA-7 with the spraying of GA₃ @ 50 ppm. These results are in line with the reports of Kumar *et al.*, (2018a), Bhadauria *et al.*, (2018), Tripathi *et al.*, (2019), Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango.

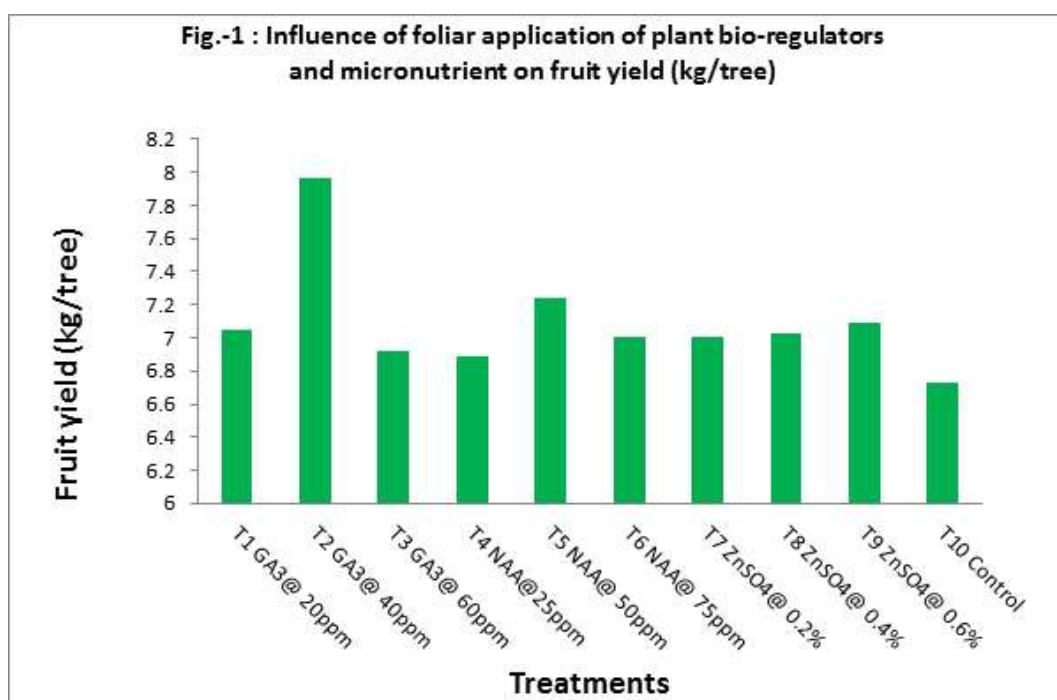
Total soluble solids and Total sugars : Maximum amount of total soluble solids (TSS) was found which was produced from the tree sprayed with GA₃ @ 75 ppm 19.57 °Brix, while minimum total soluble solids content 15.86 °Brix under control whereas maximum amount of total

sugar content was found by GA₃ @ 60 ppm 18.25% while minimum total sugar content (14.20%) under control (Table 3). This increase in total soluble solids and total sugar content of fruits may be due to the fact that the adequate amount of GA₃ improves the auxin content that acted as catalyst in oxidation process. GA₃ also indirectly influences many enzyme systems in plants, out of these the role of gibberellins in activation of amylase enzyme is well known which are responsible for the conversion of starch into sugar thus improve the TSS and total sugars contents in fruits. Gibberellins are known to play a crucial role in the sugar metabolism of plants. These results have got the support with the findings of Dubey *et al.*, (2017) in strawberry, Shukla *et al.*, (2011), Tiwari *et al.*, (2017), Kumar *et al.*, (2018a), Maurya *et al.*, (2020), Dheware and Nalage (2020) in mango. Tripathi *et al.*, (2019) also reported increased TSS and total sugar content in mango with the application of GA₃ 50 ppm + NAA 40 ppm.

Ascorbic acid : Significantly higher quantity of ascorbic acid (37.10 mg) was recorded in fruits which were produced from the plants treated with GA₃ @ 60 ppm,

Table-3 : Influence of foliar application of GA₃, Naphthalene acetic acid and Zinc Sulphate on chemical parameters of Mango cv. Amrapali fruits.

Treatments	Total soluble solid (°Brix)	Total sugars (%)	Ascorbic acid (mg/100g pulp)
GA ₃ 20 ppm (T ₁)	17.36	15.43	35.94
GA ₃ 40 ppm (T ₂)	19.45	17.96	36.88
GA ₃ 60 ppm (T ₃)	18.25	18.25	37.10
NAA 25 ppm (T ₄)	17.10	15.98	34.42
NAA 50 ppm (T ₅)	19.05	17.32	35.68
NAA 75 ppm (T ₆)	19.57	17.83	35.84
ZnSO ₄ (0.2%) (T ₇)	15.88	15.92	33.46
ZnSO ₄ (0.4%) (T ₈)	16.60	16.15	34.30
ZnSO ₄ (0.6%) (T ₉)	17.74	16.28	36.51
Control (T ₁₀)	15.86	14.20	28.52
SEm±	0.07	0.07	0.09
CD at 5%	0.21	0.23	0.28



followed by 36.88 mg in GA₃ @ 40 ppm treated plants, whereas lower amount of ascorbic acid (28.52 mg) content was recorded in fruits which were produced from the plants kept under control (Table-3). This increase in ascorbic acid content with gibberellic acid application might be due to uninterrupted synthesis of its precursor like glucose-6-phosphate during conversion of starch into various sugars and low rate of oxidation. These results have got the support with the findings of Tripathi and Shukla (2006), Dubey *et al.*, (2017) in strawberry, Shukla *et al.*, (2011) in aonla and Tripathi *et al.*, (2019), Maurya *et al.*, (2020) and Dheware and Nalage (2020) in mango.

References

1. A.O.A.C. (1980). Official method of analysis. *Association of Official Analytical Chemists* (12th edn.), Washington. D.C.
2. Aykroyd, W.R., Gopalan, C. and Balasubramanyam, S.C. (1966). The nutritive value of Indian foods and planning of satisfactory diets. I.C.M.R. New-Delhi. pp:74.
3. Bhadauria, A. S., Tripathi, V.K., Singh, A. and Gupta, S. (2018). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. *Progressive Research-An International Journal*, 13 (3): 216-219.
4. Dubey, Vishal, Meena, M.L. and Tripathi, V.K. (2017). Effect of plant bio-regulators and micronutrient on vegetative growth, yield and quality of strawberry cv. Chandler. *Progressive Research-An International Journal*, 12 (3): 330-332.
5. Dheware, R.M., Nalage, N.A., Sawant, B.N., Haldavanekar, P.C., Raut, R.A., Munj, A.Y. and Sawant, S.N. (2020). Response of micronutrient on the quality of mango cv. Alphonso under Konkan agro-climatic conditions. *Journal of Pharmacognosy and Phytochemistry*, 9 (3)2004-2006.

6. Kumar, R., Tripathi, V.K., Tomar, S. and Chaudhary, M. (2018b). Effect of best plant bio-regulators and micronutrient for achieving higher yield and quality of mango (*Mangifera indica* L.) fruits cv. Amrapali. *Journal of Plant Development Sciences*, 1 (11): 599-604.
7. Kumar, R., Tripathi, V.K., Tomar, S., Chaudhary, M. and Jeevan, R. (2018a). Effect of best plant bio-regulators and micronutrient for getting higher fruit setting in mango (*Mangifera indica* L.) cv. Amrapali. *Journal of Plant Development Sciences*, 10 (11): 701-705.
8. Maurya, P.K., Tripathi, V.K. and Gupta, S. (2020). Effect of pre-harvest application of GA₃, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali. *Journal of Pharmacognosy and Phytochemistry*, 9 (6): 2123-2127.
9. Shukla, H.S., Kumar, V. and Tripathi, V.K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits 'Banarasi'. *Acta Horticulturae*, 890: 375-380.
10. Singh, T., Tripathi, V.K. and Tiwari, P. (2017). Influence of pre-harvest application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of mango. *Progressive Research-An International Journal*, 12 (Special-IV): 2640-2644.
11. Singh, V.K. and Tripathi, V.K. (2010). Efficacy of GA₃, boric acid and zinc sulphate on growth, flowering, yield and quality of strawberry cv. Chandler. *Progressive Agriculture*, 10 (2): 345-348.
12. Tiwari, P., Tripathi, V.K. and Singh, A. (2017). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. *Progressive Research-An International Journal*, 12 (Special-IV): 2565-2568.
13. Tripathi, V.K. and Shukla, P.K. (2008). Influence of plant bio-regulators and micronutrients on flowering and yield of strawberry cv. Chandler. *Annals of Horticulture*, 1 (1): 45-48.
14. Tripathi, V.K. and Shukla, P.K. (2010). Influence of plant bio-regulators, boric acid and zinc sulphate on yield and fruit characters of strawberry cv. Chandler. *Progressive Horticulture*, 42 (2): 186-188.
15. Tripathi, V.K., Pandey, S.S., Kumar, A., Dubey, V. and Tiwari, P. (2018). Influence of foliar application of gibberellic acid, calcium and boron on fruit drop, yield and quality attributes of aonla (*Emblica officinalis*) cv. NA7. *Indian Journal of Agricultural Sciences*, 88 (11): 1784-8.
16. Badal, D.S. and Tripathi, V.K. (2021). Influence of foliar feeding of naa and boron on growth, flowering, fruiting, and yield of winter season guava (*Psidium guajava* L.) cv. L-49. *Biological Forum-An International Journal*, 13 (3): 387-391.
17. Tripathi, V.K. and Shukla, P.K. (2006). Effect of Plant bio-regulators on growth, yield and quality of strawberry cv. Chandler. *Journal of Asian Horticulture*, 2 (4): 260-263.
18. Tripathi, V.K., Singh, A., Bhadauria, A.S. and Gupta, S. (2019). Influence of GA₃ and naphthalene acetic acid alone and in combination on fruit drop, yield and quality of mango cv. Amrapali. *Progressive Research-An International Journal*, 14 (1): 10-13.
19. Vashistha, K., Yadav, A.L., Singh, H.K., Yadav, D.K. (2010). Effect of foliar spray of nutrients on fruit drop, yield and quality attributes of mango fruit (*Mangifera indica* L.) cv. Amrapali. *Plant Archives*, 10 (1): 359-360.



Bio-Efficacy of Spinetoram 12% SC (11.70% w/w) Against Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) in Maize

C.S. Chaudhari*, A.S. Totre, V.S. Shinde, S.B. Latake and S.R. Dhonde

AICRP on Maize, MPKV Rahuri, Ahmednagar (MS) India 413 722

*Email : charudatta.abs@gmail.com

Abstract

Bio-efficacy of insecticide spinetoram 12% SC was assessed against the Fall armyworm in maize during the Kharif 2019 season. The present investigation carried out in Randomized Block Design with six treatments with the standard check of Dimethoate 30% EC. The insecticide spinetoram 12% SC was evaluated at different concentration viz., 150, 200, 250 and 300 ml/ha against Fall armyworm (*Spodoptera frugiperda* (J.E. Smith) in maize. At last interval of observation 14 days after the second spray, it was found that the most superior dose of spinetoram in recording the least larval population and in reducing plant damage was 300 ml/ha i.e., 0.6 ml/liter which registered 0.22 larvae per plant and 4.17 per cent plant damage, respectively. However, spinetoram 12% SC @ 250 ml/ha i.e., 0.5 ml/liter registered 0.26 larvae per plant and 4.22 per cent plant damage and found to be at par with spinetoram 12% SC @ 300ml/ha. The highest yield is also recorded in the treatment with spinetoram 12% SC @ 300 ml/ha (78.13 q/ha) and it was also at statistically equal to spinetoram 12% SC @ 250 ml/ha (77.27 q/ha). It is concluded from the findings that the spinetoram 12% SC @ 250 ml/ha is best tool in the management of Fall armyworm in maize which is causing serious losses in maize ecosystem.

Key words : Bio-efficiency, spinetoram, armyworm, maize.

Introduction

Cereal crops play a important role in the daily diets in India and account for up to 46% of the daily calorie consumption. Maize followed by sorghum are major staple food crops grown in diverse agro-ecological zones and farming systems in India. Cereal production in India is heavily constrained by different abiotic and biotic factors. Abiotic constraints are mainly related to poor soil health, poor soil fertility management, and soil nutrient depletion that arise as a result of resource degradation and erosion. Extended droughts and unpredictable rainfall patterns are climate-change-related challenges faced by growers. Biotic constraints encompass insect pests, such as Fall armyworm and diseases. All these constraints expose small-scale farmers to hunger and other forms of vulnerability that has been recently exacerbated with the invasion of Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith).

Maize is one of the important cereal crops grown in India. Maize (*Zea mays* L.). It is one of the major food, economic and energy crops not only in India but in worldwide, which is mainly distributed in tropical and temperate regions. This new invasive species has been occurring in serious proportions, causing significant damage to the maize crop, thus posing serious treat for maize production in the country. The Fall armyworm persists on maize crop from the early crop stage till cob maturity, thus necessitating spraying of insecticides multiple times. Repeated application of chemicals with

similar mode of action would hasten the development of resistance. Hence, to delay the development of resistance to insecticides, it is essential to rotate the chemicals having different modes of action. In the current research we assessed the bio-efficacy of insecticides belonging to different chemical groups on the Fall armyworm for kharif cropping seasons in India.

Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is native to tropical and subtropical regions of the Americas and is the key insect pest of maize in tropical regions. The occurrence of FAW was reported in Africa for the first time in late 2016 in West Africa. Subsequently, FAW has rapidly spread throughout Sub-Saharan Africa (SSA) and, currently, its occurrence has been confirmed in 44 African countries. Recently during August 2018, Fall armyworm was reported for the first time in India, near Bangalore, Karnataka state on the maize crop (Ganiger *et al.*, 2018). FAW is a highly polyphagous insect pest that attacks more than 80 plant species, including maize, sorghum, millet, sugarcane and vegetable crops; nevertheless, maize is the main crop affected by FAW in India.

Fall armyworm [(*Spodoptera frugiperda*) (J. E. Smith) (Lepidoptera: Noctuidae)] is the most destructive pest of corn in Africa, the Americas and elsewhere, causing yield losses up to 100%. Resistance to many insecticides groups including *Bacillus thuringiensis* (Bt) has been reported. Thus, the efficacy of biological agents, synthetic insecticides and environmental friendly

Table-1 : Effect of Spinetoram 12% SC w/v (11.70% w/w) against larval population of Fall armyworm (*Spodoptera frugiperda*) in maize during Kharif 2019–First spray.

Trt No.	Treatments	Dose (g a.i./ha)	Number of <i>Spodoptera frugiperda</i> larvae per plant							Reduction over control (%)
			Pre-count	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	
T1	Spinetoram 12% SC	18	1.05 (1.24)*	0.78 (1.13)	0.63 (1.06)	0.60 (1.05)	0.53 (1.01)	0.71 (1.10)	0.65 (1.07)	58.34
T2	Spinetoram 12% SC	24	1.07 (1.25)	0.20 (0.84)	0.22 (0.85)	0.03 (0.73)	0.12 (0.79)	0.60 (1.05)	0.23 (0.86)	85.22
T3	Spinetoram 12% SC	30	1.03 (1.24)	0.12 (0.79)	0.07 (0.75)	0.02 (0.72)	0.08 (0.76)	0.43 (0.96)	0.14 (0.80)	90.76
T4	Spinetoram 12% SC	36	1.06 (1.25)	0.10 (0.77)	0.02 (0.72)	0.02 (0.72)	0.05 (0.74)	0.57 (1.03)	0.15 (0.81)	90.35
T5	Dimethoate 30% EC	200	0.86 (1.17)	0.92 (1.19)	0.47 (0.98)	0.34 (0.92)	0.46 (0.98)	0.57 (1.03)	0.55 (1.03)	64.69
T6	Untreated check	-	0.98 (1.22)	1.03 (1.24)	1.50 (1.41)	1.60 (1.45)	1.80 (1.52)	1.88 (1.54)	1.56 (1.44)	-
		SEm ±	0.03	0.04	0.03	0.03	0.05	0.03	0.04	-
		CD @ 5%	NS	0.12	0.09	0.09	0.15	0.10	0.16	-

*Figures in the parentheses are square root (x+0.5) transformed values, DAS-Days after spray.

Table-2 : Effect of Spinetoram 12% SC w/v (11.70% w/w) on per cent feeding damage by Fall armyworm (*Spodoptera frugiperda*) in maize during Kharif 2019–First spray.

Trt No.	Treatments	Dose (g a.i./ha)	Per cent feeding damage due to <i>Spodoptera frugiperda</i>							Reduction over control (%)
			Pre-count	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	
T1	Spinetoram 12% SC	18	10.79 (19.18)*	10.95 (19.33)	11.21 (19.56)	10.61 (19.01)	10.61 (19.01)	13.04 (21.17)	11.29 (19.63)	51.73
T2	Spinetoram 12% SC	24	13.59 (21.63)	14.11 (22.07)	6.45 (14.71)	7.15 (15.51)	8.76 (17.21)	7.15 (15.51)	8.72 (17.18)	62.69
T3	Spinetoram 12% SC	30	12.48 (20.69)	10.00 (18.44)	2.15 (8.43)	2.17 (8.47)	2.45 (9.01)	4.27 (11.93)	4.21 (11.84)	82.00
T4	Spinetoram 12% SC	36	13.95 (21.93)	9.98 (18.42)	2.41 (8.93)	2.23 (8.59)	2.33 (8.78)	3.86 (11.33)	4.16 (11.77)	82.20
T5	Dimethoate 30% EC	200	11.52 (19.84)	10.84 (19.22)	7.00 (15.34)	8.23 (16.67)	5.30 (13.31)	7.15 (15.51)	7.70 (16.11)	67.05
T6	Control	-	10.12 (18.55)	15.37 (23.08)	23.19 (28.78)	24.42 (29.61)	25.58 (30.38)	28.35 (32.17)	23.38 (28.92)	-
		SEm ±	0.33	0.41	0.39	0.36	0.42	0.53	0.50	-
		CD @ 5%	NS	1.24	1.10	1.08	1.26	1.60	1.52	-

*Figures in the parentheses are arcsine transformed values, DAS-Days after spray.

combinations between insecticides needs to be assessed. Our objectives were to evaluate the mortality of FAW larvae caused by synthetic insecticides.

Materials and Methods

The field experiment was laid out in a Randomized Block Design (RBD) during Kharif 2019 to evaluate the bio-efficacy of Spinetoram 12% SC w/v (11.70% w/w). Maize seeds were planted in with row to row spacing of 75 cm and plant to plant spacing of 20 cm. The agronomical package of practices was followed as per University recommendations except Fall armyworm control measures. Four doses of the test chemical Spinetoram 12% SC was evaluated and compared with market

standard and untreated check as mentioned in treatment list.

All the treatments were imposed by high volume knapsack sprayer fitted with hollow cone nozzle. During the study period, two sprays were given at 15 days interval and observations on larval count and per cent foliage damage of maize crop due to Fall armyworm, were recorded on randomly selected ten plant per treatment at a day before the treatment application (pre count), 1, 3, 7, 10 and 14 days after spray (DAS). Per cent reduction over untreated check was calculated. The visual observations of effect on natural enemies and phytotoxicity effect of test insecticide on maize were recorded during crop period.

Table-3 : Effect of Spinetoram 12% SC w/v (11.70% w/w) against larval population of Fall armyworm (*Spodoptera frugiperda*) in maize during Kharif 2019 – Second spray.

Trt No.	Treatments	Dose (g ai/ha)	Number of <i>Spodoptera frugiperda</i> larvae per plant							Reduction over control (%)
			Pre-count	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	
T1	Spinetoram 12% SC	18	0.71 (1.10)	0.63 (1.06)	0.50 (1.00)	0.48 (0.99)	0.41 (0.95)	0.58 (1.04)	0.52 (1.01)	63.96
T2	Spinetoram 12% SC	24	0.60 (1.05)	0.54 (1.02)	0.40 (0.95)	0.29 (0.89)	0.35 (0.92)	0.48 (0.99)	0.41 (0.96)	71.35
T3	Spinetoram 12% SC	30	0.43 (0.96)	0.58 (1.04)	0.11 (0.78)	0.13 (0.80)	0.16 (0.81)	0.32 (0.91)	0.26 (0.87)	81.99
T4	Spinetoram 12% SC	36	0.57 (1.03)	0.38 (0.94)	0.09 (0.77)	0.08 (0.76)	0.10 (0.77)	0.44 (0.97)	0.22 (0.85)	84.85
T5	Dimethoate 30% EC	200	0.57 (1.03)	0.49 (0.99)	0.35 (0.92)	0.36 (0.93)	0.34 (0.92)	0.38 (0.94)	0.38 (0.94)	73.28
T6	Untreated check	-	1.88 (1.54)	1.60 (1.45)	1.28 (1.33)	1.38 (1.37)	1.72 (1.49)	1.86 (1.54)	1.44 (1.39)	-
	SEm ±		0.03	0.04	0.03	0.03	0.04	0.04	0.06	-
	CD @ 5%		0.10	0.13	0.1	0.09	0.13	0.12	0.19	-

*Figures in the parentheses are square root (x+0.5) transformed values, DAS-Days after spray.

Table-4 : Effect of Spinetoram 12% SC w/v (11.70% w/w) on per cent feeding damage by Fall armyworm (*Spodoptera frugiperda*) in maize during Kharif 2019 – Second spray.

Trt No.	Treatments	Dose (g a.i./ha)	Per cent feeding damage due to <i>Spodoptera frugiperda</i>							Reduction over control (%)
			Pre-count	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	
T1	Spinetoram 12% SC	18	13.04 (21.17)	9.58 (18.03)	8.52 (16.97)	9.02 (17.48)	10.24 (18.66)	11.20 (19.55)	9.71 (18.16)	49.37
T2	Spinetoram 12% SC	24	7.15 (15.51)	12.61 (20.80)	6.86 (15.19)	5.62 (13.71)	6.03 (14.22)	7.68 (16.09)	7.76 (16.18)	59.54
T3	Spinetoram 12% SC	30	4.27 (11.93)	8.67 (17.12)	3.22 (10.34)	2.34 (8.80)	3.12 (10.18)	3.77 (11.19)	4.22 (11.86)	77.98
T4	Spinetoram 12% SC	36	3.86 (11.33)	8.57 (17.02)	3.03 (10.02)	2.31 (8.75)	3.23 (10.36)	3.73 (11.14)	4.17 (11.79)	78.24
T5	Dimethoate 30% EC	200	7.15 (15.51)	9.47 (17.92)	7.32 (15.70)	8.48 (16.93)	10.28 (18.70)	11.26 (19.61)	9.36 (17.82)	51.19
T6	Untreated check	—	28.35 (32.17)	21.82 (27.85)	18.63 (25.57)	20.22 (26.72)	20.98 (27.26)	22.25 (28.14)	19.18 (25.97)	-
	SEm ±		0.53	0.35	0.53	0.20	0.48	0.42	0.48	-
	CD @ 5%		1.60	1.10	1.60	0.61	1.56	1.26	1.52	-

*Figures in the parentheses are arc sin transformed values, DAS-Days after spray.

Ten plants were selected randomly from each plot and different symptoms of Fall armyworm (FAW) the larval population was recorded from one meter row length from five rows and percent damage was recorded per plot. The collected data were converted into per cent infestation, larval count per plant. Grain yield was recorded per plot (kg/plot) at harvest and yield was given as q/ha. All the data was subjected to statistical analysis after appropriate data transformation.

Results and Discussion

Larval count : Table-1 depicts the efficacy of Spinetoram 12% SC against Fall armyworm (*Spodoptera frugiperda*) in maize after first spray application. Results revealed that mean population of Fall armyworm larvae ranged from 0.86 to 1.07 per plant before first application. Significant

reduction in the Fall armyworm population was reported in all the treatments after first spray compared to untreated check. Minimum mean population was recorded in the plots treated with Spinetoram 12% SC @ 36 g/ha (0.14 larvae/plant) which was at par with Spinetoram 12% SC @ 30 g/ha (0.14 larvae/plant), resulting in highest (90.76% in both treatments) per cent reduction in larval population over untreated check. Mean larval population in untreated check was 1.56 larvae/plant, whereas in standard check Dimethoate 30% EC @ 200 g/ha, it was 0.55 larvae/plant. After second application also, significant reduction in the Fall armyworm population was reported in all the treatments (Table-3) compared to untreated check. Minimum mean population of Fall armyworm larvae was recorded in the plots treated with Spinetoram 12% SC @ 36 g/ha (0.22 larvae/plant) which was at par with

Spinetoram 12% SC @ 30 g/ha (0.26 larvae/ plant), resulting in highest percent reduction in larval population (84.85% and 81.99%, respectively) compared to untreated check. Mean larval population in standard check Dimethoate 30% EC @ 200 g/ha was 0.38 larvae per plant whereas, in untreated check it was 1.44 larvae/ plant.

Feeding Damage : Before imposing treatments, per cent feeding damage ranged from 10.12% to 13.95% (Table-2). After imposing the treatments there was significant reduction in feeding damage compared to untreated check. Minimum mean feeding damage was recorded in the treatment Spinetoram 12% SC @ 36 g/ha (4.16%) which was at par with Spinetoram 12% SC @ 30 g/ha which recorded 4.21% mean foliage damage. Amongst insecticide treatment, maximum feeding damage after first application was reported in the treatment Spinetoram 12% SC @ 18 g ai/ha (11.29%). Market standard Dimethoate 30% EC @ 200 g ai/ha reported 7.70% of mean foliage damage due to Fall armyworm. Whereas, highest (23.38%). feeding damage was recorded in untreated control. Minimum mean feeding damage after second spray was recorded in the treatment Spinetoram 12% SC @ 36 g a.i./ha (4.17%) where showed similar trend to first application results and was at par with Spinetoram 12% SC @ 30 g a.i./ha which recorded 4.22% mean foliage damage. Treatment with Dimethoate 30% EC @ 200 g a.i./ha reported 9.36% of mean foliage damage due to Fall armyworm which was at higher side compared to first application. Amongst insecticide treatment, maximum feeding damage after first application was reported in the treatment Spinetoram 12% SC @ 18 g a.i./ha (9.71%). Untreated check after second application recorded maximum per cent feeding damage (19.18%).

Due to recent invasion of Fall armyworm in maize ecosystem, there is a need to suggest not only effective insecticide but also its proper dose. However the need of use of proper dose of Spinetoram was already discussed by Belay *et. al.*, 2012. The CIBRC have given a recent adhoc advisory for management of Fall armyworm which includes spinetoram 12% SC. The recent work in management of Fall armyworm carried out by Dileepkumar, NT and Muralimohan K. 2020, also registered the superiority of spinetoram 11.7% SC among the various insecticide, tested during same *kharif* 2019,

with the least leaf damage and number of larvae/plant, which is in accordance with the present findings. Therefore, the spinetoram 12% SC @ 250 ml/ha could be the best insecticide with modern mode of action for production of higher grain yield of maize.

Conclusions

Spinetoram 12% SC @ 36 g a.i./ha was found significantly effective in reducing the incidence of Fall armyworm and delivering maximum grain yield and was at par with Spinetoram 12% SC @ 30 g a.i./ha. Hence, Spinetoram 12% SC @ 30 g a.i./ha can be recommended as minimum effective dose to control Fall armyworm in maize.

Acknowledgement

The Authors are sincerely grateful to AICRP on Maize, Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri,, Mahatma Phule Krushi Vidyapeeth Rahuri, for providing necessary facilities for complete the research work.

References

1. Belay, D.K., Huckaba, R.M. and Foster, J.E. 2012. Susceptibility of the Fall armyworm, *Spodoptera frugiperda* (Lepidoptera: noctuidae), at Santa Isabel, Puerto Rico, to different insecticides. *Florida Entomologist* 95(2): 476-478.
2. Ganiger, P.C., Yeshwanth, H.M., Mohan, M.K., Vinay, N, Kumar, A.R.V. and Chandrashekara K. 2018. Occurrence of the new invasive pest, Fall armyworm, *Spodoptera frugiperda* (J.E Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. *Current Science* 115:621-623
3. Dileep Kumar, N. T. and Murali Mohan, K. 2020. Bio-efficacy of selected insecticides against Fall armyworm, *Spodoptera frugiperda* (Noctuidae: Lepidoptera), in maize. *J. of Entomology and Zoology Studies* 8(4): 1257-1261.
4. Birhanu, S., Tadele, T., Mulatu, W., Gashawbeza, A. and Esayas, M. 2019. The Efficacy of Selected Synthetic Insecticides and Botanicals against Fall armyworm, *Spodoptera frugiperda*, in Maize. *Insects* 10(45).
5. Saliou, N., Mawufe Komi, A., Emily, K., Berita, M., El Fatih, M. Abdel-Rahman., Daisy S., Girma, H., Yeneneh T. B., Elias F., Henri E.Z.T., Sunday, E., Sevgan, S. 2020. Bioecology of Fall armyworm *Spodoptera frugiperda*, its management and potential patterns of seasonal spread in Africa. *PLoS ONE* 16(6): e0249042.



Effect of Foliar Application of NAA and Boron on Growth, Yield and Quality of Phalsa

Sangam Kumar, A.K. Dwivedi, Akash Shukla and Satya Veer

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur-208 002 (U.P.)

Email : sangamcsa032719@gmail.com

Abstract

A field experiment was conducted at Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh during the year 2020-2021, in randomized block design with three replication and ten treatments viz., T₁-Control (water spray), T₂-NAA 100 ppm, T₃-NAA 150 ppm, T₄-NAA 200 ppm, T₅-Boron 0.2%, T₆-Boron 0.4%, T₇-Boron 0.6%, T₈-NAA 100 ppm + Boron 0.2%, T₉-NAA 150 ppm + Boron 0.4%, T₁₀-NAA 200 ppm + Boron 0.6%. The results obtained clearly indicated that the foliar application of NAA and Boron proved significant effect on the growth, yield and quality parameters of Phalsa. Improvement in the length of shoots, diameter of shoot, number of shoots per plant, number of leaves per shoot, fruit set percentage, fruit diameter, fruit volume, weight of 100 fruit, yield per plant and yield per hectare were recorded in foliar application of NAA 200 ppm + Boron 0.6%. The quality traits such as TSS, total sugars, reducing sugar, non-reducing sugar, ascorbic acid and reduction in titratable acidity were also recorded with the foliar application of NAA 200 ppm+ Boron 0.6%. The control exhibited minimum values in this regard.

Key words : Phalsa, NAA, boron, growth, yield.

Introduction

Phalsa (*Grewia subinaequalis* D.C.) also known as “star apple”. It belongs to the family Tiliaceae. This family has about 41 genera and 400 species which are mostly distributed in the tropical and subtropical region of the world. It requires distinct winter and summer for better yield and fruit quality. The plants can tolerate even a temperature of 45°C and freezing temperature for a few days. Phalsa can be grown on wide range of soils, even on moderately sodic soil. However, best results are obtained in well drained, loamy soil. Fruit are good source of vitamin-A and vitamin-C, they are also fair source of phosphorous and iron. Ripe fruits are consumed fresh in desserts or processed into refreshing soft drinks like squash, RTS, sharbat etc. The attractive crimson red to dark purple colour of phalsa fruit is due to anthocyanin pigments mainly, delphinidin-3-glucoside, cyanidin-3-glucoside and pelargonidin-3, 5 diglucoside (Tiwari *et al.*, 2014).

Application of NAA increased the leaf index, length of flower panicles, fruit set, reduction of malformation and even the bio-chemical status likes carbohydrate, nitrogen and enhanced RNA and DNA level. Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set. Boron also associated with the uptake of calcium by plant and regulates the ratio of potassium and calcium. Boron influences fruit setting and yield of different plant.

Materials and Methods

The present investigation was carried out at Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh during the year 2020-2021, in randomized block design with three replication and ten treatments viz., T₁-Control (water spray), T₂-NAA 100 ppm, T₃-NAA 150 ppm, T₄-NAA 200 ppm, T₅-Boron 0.2%, T₆-Boron 0.4%, T₇-Boron 0.6%, T₈-NAA 100 ppm + Boron 0.2%, T₉-NAA 150 ppm + Boron 0.4%, T₁₀-NAA 200 ppm + Boron 0.6%. number of thirty plant and their Well-established thirty plants of phalsa cv. Sharbati, planted at a spacings of 3 m x 3 m row to row and 2.5 m x 2.5 m plant to plant were taken for the present investigation. Treatments used were T₁-Control (water spray), T₂-NAA 100 ppm, T₃-NAA 150 ppm, T₄-NAA 200 ppm, T₅-Boron 0.2%, T₆-Boron 0.4%, T₇-Boron 0.6%, T₈-NAA 100 ppm + Boron 0.2%, T₉-NAA 150 ppm + Boron 0.4%, T₁₀-NAA 200 ppm + Boron 0.6%. Proper orchard management and nutrient application practices were followed as per recommended package and practices for phalsa viz., FYM @ 10 kg/plant and N, P & K (50:25:25 gm/ plant) for proper growth and higher yield of fruit. The observation regarding number shoot per plant, number of leaves per shoot and fruit set percentage was calculated by count method. fruit diameter measured with the help of a vernier caliper. Fruit volume measured by the water displacement method. Weight of 100 fruit weighed on a physical balance. Yield per plant and yield per hectare was calculated mathematically. The quality traits such as TSS content determined with the help of hand refractometer. Total sugars ascorbic acid and

Table-1 : Effect of foliar application of NAA and Boron on vegetative growth, fruit set and Physical parameters of phalsa fruit.

Symbol	Treatments	Shoot length (cm)	Diameter of shoot (cm)	Number of shoots/plant	Number of leaves/shoot	Fruit set %	Fruit diameter (cm)	Volume of fruits (cm) ³	Weight of 100 fruits (g)
T ₁	Control (water spray)	109.56	0.61	74.23	17.42	60.86	0.81	1.05	67.61
T ₂	NAA 100 ppm	122.08	0.79	78.61	32.20	67.78	0.95	1.21	88.43
T ₃	NAA 150 ppm	128.91	0.81	81.00	34.86	69.12	0.96	1.22	90.16
T ₄	NAA 200 ppm	130.32	0.82	83.42	36.18	70.36	0.98	1.24	92.66
T ₅	Boron 0.2%	115.43	0.68	77.38	23.33	62.78	0.89	1.09	75.18
T ₆	Boron 0.4%	118.76	0.71	79.83	25.98	63.10	0.91	1.10	78.20
T ₇	Boron 0.6%	119.20	0.73	81.56	28.46	65.13	0.92	1.12	82.54
T ₈	NAA 100 ppm+ Boron 0.2%	136.92	0.88	88.26	40.76	72.30	1.05	1.28	97.38
T ₉	NAA 150 ppm+ Boron 0.4%	139.25	0.91	89.90	42.93	73.46	1.06	1.30	99.10
T ₁₀	NAA 200 ppm+ Boron 0.6%	140.19	0.94	90.35	44.00	75.35	1.08	1.33	101.05
S.E. (diff.) ±		3.10	0.0365	2.065	1.548	2.223	0.051	0.063	1.720
C.D. @ 5%		6.51	0.0814	4.34	3.255	3.309	0.108	0.130	3.616

Table-2 : Effect of foliar application of NAA and Boron on yield and quality of phalsa fruits.

Symbol	Treatments	Yield / plant(kg)	Yield/ha (q)	TSS (°Brix)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Titrateable acidity (%)	Ascorbic acid (mg)
T ₁	Control (water spray)	3.83	51.06	17.20	14.05	11.78	2.16	2.86	29.16
T ₂	NAA 100 ppm	4.36	58.72	22.34	17.21	14.10	3.02	2.60	33.05
T ₃	NAA 150 ppm	4.53	60.38	23.46	17.93	14.18	3.19	2.55	33.86
T ₄	NAA 200 ppm	4.82	61.25	24.05	17.96	14.31	3.57	2.53	34.79
T ₅	Boron 0.2%	4.15	58.76	18.99	15.84	12.89	2.86	2.64	30.42
T ₆	Boron 0.4%	4.24	60.95	20.10	16.24	13.09	3.10	2.62	31.15
T ₇	Boron 0.6%	4.41	62.18	21.68	16.72	13.38	3.31	2.57	32.10
T ₈	NAA 100 ppm+ Boron 0.2%	5.65	76.32	24.50	18.27	14.45	3.74	2.42	37.83
T ₉	NAA 150 ppm+ Boron 0.4%	5.81	78.45	24.85	18.46	14.62	3.77	2.38	38.06
T ₁₀	NAA 200 ppm+ Boron 0.6%	6.04	80.51	25.39	18.93	15.06	3.82	2.36	39.91
S.E. (diff.) ±		0.472	2.508	0.593	0.270	0.459	0.129	0.093	0.557
C.D. @ 5%		0.992	5.272	1.247	0.569	0.965	0.271	0.195	1.172

titrateable acidity were studied after harvest as per method suggested in (A.O.A.C., 1980). The data so obtained were analyzed statically.

Results and Discussion

Vegetative growth and Fruit set : A perusal data in Table-1 shows that significant response in the maximum shoot length (140.19cm), diameter of shoot (0.94cm) and number of shoots per plant (90.35) was noted with foliar application of T₁₀ (NAA 200 ppm + Boron 0.6%) followed by T₉ (NAA 150ppm + Boron 0.4%) which exhibited (139.25cm, 0.91cm, 89.90), whereas the minimum (109.56 cm, 0.61 cm, 74.23) was recorded in T₁ (control). These findings are in line with the reports of Gurunji *et al.*, (2016) in mandarin, Ali *et al.*, (2014) in olive. The maximum fruit set percentage (75.35 %) obtained with the foliar application of T₁₀ (NAA 200 ppm + Boron 0.6%) followed by T₉ (NAA 150ppm + Boron 0.4%) exhibited (73.46%) while the minimum (60.86%) fruit set percentage was expressed under the treatment of T₁ (control). concept is also similarly reported by Prasad *et al.*, (2005)

in guava, Gogoi *et al.*, (2016) in citrus and Katiyar (2010) in ber.

Fruit Size : The maximum fruit size (1.08 cm) was noted with foliar application of T₁₀ (NAA 200 ppm + Boron 0.6%) followed by T₉ (NAA 150ppm + Boron 0.4%) exhibited (1.06cm) and minimum (0.81cm) was recorded in under T₁ (control). These results are in close conformity with the finding of Rema and Sharma (1991) in phalsa, Prasad *et al.*, (2005) in Guava, and Shukla *et al.*, (2011), who also found increased fruit size in aonla with boron treatment. Tiwari *et al.*, (2017) in aonla, Badal and Tripathi (2021b) in guava found increased fruit size with NAA spray.

Fruit Weight and Volume : The weight of fruits was significantly improved by the foliar application of T₁₀ (NAA 200 ppm + boron 0.6%) was significantly higher fruit weight (101.05g) followed by treatment of T₉ (NAA 150 ppm + boron 0.4%) recorded (99.10g), while the minimum fruit weight (67.61g) was recorded under control. Badal and Tripathi (2021b), also found increased fruit size with NAA 75 ppm spray in guava. These finding are in

accordance with the reports of Rema and Sharma (1991) in phalsa, Tripathi *et al.*, (2019) in mango, Verma *et al.*, (2021) in strawberry and Kacha *et al.*, (2012) in Phalsa. Maurya *et al.*, (2020) in mango also found increased fruit weight at GA₃ @ 75 ppm followed by NAA @ 60 ppm. The maximum volume of phalsa fruits was significantly influenced by T₁₀ (NAA 200 ppm + boron 0.6%) was significantly enhanced 1.33cc volume of phalsa fruit closely followed by treatment of T₉ (NAA 150 ppm + boron 0.4%) recorded 1.30 cc volume of phalsa fruit, whereas, 1.05 cc volume was demonstrated under the treatment of untreated plant i.e., T₁ (control). Tiwari *et al.*, (2017) in aonla and Singh and Singh *et al.*, (2015) in Indian Gooseberry.

Yield : A perusal data in Table-2 shows that the yield per plant of phalsa fruit was significantly influenced with foliar application of NAA and boron and their combination treatment of T₁₀ (NAA 200 ppm + boron 0.6%) revealed the maximum (6.04 kg) yield per plant followed by treatment T₉ (NAA 150 ppm + boron 0.4%) revealed (5.81 kg) yield per plant while, the minimum (3.83 kg) yield per plant of phalsa was obtained under T₁ (control). These findings are in line with the reports of Kacha *et al.*, (2014) in phalsa. Badal and Tripathi (2021a), also found higher yield with NAA 75 ppm spray in guava. The maximum yield per hectare (80.51 q/ha) was significantly improved by the foliar application of T₁₀ (NAA 200 ppm + boron 0.6%) followed by treatment of T₉ (NAA 150 ppm + boron 0.4%) recorded (78.45 q/ha), while the minimum yield per hectare (51.06 q/ha) was recorded under T₁ (control). These finding are in accordance with the reports of Kacha *et al.*, (2014) in phalsa. Gogoi *et al.*, (2016) in citrus, and Jitendra *et al.*, (2017) in phalsa.

Total Soluble Solid (TSS) : The maximum accumulation of total soluble solid (TSS) content in phalsa fruit was recorded 17.200Brix with T₁₀ (NAA 200ppm+ boron 0.6%) and followed by treatment T₉ (NAA 150ppm+ boron 0.4%) 24.85°Brix, while the minimum 17.20 °Brix was recorded under T₁ (control). These finding are in accordance with the reports of Kumar and Tripathi (2009) in strawberry, Kumar *et al.*, (2017) in aonla and Hada *et al.*, (2017), Badal and Tripathi (2021b), also found increased TSS and total sugars with NAA 75 ppm spray in guava.

Sugar and Titratable acidity : The Significantly higher total sugars, reducing sugar and non-reducing sugar content (18.93%, 15.06% and 3.82%) was recorded with T₁₀ (NAA 200ppm+ boron 0.6%) and followed by treatment T₉ (NAA 1500ppm+ boron 0.4%) 18.46%, 14.62% and 3.77%, while the minimum was recorded in T₁ (control) 14.05%, 11.78% and 2.16%. These findings are in line with the reports of Kumar and Tripathi (2009) in strawberry, Kumar *et al.*, (2017) in aonla. Tripathi *et al.*,

(2019) also reported increased TSS and total sugars content in mango with the application of GA₃ 50 ppm + NAA 40 ppm. Maurya *et al.*, (2020) also reported the increased of TSS and total sugar in mango at spray of GA₃ 75 ppm + NAA 40 ppm. The minimum titratable acidity (2.36%) was noted with T₁₀ (NAA 200ppm + boron 0.6%) and followed by treatment T₉ (NAA 1500ppm + boron 0.4%) 2.38%, whereas, the maximum in control (2.86%). These findings are in line with the reports of Singh and Singh (2015), Tiwari *et al.*, (2017) in aonla and Verma *et al.*, (2021) in strawberry.

Ascorbic Acid : The Significantly maximum amount of ascorbic acid (39.91mg) was found with T₁₀ (NAA 200ppm+ boron 0.6%) and followed by treatment T₉ (NAA 1500ppm+ boron 0.4%) 38.06 mg. whereas, minimum amount of ascorbic acid (29.16mg) was recorded with T₁ (control). The present findings are in accordance with the results of Shukla *et al.*, (2011), Tiwari *et al.*, (2017) in aonla, and Ram *et al.*, (2016) in guava, Tripathi *et al.*, (2019), Maurya *et al.*, (2020) in mango.

References

1. A.O.A.C. (1980). Official method of analysis. *Association of Official Analytical Chemists* (12th edn.), Washington. D.C.
2. Ali, M., Ahmad, M., Anjam, N., Rehman, H. Ur., Kasana, M.I., Tariq, S. and Ramzan, A. (2014). Efficacy of boron and gibberellic acid on growth and fruit yield in olive (*Olea europaea* L.) cv. Gemlike. *International Journal of Biotechnecology*, 11(2-3): 295-298.
3. Badal, D.S. and Tripathi, V.K. (2021a). Influence of foliar feeding of naa and boron on growth, flowering, fruiting, and yield of winter season guava (*Psidium guajava* L.) cv. L-49. *Biological Forum—An International Journal*, 13 (3): 387-391.
4. Badal, D.S. and Tripathi, V.K. (2021b). Effect of foliar application of NAA and Boron on physico-chemical parameters of winter season guava (*Psidium guajava* L.) cv. Lucknow-49. *The Pharma Innovation Journal*, 10 (9): 928-932.
5. Gogoi, S., Kotoky, U. and Das, K. (2016). Effect of GA₃ and NAA on reproductive growth and yield development of Assam Lemon (*Citrus limon* L.). *Research on crops*, 17 (4): 758-762.
6. Gurunj, S., Mahato, S.K., Suresh, C.P. and Chettri, B. (2016). Impact of foliar application of growth regulators and micronutrients on the performance of Darjeeling mandarin. *American Journal of Experimental Agriculture*, 12 (4): 1-7.
7. Hada, T.S., Kanth, N. and Singh, B.K. (2017). Foliar application of different combination of boron and zinc on yield, pulp and seed attributes of winter season guava (*Psidium guajava* L.) cv L-49. *Environment and ecology*, 35 (2): 1534-1537.
8. Jitendra, Saravanan, S., Kasera, S., Lal, D. and Singh, V.K. (2017). Effect of Foliar Spray of Micro Nutrients on Plant Growth, Yield and Fruit Quality of Phalsa (*Grewia asiatica* L.). *Environment & Ecology*, 35 (4A): 2841-2845.

9. Kacha, H.L., Jat, G., and Patel, S.K. (2014). Performance of various plant growth regulators on yield and quality of phalsa (*Grewia asiatica* L.). *Hort Flora Res. Spect.*, 3 (3): 292-294.
10. Kacha, H.L., Viradia, R.R., Leua, H.N., Jat, G. and Tank, A. K. (2012). Effect of NAA, GA3 and ethereal on yield and quality of phalsa (*Grewia asiatica* L.). *Asian J. Hort.*, 7 (2): 242-245.
11. Katiyar, P.N., Yadav V., Singh, J.P. (2010). Effect of pre-harvest spray of NAA, GA3 and urea on fruiting, fruit quality and yield of ber (*Zizyphus mauritiana* Lamk.) cv. Banarasi Karaka. *Annals of Horticulture*, 3 (1): 92-94.
12. Kumar, A., Tripathi, V.K., Dubey, V., Katiyar, N.K., Tiwari, P. (2017). Influence of foliar application of calcium, zine and boron on fruit drop, yield and quality attributes of aonla (*Emblca officinalis*) cv. NA-7. *Res. on Crops*, 18 (1): 91-97.
13. Kumar, R. and Tripathi, V.K. (2009). Influence of NAA, GA₃ and boric acid on growth, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, 41 (1): 113-115.
14. Maurya, P.K., Tripathi, V.K. and Gupta, S. (2020). Effect of pre-harvest application of GA3, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali. *Journal of Pharmacognosy and Phytochemistry*, 9 (6): 2123-2127.
15. Prasad, B., Das, S., Chatterjee, D. and Singh, U.P. (2005). Effect of foliar application of urea, zinc and boron on quality of guava. *Journal of Applied Biology*, 15 (1): 44-47.
16. Rema, J. and Sharma, V. P. (1991). Effect of plant growth regulators on yield and quality of phalsa (*Grewia Subinaequalis* L.). *South Indian Hort.*, 39 (6): 327-331.
17. Shukla, H.S., Kumar, V. and Tripathi, V.K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits cv. Banarasi. *Acta Horticulture*, 890: 375-380.
18. Singh, A. and Singh, H.K. (2015). Application of plant growth regulators to improve fruit yield and quality in Indian Gooseberry. *Journal of Agri. Research*, 2 (1): 20-23.
19. Tiwari, D.K., Singh, D., Barman, K. and Patel, V.B. (2014). Bioactive compounds and processed products of phalsa (*Grewia subinaequalis* L.) fruit. *Popular Kheti*, 2 (4): sept-oct.
20. Tiwari, P., Tripathi, V. K. and Singh, A. (2017). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. *Progressive Research-An International Journal*, 12 (Special-IV): 2565-2568.
21. Tripathi, V.K., Singh, A., Bhadauria, A. S. and Gupta, S. (2019). Influence of GA3 and naphthalene acetic acid alone and in combination on fruit drop, yield and quality of mango cv. Amrapali. *Progressive Research-An International Journal*, 14 (1): 10-13.
22. Verma S., Dwivedi, A.K. and Tripathi, V.K. (2021). Effect of gibberellic acid and boron on growth, yield and yield attributory traits in strawberry (*Fragaria x ananassa* Duch.) under North Gangetic Plains. *Biological Forum—An International Journal*, 13 (3): 262-267.



Assessment of Yield and Quality Attributes of Basmati Rice-Based Cropping System under Organic Nutrient Management Practices

Ratan Deep Soni, S.B. Agrawal, R.P. Sahu, Poornima Malviya and S.K. Singh

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) 482004

Abstract

A field experiment conducted at JNKVV, Jabalpur during 2007-08 and 2008-09 in order to assess the changes occurs in quality traits of Basmati rice kernel due to cropping systems and organic nutrient management practices. This study consisted of two cropping systems (CS₁: rice-wheat and CS₂: rice-berseem) and five organic nutrient management practices (ONM₁: FYM+VC, ½ N from each, ONM₂: VC+NOC ½ N from each, ONM₃: FYM+NOC, ½ N from each, ONM₄: FYM+NOC+VC, 1/3rd N from each and ONM₅: Control). These treatments factors were put under main and sub plots respectively and arranged statistically in split plot design with three replications. Average of two years data reveal significant differences with respect to rice equivalent yield and recorded 67.49 q ha⁻¹ year⁻¹ under rice-berseem cropping system. However quality parameters were found not significant. Organic nutrient management practices in which FYM +VC+NOC 1/3rd of N from each were applied recorded highest values of REY (67.86 q ha⁻¹ year⁻¹), kernel dimensions, length (8.16 mm), breadth (1.89 mm) and L/B ratio (4.30), physical qualities water absorption capacity (3.03%), hulling % (85.16%), protein (4.66%), fat (0.75%) and carbohydrate (81.95%). But milling percent was higher (72.95%) under ONM₂ (VC+NOC) ½ of N from each. However, almost all quality traits and rice equivalent yield were found at par to each other under different organic nutrient management practices but superior over ONM₅.

Key words: Basmati rice, hulling, milling percentage, protein, fat and carbohydrates.

Introduction

Rice (*Oryza sativa* L.) is the staple food for the majority of Indians. A scented rice constitutes a small but a special group and considered best in organoleptic traits. It is cultivated in India, Afganistan, Myanmar, Indonesia, Vietnam and Bangladesh. Indian Basmati rice fetches a premium price in the world market over high quality fine rices from other countries. Apart from this, rice is a good source of carbohydrates, B-complex, vitamins, fats, protein etc. The fat content of diet determines its energy density. Moreover, milling of rice kernels have been reported to result in fat and other nutrient losses (Begun and Bhattacharya, 2000). The aromatic rice may grow and yielded satisfactory but its quality traits are expressed good under organic nutrient management production system. The aroma and other quality traits are solely dependent upon environment factors and sources of nutrients (Singh *et al*, 2002). Knowledge of physical parameters of rice such as grain dimentions, L/B ratio, hulling and milling percentage and water absorption capacity etc. is important traits. Since quality attributes of aromatic rice are influenced by source of nutrition and systems. Hence, it may be quite possible that physical and chemical characteristics of scented rice may differ under different cropping system and organic nutrient management practices, The present study, therefore was aimed at studying the yield and quality traits of basmati rice under rice based cropping systems and organic nutrient management practices.

Materials and Methods

A field study was conducted at Krishi Nagar research farm Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) during 2007-08 and 2008-09 in order to assess the changes occurs in quality with respect to physical, chemical traits of rice kernel due to change of cropping systems and organic sources of nutrients in Basmati rice. The study consisted of two cropping systems (CS₁: rice-wheat and CS₂ : rice-berseem) and five organic nutrient management practices (ONM₁: FYM+VC, ½ N from each, ONM₂: VC+NOC ½ N from each, ONM₃ : FYM+NOC, ½ N from each, ONM₄: FYM+NOC+VC, 1/3rdN from each and ONM₅: No manure (Control). These treatment factors were put in main and sub plots, respectively under the statistical split plot design with three replications. The green manure crop was uniformly grown before planting of rice crop in all the treatment plots except control. Data in relation to grain and straw yields of cropping systems were recorded separately and then computed the rice equivalent yield. A composite sample of rice grain was collected as per treatments from three replications for determining the physical and chemical quality of rice kernel. The kernel dimensions, L/B ratio, hulling milling and water absorption capacity of rice kernel were determined using standard procedures (Bhattacharya *et al* 1972, Sindhu *et al*, 1975), while protein, fat and carbohydrate percentage were determined as per the methods suggested by different workers as given below.

Table-1 : Rice equivalent yield (q/ha/year) as influenced by cropping systems and various organic nutrient management practices.

Treatments	REY (q/ha/year)		
	2007-08	2008-09	Pooled
Cropping system			
CS-1 (Rice-Wheat)	56.89	56.74	56.82
CS-2 (Rice-Berseem)	64.43	70.54	67.49
SEm $\pm$	2.41	2.21	1.83
CD (0.05%)	7.22	6.64	5.48
Organic Nutrient Management Practices (ONM)			
ONM-1	62.74	65.76	64.25
ONM-2	63.13	65.32	64.22
ONM-3	63.85	65.96	64.90
ONM-4	67.36	68.36	67.86
ONM-5 (control)	46.23	52.84	49.53
SEm $\pm$	2.00	2.10	1.74
CD (0.05%)	5.99	6.30	5.20

Table-2 : Grain length, breadth (mm) and L/B ratio of rice grain as influenced by different cropping systems and various organic nutrient management practices.

Treatments	Rice grain length (mm)			Rice grain breadth (mm)			L/B ratio		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Cropping system									
CS-1 (Rice-Wheat)	7.94	7.80	7.77	1.79	1.78	1.78	4.45	4.33	4.39
CS-2 (Rice-Berseem)	7.92	7.60	7.86	1.77	1.82	1.79	4.54	4.28	4.41
SEm $\pm$	0.35	0.09	0.17	0.04	0.05	0.05	0.27	0.16	0.20
CD (0.05%)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic Nutrient Management Practices (ONM)									
ONM-1	8.12	7.62	7.87	1.78	1.83	1.81	4.57	4.24	4.40
ONM-2	7.93	7.96	7.94	1.85	1.85	1.85	4.31	4.31	4.31
ONM-3	8.32	7.99	8.15	1.89	1.87	1.88	4.43	4.27	4.35
ONM-4	8.16	8.15	8.16	1.88	1.90	1.89	4.33	4.28	4.30
ONM-5 (control)	7.14	6.80	6.97	1.49	1.53	1.51	4.86	4.45	4.65
SEm $\pm$	0.25	0.27	0.18	0.06	0.06	0.05	0.18	0.20	0.15
CD (0.05%)	0.74	0.82	0.54	0.18	0.17	0.14	NS	NS	NS

Results and Discussion

Rice equivalent yield (qha⁻¹) : The crop yields recorded from different cropping systems were computed for rice equivalent yield. Data presented in Table-1 indicated that the significantly higher rice equivalent yield of 64.43, 70.54 and 67.49 q ha⁻¹ year⁻¹ was noted under rice-berseem cropping system during 1st, 2nd year and in pooled data, respectively. The application of nutrients through organic sources found to increase the REY of 67.36, 68.36 and 67.89 q ha⁻¹ year⁻¹ under ONM₄ during both the years, respectively and found at par to ONM₁, ONM₂ and ONM₃ but superior over control.

Physical quality traits of rice : Grain size and shape is the measure of purity of rice of a particular genotype. Therefore, randomly collected grains were used for measuring the length breadth and for computation of L/B ratio. The perusal of data presented in Table-2 indicate

that on an average rice grain produced under rice-berseem cropping system had higher numerical values (7.86 and 1.79 mm) with respect to rice grain length and breadth, respectively, which computed the higher values of L/B ratio (4.41) over rice-wheat cropping system through the differences were not significant. The nutrient management system showed significant variations for length, breadth and L/B ratio. The pooled mean data indicates that combined application of FYM, vermicompost and neem oil cake 1/3rd of N from each (ONM₄) produced significantly longest (8.16 mm) and broad (1.89 mm) grains over without organics (control). However, all the organic nutrient management practices found at par to other combinations and proportions of organics taken under study. The ratio of length and breadth was remain unaffected with the various organic practices. Such favorable response of organics with respect to grain size and shape in rice is the resultant of increased availability of nutrients which in turn must have

Table-3 : Physical quality parameters of rice grain as affected by different cropping systems and organic nutrient management practices.

Treatments	Water absorption capacity of rice kernel %			Hulling of rice grain (%)			Milling of rice grain %		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Cropping system									
CS-1 (Rice-Wheat)	2.75	2.82	2.79	80.53	82.85	81.69	69.34	69.15	69.82
CS-2 (Rice-Berseem)	2.79	2.77	2.78	82.93	83.35	83.14	69.62	70.50	70.06
SEm±	0.04	0.04	0.04	1.32	0.60	0.53	0.32	0.56	0.47
CD (0.05%)	NS	NS	NS	NS	NS	1.56	NS	NS	NS
Organic Nutrient Management Practices (ONM)									
ONM-1	2.90	2.93	2.92	82.75	83.66	83.20	69.77	69.66	69.71
ONM-2	2.83	3.02	2.92	84.62	85.02	84.82	71.33	74.17	72.95
ONM-3	2.93	2.83	2.88	83.92	84.61	84.26	69.29	69.39	69.34
ONM-4	3.07	3.00	3.03	84.91	85.42	85.16	70.50	69.77	70.13
ONM-5 (control)	2.13	2.22	2.18	72.45	76.79	74.62	66.13	66.17	66.15
SEm±	0.11	0.10	0.07	1.76	1.67	1.28	1.69	2.08	1.35
CD (0.05%)	0.32	0.29	0.22	5.26	5.02	3.85	5.08	6.23	4.05

Table-4 : Protein, fat (%) and carbohydrates in rice grain as affected by rice based cropping systems and various organic nutrient management practices.

Treatments	Protein %			Fat (%)			Carbohydrate %		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Cropping system									
CS-1 (Rice-Wheat)	4.49	4.38	4.44	0.71	0.70	0.71	79.14	79.63	79.38
CS-2 (Rice-Berseem)	4.53	4.53	4.53	0.71	0.71	0.71	79.32	80.57	79.95
SEm±	0.14	0.07	0.04	0.02	0.04	0.03	1.49	2.53	0.64
CD (0.05%)	NS	NS	NS	NS	NS	1.56	NS	NS	NS
Organic Nutrient Management Practices (ONM)									
ONM-1	4.56	4.57	4.56	0.72	0.71	0.71	81.28	81.47	81.37
ONM-2	4.59	4.59	4.59	0.72	0.72	0.72	79.85	82.47	81.16
ONM-3	4.62	4.62	4.62	0.73	0.73	0.73	81.13	80.97	81.05
ONM-4	4.66	4.67	4.66	0.75	0.75	0.75	81.75	82.16	81.95
ONM-5 (control)	4.13	3.84	3.99	0.62	0.63	0.62	72.13	73.42	72.78
SEm±	0.15	0.17	0.13	0.02	0.02	0.02	2.28	2.93	1.79
CD (0.05%)	NS	0.52	0.38	0.07	0.07	0.06	6.83	NS	5.38

improved synthesis and translocation of metabolites to various reproductive organs of plant. The findings of Kumar and Singh (2006) and Kler and Walia (2006) confirmed that continuous supply of photosynthates to sink due to release of nutrients from organic sources.

Hulling, milling and water absorption capacity of rice kernel : Hulling means removing of grain cover with the help of huller while in the milling bran layers on the outside of rice kernel are gently removed to get the inner white grain. Hence, the process of hulling and milling was done and generated data are presented in Table 3. It is evident from the data that cropping system failed to exert significant effect on these traits during both the years and pooled analysis. However, on an average, there were numerical superiorities with respect hulling (83.14%) and significantly found superior in milling (70.06%) over 81.69 and 69.82% recorded under rice-wheat cropping systems.

Similarly, the water absorption capacity of rice kernel remains unaffected with the cropping systems.

On the other hand, among the various organic practices, ONM₄ recorded the highest percentage of hulling of 84.91, 85.42 and 85.16 percent while the milling percentage was significantly higher under ONM₂ (71.73, 74.19 and 72.95%) during first, second year and pooled data, respectively. However, all the practices were found at par with each other but found superior over without organics (control) under ONM₅ for both of these parameters. The grain filling rate consequently decreased the hull thickness. Sisodia and Kewat (2009) also enclosed similar views from their study. Similarly, all the organic practices recorded the higher water absorption capacity of rice kernel over control. The higher water absorption capacity of 3.07, 3.0 and 3.03% was observed under ONM₄ in which the FYM+ VC + NOC was applied

based on 1/3rd of N from each during 2007-08 and 2008-09, respectively. The increase in milling percentage under combinations of various organics over control might be due to increase in metabolite substances in grain which are attributed with increasing nutrient availability Ebaid and EL Hissewy (2000).

Chemical quality parameters of rice : Rice contain mainly carbohydrate and some protein with virtually no fat. Rice has lowest protein contents among the cereals. The bran layers and embryo are rich in constituents than milled rice. Most of the carbohydrate in rice is starch. It is made up of long chains of glucose called amylose and amylopectin.

Chemical quality parameters of rice grain as affected by different cropping systems and organic nutrient management practices are presented in Table 4. On an average the numerical values were higher under cropping system of rice-berseem and recorded 4.53% of protein, 79.95% of carbohydrates but the content of fat was found numerically equal under both the cropping systems. Quality constituents of rice were influenced significantly due to various nutrient management practices (Table 4). The average data showed that application of FYM, Neem oil cake and Vermicompost 1/3rd of each (ONM₄) resulted in significantly higher crude protein (4.66%), carbohydrates (81.95%) and fat (0.75%) content over ONM₅ (3.99, 72.78 and 0.62%), respectively. However, the all the combinations of organic practices for these traits were found at par to each other but proved significantly superior over control. The chemical constituents of rice grain increased due to the enhancement of nutrient availability under organic nutrients (Datta and Das 2017).

References

1. AOAC (1970). Official Methods of Analysis, 11th edition. Association of Official Agricultural Chemists, Washington, D.C. pp 222.
2. Begun, Marium and Ruma Bhattacharyya (2000). Fat contents in raw and cooked Assam rice varieties. *J. Food Science Technology* 37(1): 58-60.
3. Bhattacharya K.R., Sowbhagya C.M., Indudhara Swamy Y.M. (1972). Some physical properties of paddy and their inter relationship. *J. Sci. Food Agric.* 23: 171-186.
4. Ebaid R.A. and E.I. Hissewy AA. (2000). Effect of nitrogen and potassium fertilizer levels on grain quality characters of sakha rice cultivar. *Egyptian J. App. Sci.*, 16 (7): 143-150.
5. Kler D.S. and Walia S.S. (2006). Organic, integrated and chemical farming in wheat (*Triticum aestivum*) under maize (*Zea-mays*)-wheat cropping system. *Indian Journal of Agronomy*. 51(1): 6-9.
6. Sindhu, J.S., Gill, M.S. and Bains G.S. (1975). Milling of paddy in relation to yield and quality of rice of different varieties. *J. Agric Food Chem.* 23: 1183-1185.
7. Singh V. (2006). Productivity and economics of rice (*Oryza sativa* L.)-wheat (*Triticum aestivum*) cropping system under irrigated nutrient supply system in recently reclaimed sodic soil. *Indian Journal of Agronomy*. 51(2): 81-84.
8. Sisodia Vandana and Kewat M.L. (2009). Effect of different organic sources on quality and yield of hybrid rice (*Oryza sativa* L.) *Int. J. Agric. Environ. & Biotech.* 2(1): 35-37.
9. Sadasivam S. and Manikam A. (1996). Biochemical Methods, *New Age International Publishers*, New Delhi, India pp. 8-9.
10. Singh, R.K., Singh, U.S. and Khush G.S. (2002). Aromatic rice Ist edi Oxford & IBH Publishing Co. New Delhi



Evaluation of Salt Tolerant Rice, Wheat and Mustard Varieties Under Sodict Soil Conditions

Devendra Singh and Ravindra Kumar

Department of Soil Science and Agricultural Chemistry, C.S.A. University of Agriculture and Technology, Kanpur

Abstract

A field experiment was conducted during 2015 to 2018 as a fixed layout in sodict soil at Crop Production Farm Dalipnagar in the jurisdiction of C. S. Azad University of Agriculture and Technology, Kanpur using salt tolerant and high yielding varieties CSR-23, CSR-27, CSR-30, CSR-36, CSR-43, Pant-12, NDR-359 and Kranti of rice, KRL-210, KRL-213, PBW-343, PBW-502, WH-147, K-307, K-8434, and DBW-17 of wheat and CS-52, CS-54, CS-56, Varuna, Pitamvari, Rohini, Urvashi and Kanti of mustard were tested. The grain, straw and biological yield of rice ranged from 22.63-44.29 q ha⁻¹ with the mean value of 35.81 q ha⁻¹, from 27.98-63.59 q ha⁻¹ with the mean value of 43.80 q ha⁻¹ and from 50.61-97.88 q ha⁻¹ with the mean value of 79.61 q ha⁻¹ respectively (Table-1). The maximum grain yield 44.29 q ha⁻¹ was received from CSR-36 followed by CSR-23 (41.65 q ha⁻¹), CSR-43 (39.03 q ha⁻¹), CSR-27 (38.86 q ha⁻¹) and NDR-359 (37.26 q ha⁻¹) and minimum 22.63 q ha⁻¹ from CSR-30 variety of rice. The maximum grain yield 36.70 q ha⁻¹ was received from KRL-210 followed by KRL-213 (35.23 q ha⁻¹), PBW-343 (33.98 q ha⁻¹) and PBW-502 (31.75 q ha⁻¹) and minimum 27.94 q ha⁻¹ from WH-147 variety of wheat. The maximum grain yield 58.91 q ha⁻¹ was received from CS-56 followed by CS-54 (15.04 q ha⁻¹), CS-52 (13.81 q ha⁻¹), Varuna (12.98 q ha⁻¹) and Rohini (12.28 q ha⁻¹) and minimum 10.88 q ha⁻¹ from Urvashi variety of mustard.

Key words : Soil properties, varieties, sodicty, salt tolerant.

Introduction

6.73 million hectare area has been characterized as salt affected, out of which 3.77 million hectare is sodict and remaining 2.96 million hectare is saline In India and the largest sodict area 1.35 million hectare with 35.75% of total sodicty affected area in Uttar Pradesh. The Gujarat, Maharashtra, Tamil Nadu, Haryana and Punjab are having about 80% of the total sodict lands. As per estimates of ICAR-CSSRI, Karnal used India loses 11.18 million tones of cereals, oilseeds, pulses and cash crops from 3.77 million hectare sodicty affected area every year, which is equivalent to the monetary loss of Rs. 1,50000 million. The use of salt tolerant varieties of rice, wheat and mustard has played important role in enhancing productivity, improving the socio- economic status of farmers and insuring livelihood security under such situations. Therefore, the present study was undertaken to screening of salt tolerant rice, wheat and mustard varieties under sodict soil conditions.

Materials and Methods

A field experiment was conducted during 2015 to 2018 as a fixed layout in sodict soil at Crop Production Farm Dalipnagar in the jurisdiction of C. S. Azad University of Agriculture and Technology, Kanpur using salt tolerant and high yielding varieties CSR-23, CSR-27, CSR-30, CSR-36, CSR-43, Pant-12, NDR-359 and Kranti of rice, KRL-210, KRL-213, PBW-343, PBW-502, WH-147, K-307, K-8434, and DBW-17 of wheat and CS-52, CS-54,

CS-56, Varuna, Pitamvari, Rohini, Urvashi and Kanti of mustard were tested. The soil was classified as Typic Natrustalf. The initial physico-chemical properties of soil were pH 9.30, EC 0.89 dSm⁻¹, ESP 45.3% and organic carbon 2.3 g kg⁻¹soil. The soil was sandy loam in texture having available N 134 kg ha⁻¹, available P₂O₅ 17.5 kg ha⁻¹ and available K₂O 202 kg ha⁻¹. The experiment was laid out under randomized block design with three replications. The experiment consists of eight varieties of each crop. About 30 days old seedling of rice was uprooted carefully from the seedbed and it's transplanted in last week of June in well prepared field. Sowing of wheat in second week of November and mustard second week of October for higher production. Recommended doses of fertilizers were applied through urea, DAP and muriate of potash, respectively in each crop. The half dose of N and full doses of P₂O₅ and K₂O were applied as basal and rest N applied in two equal splits at the suitable time of each crop. Agronomical operations will be applied as per requirement of crop. The estimation of physico-chemical properties were estimated by standard procedures by (3). The statistical analyses done by standard procedures by (4).

Results and Discussion

Yield of rice : The eight salt tolerant varieties were CSR-23, CSR-27, CSR-30, CSR-36, CSR-43, Pant-12, NDR-359 and Kranti of rice was tested on salt affected soil conditions. The grain, straw and biological yield of rice ranged from 22.63-44.29 q ha⁻¹ with the mean value of

35.81 q ha⁻¹, from 27.98-63.59 q ha⁻¹ with the mean value of 43.80 q ha⁻¹ and from 50.61-97.88 q ha⁻¹ with the mean value of 79.61 q ha⁻¹ respectively (Table-1). The maximum grain yield 44.29 q ha⁻¹ was received from CSR-36 followed by CSR-23 (41.65 q ha⁻¹), CSR-43 (39.03 q ha⁻¹), CSR-27 (38.86 q ha⁻¹) and NDR-359 (37.26 q ha⁻¹) and minimum 22.63 q ha⁻¹ from CSR-30 variety of rice. The highest yield of straw 53.59 q ha⁻¹ were obtained from CSR-36 followed by CSR-23 (51.43 q ha⁻¹), CSR-43 (48.03 q ha⁻¹), CSR-27 (46.56 q ha⁻¹) and NDR-359 (45.23 q ha⁻¹) and lowest 27.98 q ha⁻¹ from CSR-30 variety of rice. The maximum biological yield 97.88 q ha⁻¹ was obtained from CSR-36 followed by CSR-23 (93.08 q ha⁻¹), CSR-43 (87.06 q ha⁻¹), CSR-27 (85.42 q ha⁻¹) and NDR-359 (82.49 q ha⁻¹) and lowest 50.61 q ha⁻¹ from CSR-30 variety of rice. Similar results have been reported by (5). The salt tolerant varieties of rice were CSR-36, CSR-43, CSR-23, CSR-27 suitable for maximum production in sodic soil conditions.

Table-1 : Grain, straw and biological yield of rice (q/ha) in sodic soil conditions.

Varieties	Grain	Straw	Biological
CSR-23	41.65	51.43	93.08
CSR-27	38.86	46.56	85.42
CSR-30	22.63	27.98	50.61
CSR-43	39.03	48.03	87.06
CSR-36	44.29	53.59	97.88
Pant-12	28.98	36.22	65.20
NDR-359	37.26	45.23	82.49
Kranti	33.79	41.36	75.15
CD=0.05	2.53	2.65	2.84

Yield of wheat : The eight salt tolerant varieties were KRL-210, KRL-213, PBW-343, PBW-502, WH-147, K-307, K-8434, and DBW-17 of wheat was tested on salt affected soil conditions. The grain yield ranged from 27.94-36.70 q ha⁻¹ with the mean value of 31.84 q ha⁻¹, straw yield from 33-66-45.03 q ha⁻¹ with the mean value of 38.64 q ha⁻¹ and biological yield from 61.60-81.73 with the mean value of 70.48 q ha⁻¹ was received from wheat varieties. (Table-2). The maximum grain yield 36.70 q ha⁻¹ was received from KRL-210 followed by KRL-213 (35.23 q ha⁻¹), PBW-343 (33.98 q ha⁻¹) and PBW-502 (31.75 q ha⁻¹) and minimum 27.94 q ha⁻¹ from WH-147 variety of wheat. The highest yield of straw 45.03 q ha⁻¹ were obtained from KRL-210 followed by KRL-213 (43.20 q ha⁻¹), PBW-343 (41.39 q ha⁻¹) and lowest 33.66 q ha⁻¹ from WH-147 variety of wheat. The maximum biological yield 81.73 q ha⁻¹ was obtained from KRL-210 followed by KRL-213 (78.43 q ha⁻¹), PBW-343 (75.37 q ha⁻¹) and PBW-502 (68.76 q ha⁻¹) and lowest 61.60 q ha⁻¹ from WH-147 variety of wheat. Similar results also reported by (1 and 5). The salt tolerant varieties of wheat were KRL-210, KRL-213, PBW-343 and

PBW-502 suitable for maximum production in sodic soil conditions.

Table-2 : Grain, straw and biological yield of wheat (q/ha) in sodic soil conditions.

Varieties	Grain	Straw	Biological
KRL-210	36.70	45.03	81.73
KRL-213	35.23	43.20	78.43
PBW-343	33.98	41.39	75.37
PBW-502	31.75	37.01	68.76
WH-147	27.94	33.66	61.60
K-307	29.90	36.75	66.65
K-8434	30.17	36.94	67.11
DBW-17	29.07	35.12	64.19
CD=0.05	2.47	2.63	2.87

Yield of mustard : The eight salt tolerant varieties were CS-52, CS-54, CS-56, Varuna, Pitamvari, Rohini, Urvashi and Kranti of mustard was tested on salt affected soil conditions. The ranged from 10.88-16.77 q ha⁻¹ with the mean value of 13.30 q ha⁻¹, from 27.23-42.14 q ha⁻¹ with the mean value of 34.05 q ha⁻¹ and from 38.11-58.91 with the mean value of 47.35 q ha⁻¹ of grain, stalk and biological yield of mustard respectively (Table-3). The maximum grain yield 58.91 q ha⁻¹ was received from CS-56 followed by CS-54 (15.04 q ha⁻¹), CS-52 (13.81 q ha⁻¹), Varuna (12.98 q ha⁻¹) and Rohini (12.28 q ha⁻¹) and minimum 10.88 q ha⁻¹ from Urvashi variety of mustard. The highest yield of stalk 42.14 q ha⁻¹ were obtained from CS-56 followed by CS-54 (38.59 q ha⁻¹), CS-52 (35.20 q ha⁻¹), Varuna (34.40 q ha⁻¹) and Rohini (33.44 q ha⁻¹) and lowest 38.11 q ha⁻¹ from Urvashi variety of mustard. The maximum biological yield 58.91 q ha⁻¹ was obtained from CS-56 followed by CS-54 (53.63 q ha⁻¹), CS-52 (49.01 q ha⁻¹), Varuna (47.38 q ha⁻¹) and Rohini (45.72 q ha⁻¹) and lowest 38.11 q ha⁻¹ from Urvashi variety of mustard.^[2] The salt tolerant varieties of mustard were CS-56, CS-54, CS-52, Varuna and Rohini suitable for maximum production in sodic soil conditions. Similar results was reported by (2).

Table-3 : Grain, stalk and biological yield of wheat (q/ha) in sodic soil conditions.

Varieties	Grain	Straw	Biological
CS-52	13.81	35.20	49.01
CS-54	15.04	38.59	53.63
CS-56	16.77	42.14	58.91
Varuna	12.98	34.40	47.38
Pitamvari	11.86	29.91	41.77
Rohini	12.28	33.44	45.72
Urvashi	10.88	27.23	38.11
Kranti	12.74	31.51	44.25
CD = 0.05	1.24	1.46	1.68

Table-4 : Physico-chemical properties of soil after four year.

Soil properties/ Crops	Initial Soil Status	Rice	Wheat	Mustard
pH	9.30	8.91	9.00	8.89
EC	0.89	0.86	0.87	0.85
ESP (dSm ⁻¹)	45.3	39.2	41.0	39.7
OC (g kg ⁻¹)	2.36	3.10	3.05	2.98
N kg ha ⁻¹	134.2	165.5	162.8	155.4
P kg ha ⁻¹	17.5	19.6	19.3	18.7
K kg ha ⁻¹	202.4	214.8	211.2	209.4

Physico-chemical properties of soil : The considerable changes in physico-chemical properties of experimental soil after four year with the cultivation of different rice, wheat and mustard varieties (Table-4). The remarkable changes in soil pH from 9.30 to 8.91, EC from 0.89 to 0.86 dSm⁻¹, ESP from 45.3 to 39.2 %, organic carbon from 2.36 to 3.10 g kg⁻¹, available N from 134.2 to 165.5, available P from 17.5 to 19.6 and available K from 202.4 to 214.8 in rice, pH from 9.30 to 9.00, EC from 0.89 to 0.87 dSm⁻¹, ESP from 45.3 to 41.0 %, organic carbon from 2.36 to 3.05 g kg⁻¹, available N from 134.2 to 162.8, available P from 17.5 to 18.7 and available K from 202.4 to 209.4 in wheat and pH from 9.30 to 8.89, EC from 0.89 to 0.85 dSm⁻¹, ESP from 45.3 to 39.7 %, organic carbon from 2.36 to 2.98

g kg⁻¹, available N from 134.2 to 155.4, available P from 17.5 to 18.7 and available K from 202.4 to 209.4 in mustard crop. The maximum changes in physico-chemical properties of soil with cultivation of rice due to maximum organic materials mixed from these crop followed by wheat and mustard crop.

References

1. Mona F., Abou, A, Amel T. and Maboruaka (2008) Study of salt tolerance in wheat (*Triticum aestivum* L.) cultivation Banysoif. *Australian Journal of Crop Science*, 1 (3): 25-27.
2. Sudiq, M., Jamil, M. Mehdi, S.M., Sarfraz, M. and Hassan, G. (2002) Comparative performance of Barssica varieties under saline sodic conditions. *Asian Journal of Plant Science*, (2): 77-78.
3. Jackson, M. L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 183-192.
4. Panse, V. G. and Sukhantme, P. V. (1985) Statistical method for Agricultural Workers, ICAR, New Deldi: 145-148.
5. Kumar R, Pandey S. N., Kumar A and Yadav V.P. (2019) Comparative Performance of salt tolerant wheat and mustard varieties at different farmers field under sodic soil conditions. *Technofame A Journal of Multidisciplinary Advance Research* 8(1): 82-84.



Evaluation of Local Landraces and Released Varieties of Mungbean (*Vigna radiata* L. Wilczek) in Eastern Plain Zones of U.P.

Mayank and G.M. Lal

Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh

Abstract

The present investigation was conducted with the aim to estimate genetic variability for yield and yield attributing traits in local landraces and few released varieties of mungbean germplasm in eastern plain zones of U.P. The experiment was performed with eighteen mungbean genotypes in a randomized block design with three replications in the *Zaid* season, 2021 at Central Research Farm, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj and information were recorded for fourteen characters. Analysis of variance showed vital variation among different genotypes for all characters studied indicating presence of excellent quantity of variability among the genotypes for all the characters employed in study. Harvest index and plant height exhibited high estimates of GCV and PCV. Whereas each moderate GCV and PCV were recorded for number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of seeds per pod and biological yield that suggests that improvement in these characters may be gained to an inexpensive extent. High heritability (broad sense) was determined for all characters apart from days to 50% flowering, days to 50% pod setting and seed yield per plant. High GCV with high heritability along with high genetic advance as % of mean was determined for harvest index and plant height. Moderate GCV with high heritability along with high genetic advance as % of mean was determined for number of primary branches per plant, number of clusters per plant, number of pods per cluster and biological yield. Whereas moderate GCV with high heritability along with moderate genetic advance as % of mean was recorded for number of seeds per pod solely. This showed the very fact that these characters have considerable genetic potential and are comparably less influenced by environment, therefore fascinating for easy choice in breeding programmes. The finding of present investigation may be helpful and cogent for the future breeding programmes for developing improved genotypes.

Key words : Genetic variability, PCV, GCV, heritability, genetic advance.

Introduction

Pulses, best referred to as “poor man’s meat”, represent the foremost supply of dietary protein of the big section of vegetarian population of this planet. Besides their high nutritional worth, they have a novel characteristic of maintaining and restoring soil fertility through biological nitrogen fixation process and therefore, play an important role in sustainable agriculture. Mungbean conjointly referred to as green gram is a short period pulse crop that is grown in all parts of India. It’s the third most significant pulse crop after Chickpea and Pigeon pea. It accounts 12-13% of the overall pulse land area. Mungbean is taken into account as quality pulses due to its wonderful digestibility and high protein (25-28%) content.

Botanically Mungbean is known as *Vigna radiata* L. Wilczek belongs to family *Leguminosae*, sub-family *Papilionaceae*. It is a diploid self-pollinated species with chromosome number $2n=2x=22$ (Karpechenko, 1925). Mungbean probably originated from India (De candole, 1986) and Indo-Burma region of Hindustan centre (Vavilov, 1935). It is mainly cultivated in China, India, Burma and other parts of south-east Asia. *Vigna radiata* sub: *Sublobata* is wild progenitor of Mungbean. Landraces have better “stability of their characteristics”

and “resistance capacity to tolerate adverse influences” but lower production capacity than cultivars, and are apt to change genetically when moved to another environment (U. J. Mansholt, 1909).

The area under Mungbean production in India accounts to 38.32 lakhs ha with production of 17.84 lakhs tonnes in year 2019-20. (Source: DES, Ministry of Agriculture & Farmers Welfare (DAC & FW), Government of India, 2019-21). It is also used as fodder for livestock and incorporated in soil for enrichment of organic matter. It is consumed as ‘dal’, ‘halwa’, boiled dry bean, sprouted and roasted form’. It is a good source of Riboflavin, Vitamin C. ‘*Mung Ki Dal Ka Halwa*’ is a very famous sweet prepared from mungbean in India (Sharma, 2016). The complete success of plant breeding depends on the existence of wide range of genetic variability present in important economic characters of population. The genetic advance is the degree of gain in the characters of selected population over the base population under a particular selection pressure. It also helps to evaluate the selection procedures. If the value of genetic advance is more in the succeeding population there will be good advancement over the mean population. The estimation of heritability along with genetic advance is more reliable than the heritability alone. Johnson *et al.*, (1955) reported

that in study of estimated heritability in couple with genetic advance would provide more reliable information than the study of heritability alone. Holding the above focuses viable the current experiment was attempted to evaluate the genetic variability and isolate the reasonable attributing traits for genetic improvement programme through manipulation of genotypes.

Materials and Methods

The experiment was conducted in Randomized Block Design comprising 18 genotypes with three replications during *Zaid-2021* at Central Research Farm, Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental material for present investigation comprised of 18 genotypes of mungbean [*Vigna radiata* (L.) Wilczek] among them 8 genotypes were collected from 8 different farmers from different locations in Bihar and Jharkhand during an expedition trip (different villages from 3 districts of Bihar, 1 district of Jharkhand) while rest 10 genotypes were obtained from Birsa Agricultural University (BAU), Ranchi, Jharkhand. The descriptions of genotypes is given in Table 1. Naini is situated between the parallels of 20° 33' 40" to 21° 50' N latitude and 73° 27' 58" ' and 73° 56' 36" ' E longitude. The climate of this area is tropical characterized by fairly hot summer, moderately cold winter with humid and warm monsoon. The rainfall of this region is heavy and normally received from June to September.

In each replication and in each plot, five plants were randomly selected and tagged excluding border plants to minimize border effects. Except, days to 50% flowering and days to maturity, all the characters studied were recorded on five randomly selected plants per plot. For days to 50% flowering and days to maturity, the observations were recorded from the whole plot. All the weights were recorded in grams, with the help of a physical balance. Observations were recorded on the following 14 characters *viz.* Days to 50% flowering, Days to 50% pod setting, Days to maturity, plant height (cm), number of primary branches, number of cluster per plant, number of pods per cluster, number of pods per plant, pod length (cm), number of seed per pod, seed index (g), biological yield (g), harvest index and seed yield per plant (g). Analysis of variance for the observations recorded on different characters was carried out as per the standard procedure of Fisher (1936). Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1952). Heritability in broad sense and Genetic advance were worked out as per the procedures of Johnson *et al.*, (1955). Genetic parameters *viz.*, Mean, Range, Coefficients of variability (PCV and GCV), heritability (Broad sense) and Genetic advance

Table-1 : List of genotypes used in the experiment.

Sl. No.	Genotypes Names/ Local names (landraces)
01	Baiju (local)
02	Desla Gotta (local)
03	Desla Mahin (local)
04	Kranti (local)
05	Sona (local)
06	Desiya (local)
07	Biju (local)
08	Megha (local)
09	SML-832
10	IPM-99-125
11	Pusa BM-9
12	IPMD-604-1-7
13	PM 1520
14	IPM-2-3
15	Pusa Vishal
16	TCADM-19-21
17	DGGV-91
18	HUM (Check)

were estimated for the character studied. Analysis of variance permits estimation of phenotypic and genotypic coefficients of variability.

Results and Discussion

The mean sum of squares with respect to various traits studied has been given in Table-2. The analysis of variance showed highly significant differences among 18 genotypes for all characters studied *viz.* Days to 50% flowering, Days to 50% pod setting, Days to maturity, plant height (cm), number of primary branches, number of cluster per plant, number of pods per cluster, number of pods per plant, pod length (cm), number of seed per pod, seed index (g), biological yield (g), harvest index and seed yield per plant (g) indicating the presence of considerable amount of genetic variability among mungbean germplasm. These results are in agreement with the previous studies conducted by Kousar *et al.* (2007), Rahim *et al.* (2010), Vinay *et al.* (2010), Pathak *et al.* (2014), Singh *et al.* (2014), Tiwari *et al.* (2014), Das and Barua (2015), Pulagampalli and Lavanya (2017), Abdus *et al.* (2021). The presence of sufficient variability indicated that the materials of mungbean under study were good enough for any study. Information on the extent of genetic variability and additionally as heritability among the agronomical vital traits is the key demand to work out an appropriate plant breeding programme. Very often, the traits of interest are influenced by the environmental conditions prevailing, particularly just in case of polygenic heritable characters therefore it becomes vital to partition the entire variability components, to own data relating to the character and extent of actual variability present.

Table-2 : Analysis of Variance for various traits in mungbean.

Source	d.f.	DF50	DPS50	DM	PH	NPB	NCPB	NPPC	NPP	NSPP	PL	BY	SI	HI	SYPP
Replication	2	9.846	21.938	1.755	0.791	1.287	0.029	0.001	0.127	0.297	0.205	2.439	0.151	0.619	0.601
Treatment	17	21.626*	27.757*	51.119**	307.664**	5.448**	2.135**	1.116**	4.281**	2.521**	1.037**	45.219**	1.207**	205.89**	2.265**
Error	34	8.532	10.951	3.25	1.625	0.429	0.07	0.023	0.308	0.233	0.177	2.646	0.11	2.398	0.54

**Significant at 1%, *Significant at 5%, d.f.-Degree of freedom

Note : DF50-Days to flowering (50%), DPS50-Days to pod setting (50%), DM-Days to maturity (50%), PH-Plant height (cm), NPB-Number of branches/plant, NCPB-Number of clusters/plant, NPPC-Number of pods/cluster, NPP-Number of pods/plant, PL-Pod length (cm), NSPP-Number of seeds/pod, SI-100-seed weight (g), SYPP-Seed yield/plant (g), BY-Biological yield/plant (g) and HI-Harvest index (%).

Estimates of Range for different characters : A wide range of variability in mungbean germplasm was observed for different characters viz, days to 50% flowering (39.33-51.00 days), days to 50% pod setting (45.67-58.00 days), days to maturity (56.33-72.00), plant height (29.53-63.27 cm), number of primary branches (5.33-11.33), number of clusters per plant (5.87-8.40), number of pods per cluster (2.7-4.7), number of clusters per plant (10.13-14.60), pod length (6.77-9.67cm), number of seeds per pod (5.76-7.92), seed index (5.13-6.93g), biological yield (20.13-37.53g), harvest index (16.77-43.76) and seed yield per plant (7.4-10.40 g). The estimates of range and mean of all characters are given in table-2.

Estimates of PCV and GCV : The phenotypic coefficient of variation was found higher than their corresponding genotypic coefficient of variation, i.e. indicating that the expression of these characters are influenced by environment also. Similar findings were reported by Jyothsana and Anuradha (2013), Ahmad *et al.* (2014), Raturi *et al.* (2015), Garg *et al.* (2017), Madhuri *et al.* (2017) and Ghimire *et al.* (2018). The estimates of PCV and GCV given in table-3.

In present study, it was observed that in general, estimates of phenotypic coefficient of variation (PCV) was found higher than their corresponding genotypic coefficient of variation (GCV) indicating the influence of environment on the expression of these characters. Phenotypic coefficient of variation (PCV) ranged from 6.451% for days to maturity to 26.407% for harvest index. Genotypic coefficient of variation (GCV) ranged from 4.364% for days to 50% pod setting to 25.952% for harvest index.

High PCV and GCV was recorded for plant height and harvest index in mungbean was earlier reported by Vinay *et al.* (2010), Tiwari *et al.* (2014), Jeberson *et al.* (2015), Garg *et al.* (2017), and Pulagampalli and Lavanya (2017). Moderate PCV and GCV were recorded for number of primary branches, number of pods per cluster, biological yield, number of clusters per pod, number of seeds per pod was earlier concluded by Tabasum *et al.* (2010), Vinay *et al.* (2010), Ahmad *et al.* (2014), Hemvanthy *et al.* (2015), Jeberson *et al.* (2015), Garg *et al.* (2017), and Ghimire *et al.* (2018). While low PCV and GCV were recorded for days to 50% flowering, days to 50% pod setting, days to maturity and pod length. Similar results were reported earlier by Rahim *et al.* (2010), Viany *et al.* (2010), Ahmad *et al.* (2014), Hemavanthy *et al.* (2015), Garg *et al.* (2017) and Ghimire *et al.* (2018). The results obtained for PCV and GCV showed that there is considerable possibility of further improvement through

Table-3 : Genetic parameters of variation for yield and its attributing traits in Mungbean.

Sl. No.	Characters	Mean $\pm$ SE	Range	GCV (%)	PCV (%)	h^2 (Heritability Broad Sense) (%)	GA (5% LOS)	GA as % Mean
1.	Days to 50% flowering	46.65 $\pm$ 1.69	39.33 - 51.00	4.479	7.699	33.843	2.504	5.367
2.	Days to 50% pod setting	54.24 $\pm$ 1.91	45.67 - 58.00	4.364	7.501	33.843	2.836	5.229
3.	Days to maturity	67.94 $\pm$ 1.04	56.33 - 72.00	5.880	6.451	83.080	7.500	11.040
4.	Plant height (cm)	48.82 $\pm$ 0.74	29.53 - 63.27	20.689	20.853	98.432	20.643	42.283
5.	Number of primary branches/plant	8.19 $\pm$ 0.38	5.33 - 11.33	15.795	17.707	79.571	2.377	29.024
6.	Number of clusters/plant	7.20 $\pm$ 0.15	5.87 - 8.40	11.524	12.093	90.809	1.629	22.622
7.	Number of pods/cluster	3.66 $\pm$ 0.09	2.70 - 4.70	16.486	16.996	94.084	1.206	32.941
8.	Number of pods/plant	12.50 $\pm$ 0.32	10.13 - 14.60	9.209	10.224	81.143	2.136	17.089
9.	Number of seeds/pod	8.51 $\pm$ 0.28	6.77 - 9.67	10.258	11.722	76.588	1.574	18.494
10.	Pod length (cm)	7.01 $\pm$ 0.24	5.76 - 7.92	7.640	9.713	61.871	0.868	12.379
11.	Seed index (g) (100-seed wt.)	27.42 $\pm$ 0.94	20.13 - 33.73	9.948	11.346	76.875	1.092	17.968
12.	Biological yield (g)	6.08 $\pm$ 0.19	5.13 - 6.93	13.739	14.965	84.287	7.124	25.984
13.	Harvest index (%)	31.74 $\pm$ 0.89	16.77 - 43.76	25.952	26.407	96.585	16.674	52.540
14.	Seed yield per plant (g)	9.18 $\pm$ 0.42	7.40 - 10.40	8.259	11.502	51.557	1.112	12.216

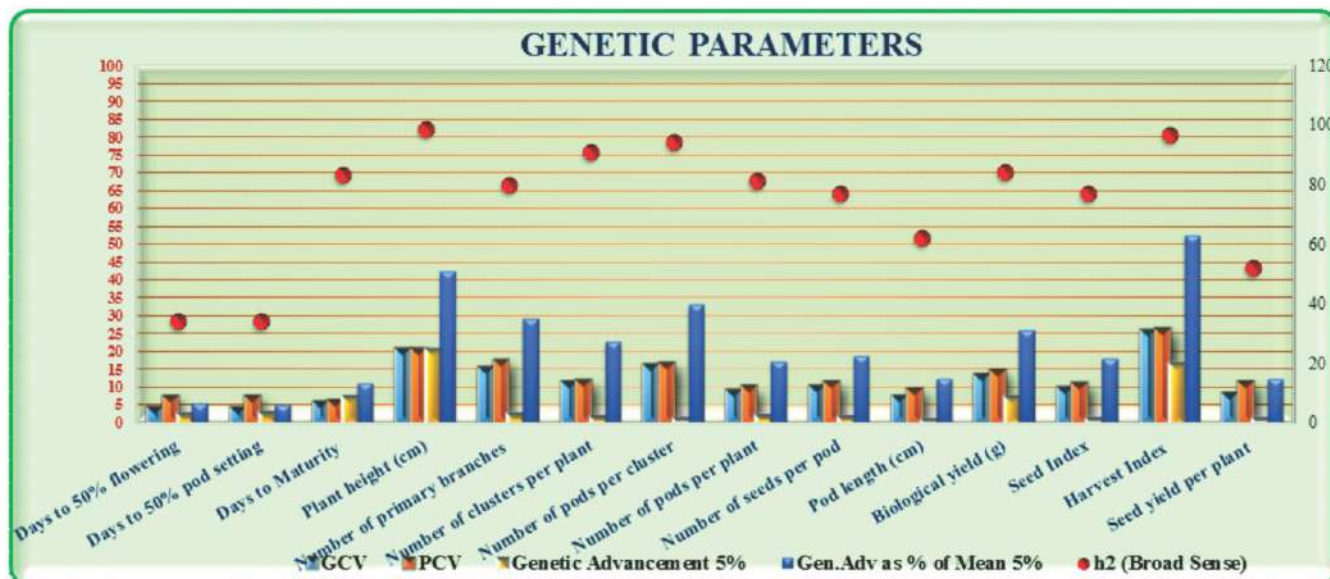


Figure-1 : Histogram representing the relationship among the GCV, PCV, Heritability, Genetic Advance and Genetic Advance as percent of mean in Mungbean.

hybridization followed by appropriate selection for these characters.

Estimates of Heritability and Genetic Advance :

Estimates of Heritability (Broad sense), Genetic Advance and Genetic Advance as percent of mean is listed in Table 3 for all characters studied. In present study, heritability (broad sense) ranged from 33.843 for days to 50% flowering to 98.432 for plant height. High heritability (broad sense) estimates (60% and above) had been observed for days to maturity, plant height, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, pod length, seed index, biological yield and

harvest index. Therefore, these characters are predominantly governed by additive gene action and could be improved through individual plant selection owing to their high heritability values.

Genetic advance varied from 0.868 for pod length to 20.643 for plant height. High genetic advance was recorded for plant height (20.643) and moderate genetic advance was recorded for harvest index (16.674) and low genetic advance was recorded for rest characters. The high or moderate value of genetic advance indicates additive gene action whereas low genetic advance value indicates non-additive gene action.

Genetic advance as % of mean varied from 5.229 to

52.54 for pod length to harvest index respectively. High genetic advance as % of mean was observed for harvest index (52.54), plant height (42.283), number of primary branches (29.024), number of pods per cluster (32.941), number of clusters per plant (22.622) and biological yield (25.984) while moderate genetic advance as % of mean was observed for number of pods per plant (17.089), pod length (12.379), number of seeds per pod (18.494), days to maturity (11.040), seed index (17.968) and seed yield per plant (12.216).

High estimate of heritability coupled with high genetic advance as percent of mean was recorded for harvest index, plant height, number of primary branches per plant, number of clusters per plant, number of pods per cluster and biological yield. High heritability with moderate genetic advance as percent of mean was recorded for number of seeds per pod only. These traits are governed by additive gene effects and therefore, may be improved through direct selection. Similar findings for harvest index was reported by Vinay *et al.* (2010), Pathak *et al.* (2014), Choudhary *et al.* (2017) and Pulagampalli and Lavanya (2017). High heritability coupled with high genetic advance as percent of mean for plant height was reported by Lavanya (2006), Rahim *et al.* (2010), Pathak *et al.* (2014) and Choudhary *et al.* (2016). High heritability coupled with high genetic advance as percent of mean for number of primary branches per plant was reported by Pathak *et al.* (2014), Choudhary *et al.* (2017) and Abdus *et al.* (2021). High heritability coupled with high genetic advance as percent of mean for number of clusters per plant was reported by Pathak *et al.* (2014), Choudhary *et al.* (2017), Wesly *et al.* (2020) and Abdus *et al.* (2021). High heritability coupled with high genetic advance as percent of mean for number of pods per cluster was reported by Pathak *et al.* (2014), Choudhary *et al.* (2017) and Abdus *et al.* (2021). High heritability coupled with high genetic advance as percent of mean for biological yield was reported by Pathak *et al.* (2014), Choudhary *et al.* (2016) and Choudhary *et al.* (2017). High heritability coupled with moderate genetic advance as per cent of mean for number of seeds per pod has been reported earlier by Reddy *et al.* (2003). The graphical representation of different variability parameters has been given in Figure-1.

Conclusions

So from the above investigation's results it may be concluded that yield was mainly influenced by number of seeds per pod, pod length, number of primary branches, biological yield, number of clusters per plant, plant height, days to maturity and harvest index. These characters have optimum variations and thus, should be given top

priority while formulating a selection strategy for improvement of yield in mungbean genotypes.

Acknowledgement

The authors would like express heartfelt gratitude to Dr. G.M. Lal (Assistant Professor, Department of Genetics and Plant Breeding, NAI, SHUATS, Prayagraj) for his continuous guidance and supervision throughout our research period. And also, equally extend our profound gratitude to Dr. (Mrs) G. Roopa Lavanya (Associate Professor, Department of Genetics and Plant Breeding, NAI, SHUATS, Prayagraj) for her valuable suggestions, guidance.

References

1. Abdus, M., Salman, S., Anuradha, Ch., Sridhar1, V., Ram E. B., Pushpavalli, SNCVL. (2021) Genetic Variability for Yield and Its Related Traits in Green gram [*Vigna radiata* (L.) Wilczek]. *Legume Research-An International Journal*, 10(1): 45-60.
2. Ahmad, S. and Belwal, V. (2020). Study of correlation and path analysis for yield and yield attributing traits in mungbean [*Vigna radiata* (L.) Wilczek]. *International Journal of Chemical Studies*, 8(1): 2140-2143.
3. Ahmad, H.B., Salsabeel, R.C., Muhammad, R., Atta, U.M., Umar, S. and Muhammad, S. (2014) Genetic variability for yield contributing traits in mungbean (*Vigna radiata* L.). *Journal of Global Innovation in Agricultural and Social Sciences*, 2(2): 52-54.
4. Allard, R.W. (1960). Relationship between Relationship between genetic diversity and consistency of performance in different environment. *Crop Science* 1: 127-132.
5. Burton, G.W. (1952). Quantitative inheritance in grasses Proc. 6th int. *Grassland congress*.1: 227-283.
6. Burton, G.W. and Devane, E.M. (1953). Estimation of heritability in tall fescus (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* 45: 478-480.
7. Choudhary, P., Payasi, S.K. and Patle, N.K. (2017). Genetic study and selection indices for grain yield of mungbean. *Legume Research*, 40(5): 836-841.
8. Choudhary, P., Payasi, S.K. and Urmaliya, K. (2016). Genetic association and path analysis for yield contributing traits in mungbean [*Vigna radiata* (L.) Wilczek]. *International Journal of Agriculture Sciences*, 8(52): 2465-2468.
9. Comstock, R. R. and Robinson, H. F. (1952). Genetic parameters, their estimation and significance. *Proceeding of Sixth International Grassland Congress*, 1: 248-251.
10. Das, T. R., Barua, P.K. (2015). Association Studies for Yield and its components in Green Gram. *International Journal of Agriculture, Environment and Biotechnology*, 8(3): 561-565.
11. Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of erasted wheat grass production. *Agronomy Journal*, 7: 179-188.
12. Dhunde, B.B., Devmore, J.P., Mahadik, S.G., Palshetkar, M.G., Vanve, P.B., Bhav, S.G. and Thorat, B.S. (2021).

- Correlation and path analysis studies on yield and its components in green gram [*Vigna radiata* L. Wilczek]. *The Pharma Innovation Journal* 10(1): 727-730.
13. Dhuppe, M.V., Madrap, I.A., Chandankar, G.D. and More, S.S. (2005). Correlation and path analysis in mungbean [*Vigna radiata* (L.) Wilczek]. *Journal of Soils and Crops*, 15(1): 84-89.
 14. Fisher, R.A and Yates, F. (1963). Statistical Tables for Biological, Agricultural and Medical Research. *Oliver and Boyd, London*: 143 p.
 15. Garg, G.K., Verma, P.K. and Kesh, H. (2017). Genetic Variability, Correlation and Path Analysis in Mungbean (*Vigna radiata* (L.) Wilczek) *International Journal of Current Microbiology and Applied Sciences*, 6(11): 21.
 16. Ghimire, S., Khanal A., Kohar, G.R., Acharya, B., Basnet, A., Kandel, P., Subedi, B., Jiban, S. and Dhaka, K. (2018). Variability and path coefficient analysis for yield attributing traits of mungbean (*Vigna radiata* L.) *Azarian Journal of Agriculture*, 5(1): 7-11.
 17. Gul, R., Khan, H., Mairaj, G., Ali, S., Farhatullah and Ikramullah (2008). Correlation study on morphological and yield parameters of mungbean [*Vigna radiata* (L.) Wilczek]. *Sarhad Journal of Agriculture*, 24(1): 37-42.
 18. Hemavathy, A.T., Shunmugavalli, N. and Anand, N. (2015). Genetic variability, correlation and path coefficient studies on yield and its components in mungbean [*Vigna radiata* (L.) Wilczek]. *Legume Research*, 38(4): 442-446.
 19. Itefa, D., Yohannes, P. and Mebeaselassie, A. (2014). Correlation and path coefficient analysis among seed yield traits of Mungbean (*Vigna radiata* L.) accessions in Ethiopia. *Annual Research & Review in Biology*, 4(1): 269-284.
 20. Jeberson, M.S., Shashidhar, K.S. and Iyanar, K. (2015). Estimation of genetic parameters for phenological traits in mungbean [*Vigna radiata* (L.) Wilczek]. *Trends in Biosciences*, 8(21): 5741-5745.
 21. Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimate of genetic and environmental variability in soyabean. *Agronomy Journal*, 47:314-318.
 22. Jyothsna, M. and Anuradha, C.H. (2013). Genetic variability, correlation and path coefficient analysis for yield and yield components in mungbean [*Vigna radiata* (L.) Wilczek]. *Journal of Research*, 41(3): 31 p.
 23. Khanpara, M.D., Vachhani, J.H., Jivani, L.L., Jethava, A.S. and Vaghasia, P.M. (2012). Correlation and path coefficient analysis in green gram [*Vigna radiata* (L.) Wilczek]. *Asian Journal of Bio Science*, 7(1): 34-38.
 24. Kousar, M., Garard, A., Jan, A. and Singh, A.K. (2007). Genetic Variability and Correlations Studies on Yield and its Components in Mungbean (*Vigna radiata* (L.) Wilczek). *Journal of Agronomy*, 6(1) : 216-218.
 25. Kiessling, H. (1912). The cultivation of regional varieties of crops in Bavaria. *Contribution to plant breeding*, 2: 74-96.
 26. Lavanya, G.R. (2006). Evaluation of mungbean germplasm for genetic variability. *Indian Journal of Plant Genetic Resources*, 19(1): 281-286.
 27. Madhuri, R.M. and Parhe, S.D. (2017). Genetic Diversity Studies in Mungbean (*Vigna radiata* L. Wilczek) Germplasm. *Trends in Biosciences*, 10(2): 868-872.
 28. Pathak, N., Mishra, M.K. and Singh, M.N. (2014). Association and multivariate analysis of yield and yield component traits in mungbean [*Vigna radiata* (L.) Wilczek]. *Indian Journal of Plant Genetic Resource*, 27(2): 136-141.
 29. Pulagampalli, R. and Lavanya, G.R. (2017). Variability, heritability, genetic advance and correlation coefficients for yield component characters and seed yield in green gram [*Vigna radiata* (L.) Wilczek]. *Journal of Pharmacognosy and Phytochemistry*, 6(4): 1202-1205.
 30. Rahim, M.A., Mia, A.A., Mahmud, F., Zeba, N. and Afrin, K.S. (2010). Genetic variability, character association and genetic divergence in mungbean [*Vigna radiata* (L.) Wilczek]. *Plant Omics*, 3(1): 1-6.
 31. Raturi, A., Singh, S.K., Sharma, V. and Pathak, R. (2015). Genetic variability, heritability, genetic advance and path analysis in mungbean [*Vigna radiata* (L.) Wilczek]. *Legume Research*, 38(2): 157-163.
 32. Sharma, S.R., Singh, D., Kumar, P., Khedar, O.P. and Varshnay, N. (2016). Assessment of Genetic Diversity in Mungbean [*Vigna radiata* L Wilczek] Genotypes *International Journal of Genetics*, 10(7): 471-474.
 33. Singh, A.K., Gautam, R.K., Singh, P.K., Kumar, N., Kumar, K. and Roy, S.D. (2014). Indigenous land races of mungbean and urdbean as potential donors for pulse improvement for tropical Bay island conditions. *Agrotechnol an open access journal*, 2(4):175.
 34. Tabasum, A., Muhammad, S. and Irum, A. (2010) Genetic variability, trait association and path analysis of yield and yield components in mungbean [*Vigna radiata* (L.) Wilczek]. *Pakistan Journal of Botany*, 42(6): 3915.
 35. Tiwari, A., Mishra, S.P. and Nag, S.K. (2014). Genetic variability, heritability and genetic advance studies for yield and its components in mungbean [*Vigna radiata* (L.) Wilczek]. *Trends in Biosciences*, 7(1): 58-60.
 36. Vinay, N.K., Lavanya, G.R., Singh, S.K. and Pandey, P. (2010). Genetic association and path coefficient analysis in mungbean [*Vigna radiata* (L.) Wilczek]. *AAB Bioflux*, 2: 251-257.
 37. Wesly, K.C., Nagaraju, M. and Lavanya, G.R. (2020). Estimation of genetic variability and divergence in Greengram [*Vigna radiata* (L.)] germplasm. *Journal of Pharmacognosy and Phytochemistry*, 9(2): 1890-1893.



Diversity and Phytosociological Analysis of Weed Species : An Important Tool for Crop Management

Thejanguzo T.R., Himshikha^{1*}, A.K. Negi¹, J.S. Butola¹, L.S. Kandari¹ and C.S. Dhanai²

¹Department of Forestry and Natural Resources, HNB Garhwal University (A Central University), Chauras Campus, Tehri Garhwal, Uttarakhand

²College of Forestry, VCSG UUHF, Ranichauri, Tehri Garhwal, Uttarakhand

*Email : bhhimshikha654@gmail.com; drbutolajs@gmail.com

Abstract

The study was conducted in Srinagar Garhwal, Uttarakhand to explore and compare the status of diversity and ecological behaviour of weed species with their seasonal distribution in a managed nursery and in wild habitats. Phytosociological analysis was done to observe frequency, density, abundance, and importance value index (IVI) and diversity indices. *Parthenium* was recorded as the dominant herbaceous species in both nursery and wild habitats. Diverse range of IVI (3.2-79.22) indicated a mixed composition of common as well as rare occurrence. *Murraya koenigii* observed as the most dominant shrub and an invasive seasonal habitat occupier. *Sida* and *Oxalis* reoccurred due to potential germination by soil seed bank of these species. Abundance/frequency ratio (0.05-2.10) confirmed significant variation in populations of these species. Maximum overlapping (Sorensen 'similarity Index, $\hat{\alpha}=0.72$) occurred during November-January indicating more ecological niche availability. Species richness ranged as 5.91-8.45 (nursery) and 2.99-4.77 (wild) with a significant value of 8.45 and 4.77, respectively. Higher $\hat{\alpha}$ values indicated nursery as a potential source of weed invasion. Low species richness as minimum 2.99 at wild habitat compared to 7.87 for nursery proved it as encouraging factor for invasive weed species. The invasive nature contributes to proliferating behaviour which shows need to bio-monitor the species. Seasonal pre-sowing treatment to soil is recommended to control the possibilities of repeated weed growth through soil seed bank under nursery conditions.

Key words : Diversity, phytosociology, habitat, nursery, weeds, seasonal variation.

Introduction

Weed species vary in their competitive ability, but they characteristically have fast-growing root system that gives them an early advantage in competition. A rapid growth of weeds in a particular time period produces negative effects on the associated plants. This further leads to production of inferior quality produce from desired crops leading to increased production costs while reducing the productive capabilities of land. It hence, a diverse weed is threat to the endemic species types (Gurevitch and Pandilla, 2004). Community analysis is an important component to understand the behaviour of species while exploring the importance of vegetation composition and its function (Warger and Morrel, 1978). Plant community indicates the association of species growing together in a particular habitat. The community analysis of weed can be approached to describe their characteristics by employing tools such as similarity and diversity indices that clarify the pattern of their performance under the associated environmental conditions.

Identification and description of weeds at nursery site has been an interesting aspect of community analysis while weed control is one of the major input costs of crop production (Rao and Nagamani, 2010). Establishment

and management of nursery is an essential requirement of forest development. However, if not managed for weed population, the saplings grown at nursery can be of lower quality and increase in production costs compared to wild habitat. Hence, prior to develop measures targeting the control mechanisms that are efficient to constitute a socially, economically and environmentally sustainable alternatives to make land resources efficiently utilized by reducing weed growth in both; nursery and wild habitats; it is important to evaluate the diverse phyto-sociological behaviours of weed communities in terms of seasonal diversity and variations.

Roberts (1989), suggested that there are three principles of phyto-sociology viz., the analytical, the synthetic and syntaxonomy (establishing the phytosociological hierarchy). As the present study was intended to screen, identify and to analyse the seasonal distribution, abundance and other ecological variables important in exploring the weed species particularly in nursery and wild habitat under subtropical conditions in Garhwal region of Western Himalaya, India.

The present study was designed to observe diversity and phytosociology of weed species to compare the species structure, to determine any similarity among

weed species and their seasonal distribution in a managed nursery and in wild habitats. The study will also unfold any possibility of species migration and overlapping. This can also serve as a base to design effective and species-specific weed management techniques for better growth and yield of seedlings.

Materials and Methods

The study was conducted in HNB Garhwal University, Chauras campus (78°48'03"E and 30°13'26" N at 567m above sea level), Uttarakhand. The departmental forestry nursery (area 1.5 ha) and surrounding wild habitat (area 3.5 ha) were selected as Site I and Site II for study during August 2018-July 2019. The forestry nursery area is undisturbed while the wild area periodically disturbed due to atherogenic and other biotic factors. The area predominantly holds forestry species such as *Bombax ceiba*, *Toona ciliata*, *Melia azedarach*, *Bauhinia* sp., *Ficus* sp. *Acacia catechu* etc. The temperature ranged as minimum 2.32°C-22.19°C (Winters) and maximum 24.55°C-42.51° (Summers) and average rainfall 0.2 mm (December) to 218.95 mm (August). Random technique was applied to collect the data from the quadrates plotted as 5 x 5 m sample plot for the shrub species in one 10x10 m, and 1x1 m for herbaceous species (Mishra 1968) at 25 m apart. Total thirteen quadrates; six quadrates at nursery and seven quadrates were laid at wild area (Fig 1). The sampling period was divided into four seasons being 1st season as August-October, 2nd as November-January, 3rd as February-April and 4th as May-July.

The quantitative community analysis was done (Mishra, 1968; and Dombois and Ellenberg 1974) on following aspects :

(i) Frequency

$$(a) \text{ Frequency} = \frac{\text{No. of quadrate in which individuals occurred}}{\text{Total no. of Quadrate}} \quad 100$$

$$(b) \text{ Relative Frequency} = \frac{\text{Frequency of an individual species}}{\text{Frequency of all species}} \quad 100$$

(ii) Density

$$(a) \text{ Density} = \frac{\text{Total no. individual of a species present in all the quadrates}}{\text{Total number of Quadrates}}$$

$$(b) \text{ Relative Density} = \frac{\text{Density of an individual species}}{\text{Density of all the species}} \quad 100$$

(iii) Abundance

(a) Abundance

$$= \frac{\text{Total no. of individual of a species in all quadrates}}{\text{Total no. of quadrate in which species is present}} \quad 100$$

(iv) Dominance

$$(a) \text{ Basal area} = \frac{(CBH)^2}{4}$$

(CBH=Circumference at breast height)

$$(b) \text{ Relative Dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all the species}} \quad 100$$

(v) Importance Value Index (IVI) for herbaceous species = Relative Frequency + Relative Density + Relative Abundance (RF+RD+RA)

Diversity Indices

(i) Shannon-Weiner's Index (H') to evaluate values of species diversity.

$$\text{Formula} = \frac{ni}{N} \log \frac{ni}{N}$$

Where N = total number of species, ni=number of individuals values are 0-1, where 1 being complete evenness and 0 being no diversity

(ii) Margalef's Index (Dmg) to measure species richness.

$$\text{Formula} = \frac{S - 1}{\log N}$$

where S = total number of species, N = total number of individuals

(iii) Simpson's Index (D) to estimate dominance (the higher the value, the lower in diversity) which indicates abundance of most common species and their importance to diversity.

$$\text{Formula} = 1 - \frac{ni * (ni - 1)}{N * (N - 1)} \quad (\text{Value lies between 0 and 1})$$

Where, n=the total number of individuals of a particular species; N= the total number of individuals of all species

(iv) Pielou's Index (E) for species evenness which ranges from 0 (no evenness) to 1 (complete evenness).

$$\text{Formula} = \frac{H}{\log S}$$

Where, H = Shannon and Weaver Index (1949) and S = species number

$$(v) \text{ Whitford Index (WI)} = \frac{\text{Abundance}}{\text{Frequency}}$$

where, abundance= percentage of the total number of species present in community, frequency= the number of sampling units or quadrats in which a species occurs.

Table-1 : Species diversity and Seasonal occurrence.

Family and species count	Species	Nursery area (Site I)				Wild area (Site II)			
		Season 1 st	Season 2 nd	Season 3 rd	Season 4 th	Season 1 st	Season 2 nd	Season 3 rd	Season 4 th
Amaranthaceae (3)	<i>Aerva</i> sp.	+	+	+					
	<i>Chenopodium album</i>			+	+				
	<i>Amaranthus</i> sp.				+				
Acanthaceae (1)	<i>Dicliptera</i> sp.	+	+	+	+				
Apocynaceae (1)	<i>Carissa carandas</i>	+	+	+	+				
Asparagaceae (1)	<i>Asparagus adscendens</i>	+	+	+	+				
Asteraceae (8)	<i>Ageratum conyzoides</i>		+	+					
	<i>Artemisia nilagirica</i>	+			+				
	<i>Erigeron bonariensis</i>			+	+			+	+
	<i>Gnaphalium</i> sp.			+				+	
	<i>Launaea sarmentosa</i>		+	+			+	+	
	<i>Parthenium hysterophorus</i>	+		+	+	+		+	+
	<i>Saussurea heteromalla</i>		+	+			+	+	
	<i>Xanthium strumarium</i>					+		+	+
Cannabaceae (1)	<i>Cannabis sativa</i>			+	+	+		+	+
Caryophyllaceae (1)	<i>Stellaria media</i>	+	+	+			+	+	
Cyperaceae (1)	<i>Cyperus</i> sp.			+	+				
Euphorbiaceae (1)	<i>Euphorbia hirta</i>	+							
Fabaceae (1)	<i>Desmodium triflorum</i>	+							
Lamiaceae (1)	<i>Ajuga</i> sp.	+	+	+					
Malvaceae (4)	<i>Malvestrum</i>	+		+	+				
	<i>Sida acuta</i>	+	+	+	+	+	+	+	+
	<i>Sida cordifolia</i>	+		+	+				
	<i>Urena lobata</i>	+							
Oxalidaceae (1)	<i>Oxalis corniculata</i>	+	+	+			+	+	
Poaceae (1)	<i>Digitaria</i> sp.					+			+
	<i>Eleusine</i> sp.	+							
	<i>Eragrostis</i> sp.	+							
Portulacaceae (1)	<i>Portulaca</i> sp.	+	+	+	+				+
Rhamnaceae (1)	<i>Ziziphus mauritiana</i>	+	+	+	+	+	+	+	+
	<i>Galium</i> sp.			+					
Rubiaceae (2)	<i>Oldenlandia</i> sp.	+							
Rutaceae (1)	<i>Murrayakoenigii</i>	+	+	+	+	+	+	+	+
Scrophulariaceae (1)	<i>Verbascum thapsus</i>		+	+			+	+	
Solanaceae (2)	<i>Physalis</i> sp.					+			+
	<i>Solanum nigrum</i>	+			+				
Verbanaceae (1)	<i>Lantana camara</i>	+	+	+	+	+	+	+	+
	Total	23	16	25	18	9	9	14	11

(vi) Sorensen's similarity Index () measures and compare communities with diversity data.

$$\text{Formula} = \frac{2c}{a+b}$$

where a and b are the number of species in two sites and c is the number of species shared by the two sites.

Results and Discussion

Species diversity, Seasonal occurrence and distribution : A total of 37 weeds species belonging to 21 families were recorded in nursery and 17 species (12 families) in wild habitats. 17 species were common to both habitats. Asteraceae was the dominant family (8 species;

7 at nursery and 6 at wild). Least number of species were recorded from Poaceae, Fabaceae and Rubiaceae families. The reported weed species can be categorised into Species-I, II and III composed of seasonal as well as perennial species. The group of species-I (18 sp.) included those counts found only at nursery locality. The group of species-II (03 sp.) were reported only at wild i.e. *Digitaria*, *Physalis* and *Xanthium*. The group of species-III (12 sp.) included common species like *Cannabis sativa*, *Oxalis corniculata* and *Stellaria media* showing locality overlapping. On seasonal distribution pattern, maximum species were reported during 1st season (27) followed by 3rd (25), 4th (20) and 2nd season (16 species). At wild habitat, 14 sp. were recorded during season 3rd followed

Table-2 : Importance Value Index (IVI) of weed species.

Species	Nursery (Site I)				Wild (Site II)			
	Season 1 st	Season 2 nd	Season 3 rd	Season 4 th	Season 1 st	Season 2 nd	Season 3 rd	Season 4 th
<i>Aerva</i> sp.	7.26	12.47	5.57					
<i>Ageratum conyzoides</i>		11.69	4.88					
<i>Ajuga</i> sp.	5.78	7.2	3.2					
<i>Amaranthus</i> sp.				6.92				
<i>Artemisia nilagirica</i>	12.17			9.35				
<i>Asparagus adscendens</i>	5.41	7.2	3.2	3.93				
<i>Cannabis sativa</i>			3.74	6.94	46.32		34.95	42.82
<i>Carissa carandas</i>	19.44	32.75	15.21	19.49				
<i>Chenopodium album</i>			14.71	19.54				
<i>Cyperus</i> sp.			17.56	25.94				
<i>Desmodium triflorum</i>	7.26							
<i>Dicliptera</i> sp.	13.32	18.81	11.29	6.94				
<i>Digitaria</i> sp.					29.61			32.4
<i>Eleusine</i> sp.	5.25							
<i>Eragrostis</i> sp.	8.05							
<i>Erigeron bonariensis</i>			6.59	4.54			7.43	8.88
<i>Euphorbia hirta</i>	6.52							
<i>Galium</i> sp.			12.36					
<i>Gnaphalium</i> sp.			16.92				6.41	
<i>Lantana camara</i>	30.93	24.54	17.95	23.44	45.12	65.15	38.8	41.59
<i>Launaeasarmentosa</i>		24.54	25.82			49.98	41	
<i>M. lianum</i>	11.64		4.88	13.73				
<i>Murraya koenigii</i>	41.95	42.56	31.21	39.91	54.94	79.22	46.93	49.62
<i>Oldenlandia</i> sp.	4.09							
<i>Oxalis corniculata</i>	15.23	21.09	15.84			9.75	5.77	
<i>Parthenium hysterophorus</i>	16.66		26.86	41.57	44.89		34.78	39.31
<i>Physalis</i> sp.					23.65			28.04
<i>Portulaca</i> sp.	14.48	28.1	17.75	21.39				4.56
<i>Saussurea heteromalla</i>		12.85	5.91			11.22	6.6	
<i>Sida acuta</i>	32.31	25.47	24.1	38.2	9.18	14.86	9.47	12.91
<i>Sida cordifolia</i>	9.86		4.82	6.94				
<i>Solanum nigrum</i>	3.52			7.3				
<i>Stelleria media</i>	5.25	7.2	3.74			26.52	17.14	
<i>Urena lobata</i>	18.52							
<i>Verbascum thapsus</i>		6.43	2.67			18.57	12.56	
<i>Xanthium strumarium</i>					30.37		24.08	24.72
<i>Ziziphus mauritiana</i>	5.25	7.2	3.2	3.93	16.21	24.72	14.07	15.13

by season 4th (11) and least during season 1st and 2nd as 9 weed species in each. At nursery, maximum weed species (25) were recorded during season 2nd (November-January) followed by 23 species during season 1st (August-October), 18 species in season 4th (May-July) and least (16) during season 2nd (November- January). The possible reason behind the observed disturbance were: different growth seasons, species incorporation with external material like soil, manure, irrigation water etc at site, which may act a potential source of species introduction at any place.

Two species *Sida cordifolia* and *Malvastrum coromandelianum* were recorded at nursery during all seasons except in winters i.e. November-February with no occurrence at wild. *Ageratum* was reported at nursery

only during season 3rd and 4th (March-July). *Launaea*, *Saussurea*, and *Verbanum* were common at both sites during November-March period (season 2nd and 3rd) with no other record. *Gnaphalium* as the only common to both localities with no other record has proven this species confined to spring season only. *Lantana*, *Murraya*, *Ziziphus* and *Sida acuta* sp. were abundant at both sites during all seasons which proves them as seasonal habitat occupier and widely adoptable in terms of climatic and habitat variations. These species have shown overlapping possibly due to frequent seed dispersal through air, animals and birds. *Carissa*, *Asparagus*, *Portulaca* and *Diclipteria* were reported only at nursery during all seasons. During March-July; *Chenopodium* and *Cyperus* were recorded at nursery with no occurrence at wild. Weed species diversity was high and significant in

Table-3 : Abundance/frequency ratio and distribution pattern of weed species.

Species	Nursery (Site I)				Wild area (Site II)				Pattern
	Season I	Season II	Season III	Season IV	Season I	Season II	Season III	Season IV	
<i>Aerva sp.</i>	0.15	0.11	0.11						R
<i>Ageratum conyzoides</i>		0.08	0.08						R
<i>Ajuga sp.</i>	0.09	0.18	0.18						R
<i>Amaranthus sp.</i>				0.11					R
<i>Arthimiesianilagirica</i>	1.08			0.72					C
<i>Asparagus adscendens</i>	0.08	0.18	0.18	0.18					R
<i>Cannabis sativa</i>			0.24	0.48	0.37		0.32	0.43	R+r
<i>Carissa carandas</i>	0.06	0.05	0.05	0.05					R
<i>Chenopodium album</i>			0.24	0.29					R+r
<i>Cyperus sp</i>			0.1	0.15					R
<i>Desmodium triflorum</i>	0.15								R
<i>Dicliptera sp.</i>	1.2	1.08	1.08	0.48					C
<i>Digitaria sp.</i>					0.19			0.28	R
<i>Eleusine sp.</i>	0.36								R
<i>Eragrostis sp.</i>	0.06								R
<i>Erigeron bonariensis</i>			0.15	0.24			0.42	0.56	R+r+C
<i>Euphorbia hirta</i>	0.12								R
<i>Galium sp.</i>			0.2						R
<i>Gnaphalium sp.</i>			0.29				0.05		R+ r
<i>Lantana camara</i>	0.15	0.1	0.36	0.08	0.36	0.36	0.36	0.42	R+ r
<i>Launaeasamentosa</i>		0.1	0.16			0.16	0.17		R
<i>M. coromandelianum</i>	0.64		0.3	0.16					R+r+C
<i>Murraia koenigii</i>	0.23	0.17	0.08	0.2	0.21	0.21	0.21	0.34	R+ r
<i>Oldenlandia sp.</i>	0.24		0.17						R
<i>Oxalis corniculata</i>	0.22	0.17	0.15			0.28	0.28		R+ r
<i>Parthenium hysterophorus</i>	0.14		0.53	0.77	0.15		0.13	0.24	R+r+ C
<i>Physalis sp.</i>					0.24			0.41	R+ r
<i>Portulaca sp</i>	1.32	1.8	0.8	1.92				0.14	R+r+C
<i>Saussurea heteromalla</i>		0.12	0.12			0.35	0.35		R+r
<i>Sida acuta</i>	0.23	0.28	0.47	0.69	0.09	0.14	0.16	0.26	R+r+C
<i>Sida cordifolia</i>	0.84		0.36	0.48					R+r+C
<i>Solanum nigrum</i>	0.18			0.12					R
<i>Stelleria media</i>	0.36	0.18	0.24			0.37	0.42		R+r
<i>Urena lobata</i>	1.74								C
<i>Verbascum Thapsus</i>		0.12	0.12			0.08	0.1		R
<i>Xanthium strumarium</i>					1.96		1.82	2.1	C
<i>Ziziphus mauritiana</i>	0.36	0.18	0.18	0.18	0.3	0.33	0.32	0.35	R+r

A/f Values less than 0.025=regular (R); 0.025-0.050=random (r); more than 0.050=contagious (C)

dormant as well as orthodox seed types. Compare to wild area, nursery has shown abundance of species during all four seasons due to more suitable environmental conditions and sufficient availability of resources. *Parthenium*, *Xanthium*, *Stelleria*, *Oxalis* etc. have been reported recurrently due to their collective soil seed bank germination potential acting as a reservoir over a period of time (Baskin and Baskin, 2014). Also, a large number of seeds especially for *Portulaca*, *Murraia* etc. produced, stored and spread in soil allows recurred infestation of the area after a new practice as done at nursery. Hence, proper seasonal soil treatment is required for successful eradication of these species. Further, a change in species to be sown at nursery and their management practices

holds a temporal dimension to modify the soil micro environment, leading to change in soil seed bank. *Verbascum thapsus* and *Saussurea heteromalla* were common during November-April period due to favourable winter climatic conditions. Rare density of *Xanthium*, *Digitaria* and *Physalis* disqualify them as invasive species at wild habitat. Least species occurrence at both site during November-January was mainly due to less favourable conditions such as low temperature, limited soil moisture and frost conditions. It is further proven by least Diversity Index values indicating almost no diversity at both sites during this season. Occurrence of *Oldenlandia* has been reported to be dispersed from the other regions while *Amaranthus*, *Eleusine*, *Eragrostis*,

Table-4 : Diversity Indices of weed species.

DI	Description	Season 1 st		Season 2 nd		Season 3 rd		Season 4 th	
		Nursery	Wild	Nursery	Wild	Nursery	Wild	Nursery	Wild
H'	Species Occurrence	1.12	0.08	0.97	0.74	1.18	0.95	1.03	0.91
Dmg	Species Richness	7.87	2.99	5.91	3.2	8.45	4.77	6.08	3.61
D	Concentration of dominance	1	0.98	0.99	0.97	1	0.99	0.99	0.99
E	Species Evenness	0.82	0.9	0.81	0.78	0.85	0.83	0.82	0.87
B	Species Overlapping	0.31		0.72		0.67		0.55	

Desmodium triflorum, *Galium* at nursery during a limited period have not shown much acceptance to variations to climatic and edaphic conditions with no other record at any time, which may be due to their less competitive behaviour.

Phytosociological Analysis

Comparative study of frequency, density and abundance : Comparatively; the frequency, density and abundance of the weed species at nursery was higher than the wild and counted highest during February-April with respective values as 1050, 115 and 253.85 for nursery and 585, 75.57 and 155.42 for wild area. A low level of density (1.00- 3.33, max. 22.79) has proven specific species occurred as non-invasive to outer localities (0 stage of invasion) as mentioned by Inderjit (2005). Values were the least during November-January at wild habitat (Fig.-2).

Importance value index (IVI) : A variation in IVI values of reported weed species (3.2 for *Asparagus* and *Ajuga* to 79.22 for *Murraya*) indicates that the area holds a mixture of common as well as rare occurrence of weed species. *Murraya koenigii* was reported as dominant weed species in all seasons at both sites (IVI=41.95 and 54.95 in season 1st, 54.94 and 42.56 in 2nd, 79.22 and 31.21 in 3rd) except during season 4th at nursery. High IVI value of *Murraya* displays its higher relative frequency, dominance in existence, dense composition and more competitive behaviour. Asteraceae family is recorded to be collectively dominant in nature due to high species richness, suitable niche conditions and species abundance during all the seasons in Nursery and wild habitat. This is supported by Rao and Murugan (2006); Reddy (2008) and Singh *et al.* (2010), who conferred it as dominant invasive family. This invasive nature contributes to high IVI due to proliferating behaviour, tolerance to various environmental stress conditions which indicates a need to bio-monitor the species to control its population in the nursery. High IVI of *Digitaria*, *Xanthium* and *Physallis* sp. at wild and established them as invasive which may lead to a spread at nursery locations. *Lantana camara* was observed as a co-dominant species at both the sites during November-January with an average IVI value (49.49), as the regeneration is readily achieved under given conditions.

Similar IVI values (47.72) were obtained by Rai and Singh (2015). The peak IVI value (47.57) of *Parthenium hysterophorus* was recorded during May-July at nursery and 39.31 at wild. It is due to its aggressiveness and allelopathic effects on the neighbouring plants as earlier suggested by Adkins and Sowerby (1996). However, the lower IVI values (11.34) for this species was reported by Pragada *et al.* (2011) due to employment of more sampling plots. *Solanum nigrum* and *Oldenlandia* had the least IVI with 4.09 and 3.52 followed by *Verbascum* sp. (IVI 2.67) and *Ziziphus* sp. having IVI 3.02. On comparative aspect, *Sida acuta* has shown variation in IVI values during all seasons. The species has shown dominance at Nursery (IVI 24.1 to 38.2) when compared with its wild habitat (IVI 9.18 to 14.86) while *Ziziphus* has proven itself as more dominant at wild (IVI 14.07 to 24.72), when compared to its growth in nursery (IVI 3.2 to 5.25).

Spatial distribution patterns, diversity indices and overlapping

Abundance/ frequency ratio : In the findings, the range of Abundance-frequency ratio lies between 0.05-2.10, which signifies a huge variation of weed population in the area. At nursery, majority of species had regular (maximum 18 species) followed by random (maximum 07) and contagious distribution (maximum 05 species). Maximum variation in distribution patterns were observed during season 3rd (Regular 18, random 04 and contagious 03 species) followed by season 1st (regular 14, random 04 and contagious 05 species). At wild habitat, least variation was observed during season 2nd (regular 04, random 05, no species under contagious pattern) followed by season 1st (regular 05, random 02, contagious 02 species). At nursery, A/f ratio ranged from 0.01 for *Cyperus*, *Lantana* and *Launea* (season 3rd) to 1.92 for *Portulaca* sp. (season 4th). At wild, *Xanthium* accounted maximum A/f ratio as 2.1 during season 4th with highly contagious pattern (1.96), and minimum for *Verbascum* (0.1) during season 3rd. During February-April; least values accounted for *Cyperus* (0.01) in regular and highest (1.82) for *Xanthium* in contagious form. During May-July; highest values of A/f accounted for *Xanthium* (2.1) in for of contagious pattern while minimum was accounted for *Portulaca* (0.14) in regular distribution. *Eragrostis*, *Sida*, *Portulaca*,

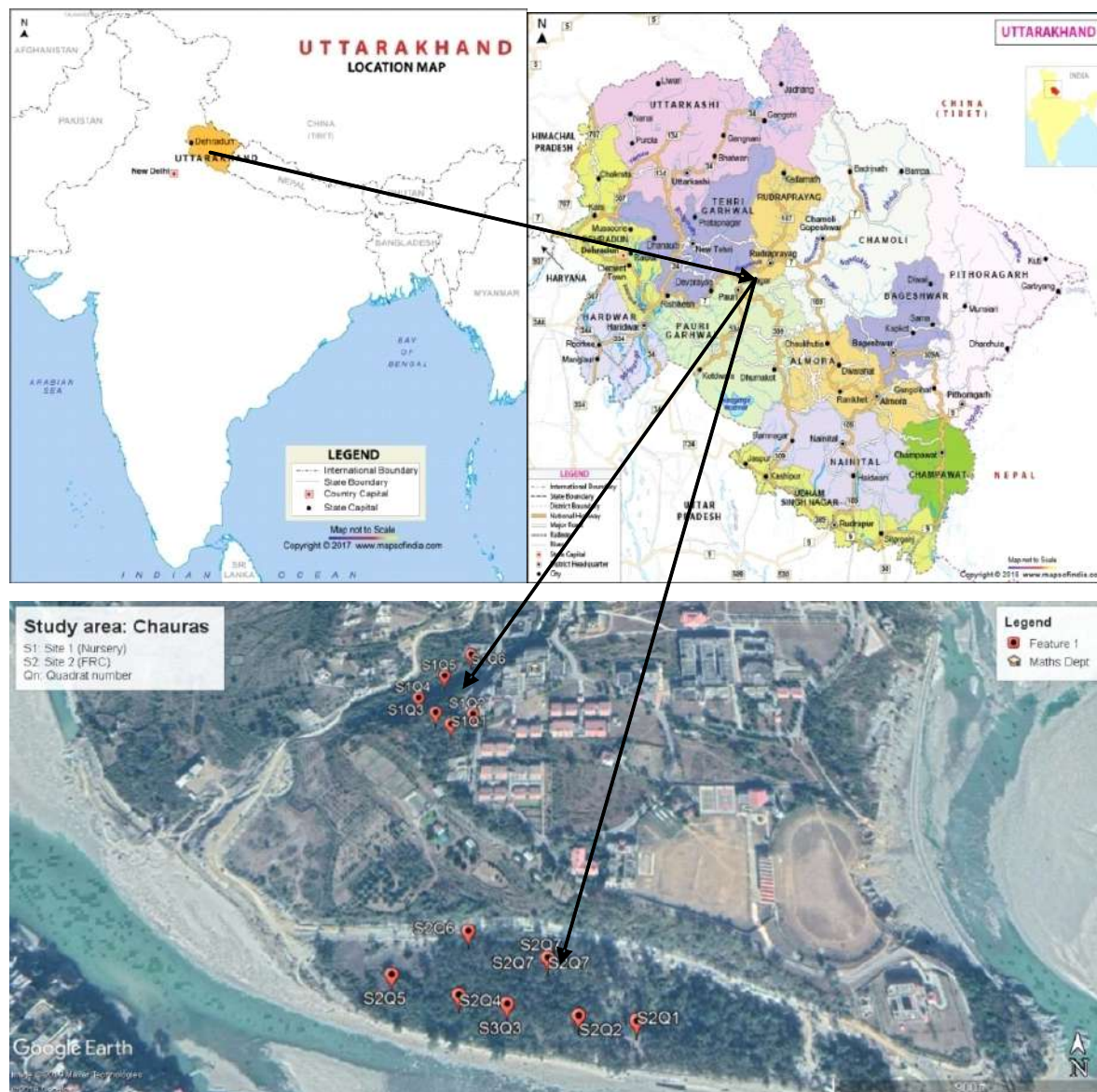


Figure-1 : Study Area Map (Source: www.mapofindia.com and Google Earth)

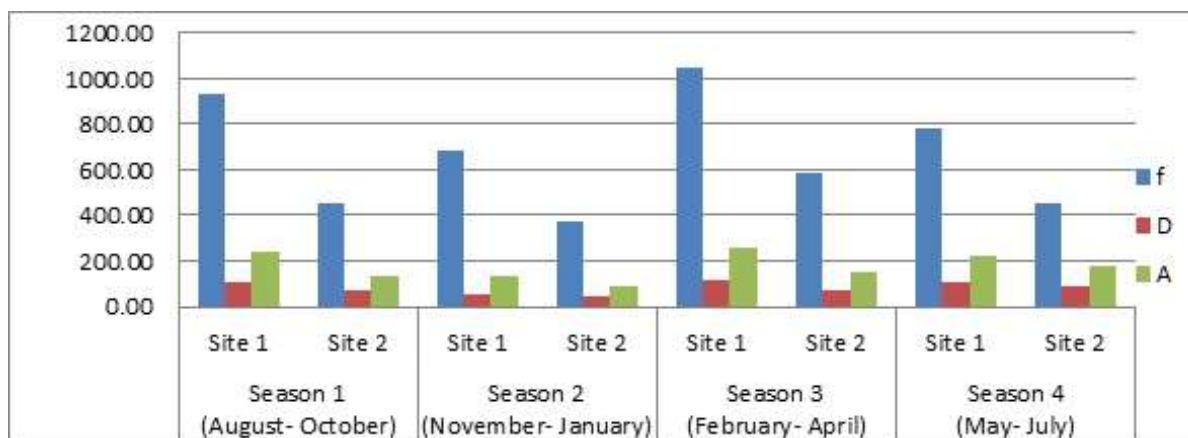


Figure-2 : Frequency, Density and Abundance of weed species (Blue=Frequency; Red=Density; Green=Abundance).

Parthenium and *Malvastrum* showed all type of distribution pattern. Contagious distribution of *Xanthium* (only in wild area), *Urena*, *Dicliptera* and *Artemisia* (only in nursery) indicated favourable conditions and resources at their respective sites indicating a possibility that these species may pose threat to the desired species under favourable conditions, if not managed accordingly on time (Table-3).

Diversity Indices and overlapping : The values of diversity indices were counted highest at nursery (1.12) than at wild (0.95) at wild area. Here, diversity ranged as 0.97-01.18, and 0.74-0.95. In nursery, the highest diversity index ($H'=1.12$) was recorded during August-October and during February-March ($H'=0.95$) in wild habitat, which confirmed this time period as most favourable for weed growth. More evenness, richness, similarity, overlapping and the high values of H' Index during rainy and spring season confirmed more species richness at nursery as compared to wild habitat. Maximum species richness (R) calculated for nursery was 5.91-8.45 and 2.99-4.77 for wild with a significant value of 8.45 and 4.77. The highest level of diversity of the weed species was during spring season (February-April) indicated this period as most suitable period for weed growth. The species richness and dominance were considerably similar in summers (May-July). However, the findings of Sinha (2017) with higher value of diversity indices counters the present study due to numerous clustering of species indicating closer and strong association of the weed species and consistent distribution in their natural habitat. The phyto-diversity in terms of dominance level was highest in nursery ($D=1.0$) with an evenness or uniformity as 0.82 and 0.85 hierarchically followed in season 4th and 2nd (0.99) with evenness value as 0.82 and 0.81. In wild habitat, it was recorded the highest in season 4th as 0.99 with evenness of species as 0.87, followed by season 1st (0.98) and 2nd ($D=0.97$). The lowest diversity (0.97 and 0.74) and species richness (2.99 and 5.91) at nursery and wild was observed during November-January; confirming almost no diversity in this period in terms of occurrence. This finding is supported by Concenco *et al.* (2012) on weeds occurrence during winters. A low species richness at wild (minimum 2.99 compared to 7.87 for Nursery; during August-October) proved wild habitat as encouraging factor for invasion of weed species. On the other way, more resource availability, and activities such as tillage etc. promotes accumulation and proliferation of weeds from wild to nursery habitat. Higher values of Simpson index pertaining to species concentration or dominance supports to the idea that nursery can also act as a source for invasion. This is supported by Inderjit (2005) that proliferation of and spread of species are time dependent.

This further approves rainy and spring season as an important time period to control weed population, and a need to establish additional criterion for successful weed management and prevention of weed spread during this period at Nursery. On compositional aspect of the weed communities, the beta diversity indices showed considerable homogenous composition during November-July, confirming a close proximity of species to form a natural community in late succession stage. The weed communities in both the site had shown the maximum similarities of species (overlapping) during 2nd as $\hat{\alpha}=0.72$ during 3rd as $\hat{\alpha}=0.67$, season 4th as $\hat{\alpha}=0.55$ and least during season 1st as $\hat{\alpha}=0.31$. A mild similarity among the reported weed species was observed during August-October. Maximum overlapping has contributed to weed growth indicating co-existence behaviour of their population at both niches during most of the time period (Table-4). Overall, the values of similarity index are slightly on higher side due to in the management of the weed population as earlier revealed by Ramirez *et al.* (2015).

Conclusions

It is concluded that high species diversity in terms of occurrence, concentration, counts and dominance reflects the requirement of more adaptive measures specifically designed to reduce the competition between individuals of desirable species and management of weed species at nursery. However, the value for evenness did not vary much between both sites, which exhibits possibilities of species spread from/to surrounding lands that might have taken place previously and which can be in continuation if not controlled successfully. Also, the invasive nature contributes to proliferating behaviour which shows need to bio-monitor the species. For this, seasonal pre-sowing treatment, to nursery soil -recommended to control the possibilities of repeated weed growth through soil seed bank under nursery conditions.

References

1. Adkins S.W. and Sowerby M.S. (1996). Allelopathic potential of *Parthenium hyperphorum* L. in Australia. *Plant prot. Q.1*: 20-23
2. Baskin C.C. and Baskin J.M. (2014). Germination ecology of seeds in the persistent seed bank. In: *Seeds: ecology, biogeography, and evolution of dormancy and germination* (Eds. Baskin CC and Baskin JM) 2nd ed. Academic press, Elsevier, New York p133-164
3. Concenco G., Silva C.J., Staut L.A., Pontes C.S., Launrindo L.C.A.S. and Souza NCDS. (2012). Weed occurrence in areas submitted to distinct winter crops. *Plant daninha*, 30 (4):747-755.
4. Dombois, M. and Ellenberg H. (1974). Aims and methods of vegetation ecology. *John Wiley and Sons*, New York. 547p
5. Gurevitch J, and Padilla D.K. (2004). Are invasive species a

- major cause of extinctions? *Trends Ecol. Evol.* 19:470-474.
6. Inderjit (2005). Plant invasions: Habitat invisibility and dominance of Invasive plant species. *Plant and soil*, 277 (1): 1-5.
 7. Mishra R. (1968). Ecology Work Book. Oxford and IBS Publishing Company, Calcutta. 224
 8. Pragada P.M., Padal S.B., Krishna B.R., Rao D.S. and Narauana V.K. (2011). Ecological aspects of weed flora of turmeric (*Curcuma longa* L.) fields of Vishakhapatnam District, A.P. India. *Journal of biodiversity and environmental sciences* 1(6): 30-38.
 9. Rai P.K. and Singh M.M. (2015). *Lantana camara* invasion in urban forest of an Indo-Burma hotspot region and its ecosustainable management implication through biomonitoring of particulate matter. *Journal of Asia-Pacific Biodiversity* 8(4): 375-381.
 10. Ramirez J.S., Hoyos C.V. and Plaza T.G. (2015). Phytosociology of weeds associated with rice crops in the department of Tolima, Colombia. *Agronomia Columbiana* 33(1): 1-11.
 11. Rao A.N. and Nagamani A. (2010). Integrated weed management in India-Revisited. *Indian journal of weed science* 42(3&4): 123-135.
 12. Rao R.R. and Murugan R. (2006). Impact of exotic adventives weeds on native biodiversity in India: Implications for conservation. In: *Invasive alien species and biodiversity in India* (Eds. Rai LC and Gaur JP). Banaras Hindu University, Varanasi 93-109.
 13. Reddy C.S. (2008). Catalogue of invasive alien flora of India. *Life science journal* 5(2): 84-89.
 14. Roberts D.W. (1989). A dynamical systems perspective on vegetation theory. *Vegetation*, 69: 27-33.
 15. Singh K.P., Shukla A.N. and Singh J.S. (2010). State level inventory of invasive alien plants, their source region and use potential. *Current science*, 99(1): 107-114.
 16. Sinha M.K. (2017). Studies on weed diversity in Korla District (C.G.) in India. *Advances in Plant and Agriculture Research*, 7(2): 246-252.
 17. Warger, M.J.A. and Marrel E. (1978). The Braun-Blanquet approach. In: *Ordination and Classification of Plant communities* (Ed. Whittaker RH). 2nd edition The Hague: Dr. W. Junk. Pp. 287-399.



Effect of Integrated Nutrient Management on Growth, Yield and Quality of Tissue Cultured Banana cv. Grand Naine

Satya Veer, A.K. Dwivedi, Akash Shukla, Shubham Gupta and Sangam Kumar

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur-208002 (U.P.)

Email : akashshukla503@gmail.com

Abstract

The present investigation was conducted in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology Kanpur (U.P.) India, during the cropping season 2019-20. The experiment was laid out in Randomized Block Design with three replications and nine treatments. It was recorded that the pseudostem height at shooting (148.90 cm), pseudostem girth at shooting (64.50 cm), total number of leaves per plant (27.68), number of functional leaves at the emergence of inflorescence (11.95), length of inflorescence (114.10 cm), number of days from planting to flowering (253.64 days) and number of days from flowering to harvesting (126.95 days) as compared to others was maximum in the plants supplied with 100% RDF of NPK + 50g *Azospirillum* + 50g PSB per plant. The same treatment also results in maximum bunch weight (21.95 kg), number of fingers per bunch (153.10), number of hands per bunch (6.83) and number of fingers per hand (17.15), finger weight (145.96 g), finger length (17.59 cm), finger diameter (12.73 cm), TSS (20.43 °Brix), titratable acidity (0.43%) and total sugars (18.15%).

Key words : Banana, NPK, *Azospirillum*, PSB, growth, yield and quality.

Introduction

Banana (*Musa* spp.) is one of the important fruit crops of the tropics. Banana, the world's largest monocotyledonous, monoecious, monocarpic, perennial herb belongs to the family *Musaceae* originated in Asia. India is the largest producer of banana contributing 25.58% of world production. In India total area under banana cultivation is 883.77 million hectares with a production of 30807.50 million tonnes and productivity is 37mt ha⁻¹. Among all the fruits, banana is plentiful, most nourishing and relatively a cheaper source of nearly all essential nutrients including vitamins and minerals and a rich source of energy. It provides a more balanced diet containing a sufficient amount of carbohydrates and nearly all the essential nutrients including minerals, vitamins. By nature, banana is a heavy consumer of nutrients and requires large quantities of nutrients for its growth, development and yield. The requirements of these nutrients are generally supplied by inorganic fertilizers. But this often results in extremes situations for the soil, crop and climate involved. The soil has lost its biological dynamic owing to repeated and indiscriminate use of chemical fertilizer. Integrated nutrient management (INM) was found to be beneficial for the maintenance of soil fertility and plant nutrient supply to an optimum level, for sustaining desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. The basic principle of INM is the maintenance of soil fertility, sustainable agricultural productivity. Nitrogen-fixing bacteria and phosphate

solubilizers are the main bio-fertilizers for horticultural crops. These micro-organisms are either free-living in the soil or symbiotic with plants and contribute directly or indirectly towards the nitrogen and phosphorus nutrition of plants. When the bio-fertilizers such as *Azospirillum* and PSB are used in crop as a soil application, then there was a significant increase in yield of crop occurs with lower soil pH and make the dissolution of bound forms of phosphate to available form.

Materials and Methods

The present experiment was conducted in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) India, during the cropping season 2019-20. The planting was done at a spacing of 2.5 m x 2.5 m on 15th September, 2019. The application of NPK (110 + 30 + 330g NPK), bio-fertilizer (*Azospirillum* 50 gm) and PSB 50gm were done at the time of planting following the treatment schedule. The experiment was laid out in Randomized Block Design with three replications and nine treatments, viz., T₀-Control (without fertilizers and bio-fertilizers), T₁-75% RDF of NPK, T₂-75% RDF of NPK + 50g *Azospirillum*, T₃-75% RDF of NPK + 50g PSB, T₄-75% RDF of NPK + 50g *Azospirillum* + 50g PSB, T₅-100% RDF of NPK, T₆-75% RDF of NPK + 50g *Azospirillum*, T₆-100% RDF of NPK + 50g *Azospirillum*, T₇-100% RDF of NPK + 50g PSB and T₈-100% RDF of NPK + 50g *Azospirillum* + 50g PSB. The observation regarding on vegetative, reproductive, as well as yield and quality attributes were made accordingly.

Table-1 : Effect of Integrated Nutrient Management on vegetative characters of tissue cultured banana cv. Grand Naine.

Treatment	Pseudostem height at shooting (cm)	Pseudostem girth (cm)	Total number of leaves per plant	Number of functional leaves per plant at the time of emergence of inflorescence
T ₀	126.45	53.93	22.63	9.15
T ₁	130.40	55.61	23.35	9.50
T ₂	134.15	57.21	24.10	9.75
T ₃	136.65	58.30	24.51	9.95
T ₄	137.15	58.51	24.65	9.98
T ₅	138.80	59.20	24.85	10.05
T ₆	140.45	59.90	25.15	10.20
T ₇	143.15	61.10	25.65	10.42
T ₈	148.90	64.50	27.68	11.95
SEm	2.50	0.80	0.60	0.23
CD at 5%	7.49	2.42	1.81	0.69

Table-2 : Effect of Integrated Nutrient Management on reproductive characters of tissue cultured banana cv. Grand Naine.

Treatment	Length of inflorescence (cm)	No. of days from planting to flowering	No. of days from flowering to harvesting	Bunch weight (kg)	Number of fingers per bunch	Number of hands per bunch	Number of fingers per hand	Finger weight (g)
T ₀	87.37	262.45	131.35	16.81	117.25	5.23	13.13	111.75
T ₁	90.73	256.85	128.55	17.45	121.71	5.44	13.65	116.18
T ₂	93.15	256.25	128.25	17.91	124.92	5.57	14.00	119.15
T ₃	95.05	256.60	127.90	18.30	127.64	5.70	14.35	122.13
T ₄	95.39	254.95	127.65	18.45	128.68	5.81	14.45	122.98
T ₅	95.96	259.15	129.70	18.46	129.42	5.77	14.45	122.98
T ₆	97.40	258.10	129.15	18.75	130.78	5.86	14.70	125.11
T ₇	99.51	257.25	128.70	19.15	133.57	5.95	14.96	127.33
T ₈	114.10	253.64	126.95	21.95	153.10	6.83	17.15	145.96
SEm	1.34	1.54	0.43	0.42	1.75	0.21	0.44	0.21
CD at 5%	4.03	4.62	1.31	1.26	5.25	0.63	1.32	6.34

Results and Discussion

Vegetative characters : A perusal data in Table-1 shows the height and girth of pseudostem were increased significantly with the use of an integrated dose of nutrients along with bio-fertilizers. The maximum height (148.90 cm) and girth (64.50 cm) of pseudostem were obtained with the application of 100% RDF of NPK +50g *Azospirillum* + 50g PSB per plant (T₈). The height and girth of pseudostem get reduced with the reduction in doses of different levels of chemicals and bio-fertilizer and they were the minimum under control (T₀) (126.45cm and 53.93cm, respectively). These results are in close conformity with the finding of Kumar *et al.*, (2008), Hazarika *et al.*, (2011), and Nayyer *et al.*, (2014), in bananas and Tripathi *et al.*, (2010) in strawberry.

The Significantly maximum number of leaves (27.68) and number of functional leaves per plant (11.95) at the time of emergence of inflorescence were produced in the plants treated with 100% RDF of NPK +50g *Azospirillum* + 50g PSB per plant (T₈). Whereas, the minimum number of leaves and number of functional leaves per plant at the

time of emergence of inflorescence (22.63 and 9.15 respectively) were recorded under control (T₀). These findings are in complete agreement with that of Hazarika *et al.*, (2011), and Nayyer *et al.*, (2014), Gogoi *et al.*, (2004) in banana.

Reproductive characters : A perusal data in Table-2 shows the maximum length of inflorescence (114.10 cm) was recorded in the plants which were fertilized with 100% RDF of NPK +50g *Azospirillum* + 50g PSB per plant (T₈). However, the minimum length of inflorescence (87.37 cm) was recorded in the plants under control (T₀). The minimum number of days taken from planting to flowering was recorded in the plants which were treated with 100% RDF of NPK +50g *Azospirillum* + 50g PSB per plant (T₈) (253.64 days), whereas, the maximum number of days (262.45 days) taken for flowering were recorded in control (T₀). These findings are in line with the findings of Hazarika *et al.*, (2011), and Nayyer *et al.*, (2014), Tripathi (2017) in banana.

The present investigation that the minimum number of days (126.95 days) taken from flowering to harvesting

Table-3 : Effect of Integrated Nutrient Management on quality characters of tissue cultured banana cv. Grand Naine.

Treatment	Finger length (cm)	Finger diameter (cm)	Total soluble solid ($^{\circ}$ Brix)	Titrateable acidity	Total sugar (%)
T ₀	13.47	9.75	15.65	1.12	15.41
T ₁	14.01	10.14	16.27	0.78	15.89
T ₂	14.36	10.39	16.68	0.74	16.35
T ₃	14.72	10.65	17.09	0.72	16.66
T ₄	14.85	10.75	17.26	0.70	16.72
T ₅	14.82	10.73	17.22	0.91	16.92
T ₆	15.08	10.92	17.53	0.85	17.12
T ₇	15.35	11.11	17.83	0.81	17.45
T ₈	17.59	12.73	20.43	0.43	18.15
SEm+	0.59	0.33	0.59	0.02	0.07
CD at 5%	1.78	0.99	1.78	0.06	0.23

were recorded in the plants which were treated with 100% RDF of NPK +50g *Azospirillum* + 50g PSB per plant (T₈). However, the maximum number of days (131.35 days) taken from flowering to harvesting were recorded in the control plants (T₀). These results have got the support with the findings of Tripathi *et al.*, (2014a), Tripathi *et al.*, (2015b), who also got an advanced duration of harvesting (earliness) by approximately one month which extended the period of harvesting by the application of *Azotobacter*, PSB and vermicompost in strawberry. A similar result was reported in Tripathi *et al.*, (2010), Tripathi *et al.*, (2016) in strawberry and Singh and Tripathi (2020a) in papaya, Nayyar *et al.*, (2014), Tripathi (2017) in banana.

The maximum bunch weight (21.95 Kg) and fingers weight (145.96 g) were recorded in the plants fertilized with the 100% RDF of NPK +50g *Azospirillum* + 50g PSB (T₈). Whereas the minimum bunch weight (16.81 Kg) and finger weight (111.75 g) was recorded from the untreated control plants (T₀). These findings are in line with the findings of Hazarika *et al.*, (2011) and Nayyar *et al.*, (2014), Tripathi (2017) in banana.

The maximum number of hands (6.83), number of fingers per hand (17.15) and fingers per bunch (153.10) was recorded when the plants were fertilized with 100% RDF of NPK +50g *Azospirillum* + 50g PSB closely followed by 100% RDF of NPK + 50g PSB (T₇) (5.97, 14.96 and 133.57 respectively). However, minimum number of hands (5.23), fingers per hand (13.13) and fingers per bunch (117.25) were recorded under control (T₀). These findings are in line with the findings of Hazarika *et al.*, (2011), and Nayyar *et al.*, (2014), Tripathi (2017) in banana.

Quality characters : A perusal data in Table-3 shows the maximum finger length (17.59 cm) and diameter (12.73 cm) were recorded in the plants fertilized with 100% RDF of NPK + 50g *Azospirillum* +50g PSB (T₈) followed by 100% RDF of NPK + 50g PSB (T₇), whereas, the minimum

values (13.47 cm) and diameter (9.75 cm) were recorded under control (T₀). The results are in accordance with the finding of Kumar *et al.*, (2015) in guava, Nayyar *et al.*, (2014), Tripathi (2017) in banana, Gupta and Tripathi (2012), Tripathi *et al.*, (2014a), Tripathi *et al.*, (2015b), Katiyar *et al.*, (2012) in ber, Singh and Tripathi (2020a) in papaya.

In the present investigation, it was observed that the TSS and total sugars content of fingers were significantly increased by different levels of chemical and bio-fertilizers applications. The maximum TSS (20.43 $^{\circ}$ Brix) and total sugars (18.15%) contents were recorded in the fingers produced from the plants fertilized with 100% RDF of NPK + 50g *Azospirillum* +50g PSB (T₈) followed by 100% RDF of NPK + 50g PSB (17.83 $^{\circ}$ Brix and 17.45%, respectively), treated plants whereas the minimum contents (15.65 $^{\circ}$ Brix and 15.41%, respectively) were under control. These findings are in agreement with the results of Tripathi *et al.*, (2010), Mishra and Tripathi (2011) in strawberry, Katiyar *et al.*, (2012) in ber, Tripathi *et al.*, (2015a) in aonla, Tripathi (2017) in banana, Singh and Tripathi (2020b) also reported that the application of vermicompost with 100% NPK resulted in maximum TSS, total sugars and reduction in titrateable acidity of papaya fruit.

The maximum titrateable acidity (1.12%) was recorded in the finger produced from the unfertilized plants (T₀), whereas, the minimum acidity (0.43%) was recorded at 100% RDF of NPK + 50g *Azospirillum* +50g PSB (T₈) treated plants. The view was corroborated with the observations of Attia *et al.*, (2009), Nayyar *et al.*, (2014), Tripathi (2017) in banana and Singh and Tripathi (2020a) in papaya.

Conclusions

It is concluded that plants fertilized with 100% RDF of NPK + 50g *Azospirillum* + 50g PSB per plant significantly increased the growth, yield and quality characters, on the basis of these observations this can be suggested that for

getting substantial higher growth, yield and quality fingers, the tissues cultured plants of banana cv. Grand Naine should be fertilized with 100% RDF of NPK + 50g *Azospirillum* + 50g PSB as soil application in the plains of central Uttar Pradesh, India.

References

1. Attia, M.; Ahmed, M.A. and M.R. El-Sanbaty (2009). Use of biotechnologies to increase growth, productivity and fruit quality of Moghrabi banana under different rates of phosphorous. *World Journal of Agricultural Science*, 5 (2): 211-220.
2. Gogoi, D., Kotoky, U. and Hazarika, S. (2004). Effect of bio-fertilizer on productivity and soil characteristics in banana. *Indian Journal Horticulture*, 61: 354-56.
3. Gupta, A.K. and Tripathi, V.K. (2012). Efficacy of *Azotobacter* and vermicompost alone and in combination on vegetative growth, flowering and yield of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler. *Progressive Horticulture*, 44 (2): 256-261.
4. Hazarika, T.K., Nautiyal, B.P. and Bhattacharya, R.K (2011). Effect of INM on productivity and soil characteristics of tissue cultured banana cv. Grand Naine. *Progressive Horticulture*, 43 (1): 30-35.
5. Katiyar, P.N., Tripathi, V.K., Sachan, R.K., Singh, J.P. and Chandra, Ram (2012). Integrated Nutritional Management Effects on The Growth, Flowering, Fruiting and Yield of Rejuvenated Ber (*Zizyphus mauritiana* Lamk.) cv. Banarasi Karaka. *Hort Flora Research Spectrum*, 1 (1): 38-41.
6. Kumar, A., Tripathi, V.K., Dubey, A.K., Dubey, V. (2015). Effect of Integrated Nutrient Management on Fruits Set, Yield and Physico-Chemical Parameters of Winter Season Guava (*Psidium guajava* L.) cv. L-49. *Progressive Research-An International Journal*, 10 (Special-VII): 3722-37240.
7. Kumar, D., Pandey, V. and Anjaneyulu, K. (2008). Effect of planting density and nutrient management on growth, yield and quality of micro propagated banana cv. Rasthali (AAB-Pathkapoor). *Indian Journal of Horticulture*, 65: 272-76.
8. Mishra, A.N. and Tripathi, V. K. (2011). Influence of different leaves of *Azotobacter*, PSB alone and in combination on vegetative growth, flowering, yield and quality of strawberry cv. Chandler. *International J. Applied Agriculture Research*, 6 (3): 203-210.
9. Nayyer, M. A., Tripathi, V.K., Kumar, S., Deepa, Lal and Tiwari, B. (2014). Influence of Integrated Nutrient Management on Growth, Yield and Quality of Tissue Cultured Banana (*Musa x paradisiaca*) cv. Grand Naine. *Indian Journal Agricultural Science*, 84 (6): 680-683.
10. Singh A. and Tripathi V.K. (2020a). Influence of Integrated Nutrient Management on flowering, fruiting, yield, quality parameters of papaya (*Carica papaya* L.). *International Journal of Agriculture Sciences*, 12 (18): 10194-10197.
11. Singh A. and Tripathi V.K. (2020b). Influence of Integrated Nutrient Management on growth, yield and quality parameters of papaya (*Carica papaya* L.). *Journal of Pharmacognosy and Phytochemistry*, 9 (5): 2022-2026.
12. Tripathi, V.K. (2017). Influence of Integrated Nutrient Management in Ratoon Crop of Tissue Cultured Banana. *Progressive Research-An International Journal*, 12 (Special-IV): 2577-2580.
13. Tripathi, V.K., Kumar, S. and Gupta, A.K. (2015b). Influence of *Azotobacter* and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. *Indian Journal of Horticulture*, 72 (2): 201-205.
14. Tripathi, V.K., Kumar, S., Kumar, K., Kumar, S., Dubey, V. (2016). Influence of *Azotobacter*, *Azospirillum* and PSB on vegetative growth, flowering, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, 48 (1): 49-53.
15. Tripathi, V.K., Mishra, A.N., Kumar, S., Tiwari, B. (2014a). Efficacy of *Azotobacter* and PSB on Vegetative Growth, Flowering, Yield and Quality of Strawberry cv. Chandler. *Progressive Horticulture*, 46 (1): 48-53.
16. Tripathi, V.K., Bahadur, S., Dubey, V. and Kumar, A. (2015a). Influence of Integrated Nutrient Management on Yield and Physicochemical Parameters of Aonla cv. Na-7. *Progressive Research-An International Journal*, 10 (Special-VI): 3493-3496.
17. Tripathi, V.K., Kumar, N., Shukla, H.S. and Mishra, A.N. (2010). Influence of *Azotobacter*, *Azospirillum* and PSB on growth, yield and quality of strawberry cv. Chandler. In *National Symposium on Conservation Horti.*, from March, 21-23, 2010 at Dehradun, pp: 98-99.



Breeding for White Rust Resistance in Indian Mustard (*Brassica juncea* L.)—A Review

B.L. Meena*, H.S. Meena and H.K. Sharma

ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan

Corresponding authors Email : blmeena.icar@gmail.com

Abstract

In India, rapeseed-mustard (*Brassica species*) are placed at second position in total acreage (23.91 per cent) and production (27.19 per cent) after soybean among oilseeds crops. There are three ecotypes of *Brassica* ($2n = 20$) i.e. *Brassica campestris* ssp. *Oleifera* viz., yellow sarson, brown sarson and toria, collectively called rape (syn. *B. rapa* L.), *B. juncea* or brown mustard ($2n = 36$) and *Eruca sativa* or Taramira ($2n = 22$) are commercially cultivated. Among these, Indian-mustard (*Brassica juncea*) accounts for >80 per cent of the area under rapeseed-mustard crops in the country. Breeding system for a crop species mainly depends upon its mode of pollination. Therefore, in plant breeding, breeders need to be aware of the existing genetic variability in terms of nature and magnitude, and wild relatives of a crop species, its reproductive behavior, adaptation to environments and cropping systems, and usage for the objective and methods chosen for its genetic improvement. The effectiveness and efficiency of selection is greatly advanced when the magnitude and nature of genetic variation is understood, and rapid and reliable screening techniques are available.

Introduction

The family Brassicaceae includes 338 genera and 3709 species (Warwick *et al.*, 2006) comprising crops, weeds and ornamental plants (Love *et al.*, 2005). In this family, there exists a vast diversity of economically important crop forms that are the major source of edible and non-edible oil, vegetable, forages, fodder and condiments. In the genus *Brassica* of the family Brassicaceae, rapeseed-mustard play an important role in human and animal diet, and generally crushed to yield oil (vegetable oil for cooking) and residual protein-rich meal, which is used mainly for animal feed. In India, rapeseed-mustard (*Brassica species*) are placed at second position in total acreage (23.7 per cent) and production (26 per cent) after soybean among oilseeds crops. In India, three ecotypes of *Brassica* ($2n = 20$) i.e. *Brassica campestris* ssp. *Oleifera* viz., yellow sarson, brown sarson and toria, collectively called rape (syn. *B. rapa* L.), *B. juncea* or brown mustard ($2n = 36$) and *Eruca sativa* or Taramira ($2n = 22$) are commercially cultivated. Among these, Indian-mustard (*Brassica juncea*) accounts for nearly 75-80 per cent of the area under rapeseed-mustard crops in the country. Although, the breeding system for a crop species mainly depends upon its mode of pollination. Therefore, in plant breeding, breeders need to be aware of the centre of origin, existing genetic variability in terms of nature and magnitude, and wild relatives of a crop species, its reproductive behavior, adaptation to environments and cropping systems, and usage for the objective and methods chosen for its genetic improvement. Oilseed Brassicas include a number of crop species ranging from completely cross-pollinated (diploid cultivated species) to self-pollinated (tetraploid species). However, self-

pollinated species also behave as often cross-pollinated species with cross pollination to an extent of 14-30 per cent due to the stray pollen contamination and visit by various types of bees particularly honey bees (Rai and Singh, 1976; Rakow and Woods, 1987; Chauhan and Kumar, 1991). Here, we will emphasize primarily on the breeding of Indian mustard (*Brassica juncea*) for disease resistance.

Centre of Origin of *Brassica juncea* : Although the centre of origin of *B. juncea* is not entirely clear, but it is believed to have been derived from natural interspecific hybridization between *B. nigra* ($n=8$) and *B. rapa* ($n=10$), since, *B. juncea* is an amphidiploid with a chromosome number of $2n = 36$. Several views have been expressed for the centre of origin of *B. juncea*. According to Prakash and Hinata (1980) the species originated in the middle-east Asia and neighboring regions where distributions of *B. nigra* and *B. rapa* overlap. Contrarily, Hemingway (1976) argued that *B. juncea* has probably arisen by hybridization between different *B. campestris* and *B. nigra* genotypes at several different times and localities resulting in secondary centres of origin in China, northeastern India and the Caucasus. Recently, Spect and Diederichsen (2001) support the view that *B. juncea* probably evolved somewhere between Eastern Europe and China, where the progenitor species are sympatric. Although, *B. juncea* species occurs in the temperate as well as tropical regions of the world such as a weed in the south of the European part of Russia, the Caucasus, central Asia and southern Siberia and as a casual or feral plant in south and southeast Asia, Africa and America.

Cytological analysis of chromosome pairing in the progeny of interspecific crosses has clearly established

that the three species with higher chromosome numbers are amphidiploids, derived from the mongenomic or diploid species (U, 1935) (Figure-1).

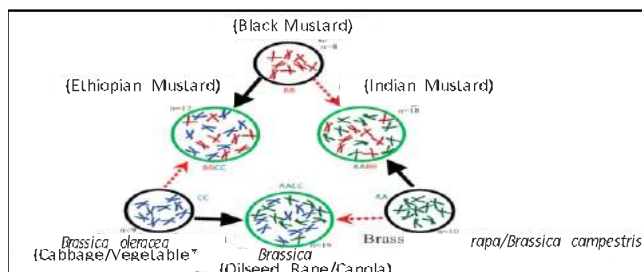


Fig.-1 : The "Triangle of U" Diagram, Showing the Genetic.

Relationships

Among Species of the Genus *Brassica*. Chromosomes from each of the genomes A, B and C are represented by different colors. Black and green circles represent diploids and allopolyploids species, respectively. Black (Solid) and Red (broken) arrows in the allopolyploid represent female and male parents, respectively.

The adaptation of improved genotypes of different maturity groups to such systems as; early, medium or full maturity is an important objective in Indian mustard improvement. In addition, comprehensive understanding of different plant attributes such as appropriate duration, rapid early growth, total biomass production and/or high harvest index, and resistance to biotic and abiotic stresses peculiar to the region are specifically needed to realize yield gains and stability. Some objectives will be common across systems but others will be region specific. Major objectives relevant to Indian mustard growing regions are given in Table 1. The effectiveness and efficiency of selection is greatly advanced when the magnitude and nature of genetic variation is understood, and rapid and reliable screening techniques are available.

Breeding Objectives : Increased seed yield with acceptable seed quality and stability in yield performance across environments is the major breeding objective not only in Indian mustard but also in all crop improvement programmes. Stability in production is sought by incorporating resistance or tolerance to major biotic stresses, such as diseases like Alternaria blight [*Alternaria brassicae* (Berk.) Sacc.], white rust [*Albugo candida* (Pers. Ex Lev.) Kuntze], powdery mildew [*Erysiphe cruciferarum*] and Sclerotinia rot [*Sclerotinia sclerotiorum* (Lib.) de Bary] and the insect pests like mustard aphid [*Lipaphis erysimi*], painted bug [*Bagrada cruciferarum* [*Bagrada hilaris*]], sawfly [*Athalia lugens proximo*], pea leaf miner [*Chromatomyia horticola*] and flea beetle [*Phyllotreta cruciferae*]], parasitic weeds (broomrape [*Orobanche*]) and such abiotic stresses as

frost, early or terminal heat, drought, acid, and saline toxicity.

At national level, Indian-mustard is grown in a diverse array of cropping systems. Therefore, it requires the nomination of clear objectives with respect to general and/or specific adaptation of the crop to the existing or new cropping systems. White rust, caused by *Albugo candida*, is an economically important disease of Indian mustard (*B. juncea*), particularly in India. The disease is characterized by two types of symptoms. Initially isolated white pustules or blisters are formed on the leaves and often appear in a circular arrangement around a big central pustule. In later stages, the young stem, inflorescence, floral parts and young siliques will be infected. The pathogen becomes systemic in infected tissues and causes various types of malformations with prominent hypertrophy and hyperplasia that appears swellings or distortions and finally form "stagheads". These malformations and deformities are the result of hormonal imbalance induced by the pathogen.

Specialized races of *A. candida* are recognized that attack on specific host species. Biological races 1 and 2 are reported from Kangra Valley in Himachal Pradesh. Eleven pathotypes have been reported on different species in North America, which are AC1 (*Raphanus sativus*), AC2 (*Brassica juncea*), AC 2V (*B. nap us*), AC3 (*Armoracia rusticana*), AC4 (*Capsella bursa-pastoris*), ACS (*Symbrium officinale*), AC6 (*Rorippa islandica*), AC7 (*Brassica rapa*), AC7V (*Bras sica rapa* cv. Reward), ACS (*Brassica nigra*), AC9 (*B.oleracea*), AC10 (*Sinapis alba*) and AC11 (*Brassica carinata*). Two additional pathotypes AC12 (*Brassica juncea*) and AC13 (*B rapa* var Toria) were reported from India. Nine of 11 reported from North America also exist in India (Verma *et al.*, 1999). Four new distinct pathotypes AC-14, AC-15, AC-16 and AC-17 have been reported by Gupta and Saharan (2002) based on differential interaction of 11 host differentials. Kaur *et al.* (2011) collected *A. candida* isolates from *B. juncea*, *B. rapa*, *B. oleracea*, *B. tournefortii*, *Raphanus raphanistrum*, *R. sativa*, *Eruca vesicaria* subsp. *sativa*, *Capsella bursa-pastoris* and *Sisymbrium irio* from different locations in Western Australia (W.A.) to characterize their pathogenicity on different cruciferous host differentials. They reported a new distinct pathogenic strain within race 7 infecting *B. rapa* that had characteristics different from races 7A or 7V. The strains from *B. tournefortii* and *S. irio* being highly host specific, failing to be pathogenic on any other differentials. *B. tournefortii* was host to a strain attacking *B. juncea* and *E. vesicaria* subsp. *sativa*. The strain from *R. raphanistrum* showed a relatively wide host range among the differentials tested. The *B. oleracea* isolate (race 9) was pathogenic to *B. juncea* 'Vulcan' while isolate from *B.*

juncea (race 2V) was not pathogenic on *B. oleracea*. Further, the strain from *C. bursa pastoris* (race 4) was pathogenic on *B. juncea* Vulcan but *B. juncea* strain was not pathogenic on *C. bursa pastoris*. In contrast, the strain from *R. sativus* (race 1) was pathogenic on *B. juncea* and the *B. juncea* strain was also pathogenic on *R. sativus*. Field isolates from *B. rapa*, *B. tournefortii*, *E. vesicaria* subsp. *sativa*, and *S. irio* were all nonpathogenic on *B. juncea*. Isolates from *B. juncea* and *R. raphanistrum* were pathogenic on *B. napus* (FAN 189). The study highlighted the pathogen (*A. candida*) diversity and the particular crucifer weeds involved in pathogen inoculum carryover between successive Brassica crops.

White Rust Resistance : The major challenge in breeding for white rust resistance in Brassicas is the prevalence of large number of pathotypes of *Albugo* parasitizing different cruciferous species (Pound and Williams, 1963 and Liu et al., 1996). Race 2 of *A. candida* infects *B. juncea* (Lakra and Saharan, 1988 and Petrie, 1988). Genetic analysis of available white rust resistance through biometrical techniques has revealed a digenic mode of inheritance with duplicate gene action in *B. napus* (Verma and Bhowmik, 1989 and Fan et al., 1983) and monogenic dominant resistance in *B. juncea* (Tiwari et al., 1988; Bansal et al., 1999 and Sachan et al., 2000) as well as in *B. rapa*, *B. carinata* and *B. nigra* (Delwiche and Williams, 1974 and 1981).

Inheritance of white rust (*Albugo candida*, race 2) resistance in Indian mustard (*Brassica juncea*) was studied by Tiwari et al. (1988) using crosses between one resistant and two susceptible cultivars. The reaction of F₁ (all resistant) and segregation of resistant and susceptible plants in F₂ (3: 1) and backcrosses (1: 1) indicated the resistance as dominant monogenic and controlled by nuclear genes and can be easily transferred to adapted susceptible genotypes via backcrossing.

Vignesh et al. (2009) investigated the mode of inheritance using indigenously developed resistance source and allelic relationship of genes for white rust resistance in two different sources viz., Bio-YSR (*Brassica juncea*) and NPC-12 (*B. carinata*). The inheritance of resistance in donors when crossed with two highly susceptible cultivars, Varuna and Bio-902 indicated the presence of a single dominant gene for white rust resistance. The cross between two resistant sources from *B. juncea* and *B. carinata* segregated in 15:1 (resistant: susceptible) ratio in F₂ indicated the involvement of two different genes governing white rust resistance in these sources. Adhikari et al. (2003) reported a avirulence gene AvrAcl in *A. candida* and suggested that a single dominant gene controls avirulence in race AC 2 to *B. rapa* cv. Torch.

Changes in race composition of pathogen have often resulted in short-lived efficiency of host resistance in improved cultivars. Therefore, it is necessary to identify new sources of white rust resistance for durable resistance. White rust resistant donor Bio-YSR has been developed in *B. juncea* which is better under Indian conditions can be utilized in breeding programmes. Some new white rust resistant genotypes of *B. juncea* viz., DRMR 2019 and DRMR 2035 has been developed at ICAR-DRMR, Bharatpur and registered by NBPGR, New Delhi.

Breeding Methods : The effort has also been made through inter-specific hybridization between *B. juncea* and *B. carinata* to transfer white rust resistance into well adapted high yielding back-ground of *B. juncea* from *B. carinata* through pedigree selection. The monogenic resistance with complete dominance in *B. carinata* could be partially introgressed into *B. juncea* cultivars through selection of disease-free plants in segregating gene-rations grown under heavy disease pressure and repeated back crossing. With the use of resistant gene (L 6) from Canada, many white rust resistance lines have been developed in the genetic background of high yielding varieties. The varieties Basanti, JM-1, JM-2 and JM-3 have been released for general cultivation in white rust prone areas of India.

Molecular Studies : In the genus Brassica, molecular mapping of genes has been reported for various traits like seed coat colour, growth habit, oil content, fatty acid content and resistance to diseases, including white rust (Quiros et al., 2001; Lakshmikumaran et al., 2003). Sources of resistance against white rust are available in east European *B. juncea* gene pool. Genetic analysis of white rust resistance in *B. juncea* has been undertaken at the molecular level to locate gene/s and to identify markers for marker-assisted introgression of the traits using RFLP (Cheung et al., 1998), RAPD (Prabhu et al., 1998; Mukherjee et al., 2001), AFLP (Somers et al., 2002), CAPS (Varshney et al., 2004) and IP markers (Panjabi-Massand et al., 2010). A locus (ACAI) controlling resistance to white rust has been mapped in *B. napus* (Ferreira et al., 1995) and *B. rapa* (Kole et al., 1996), using restriction fragment length polymorphism (RFLP) markers.

Tanhuanpaa (2004) tagged a locus for white rust resistance in a F₂ population of *Brassica rapa* ssp. *oleifera* employing bulked segregant analysis with random amplified polymorphic DNA (RAPD) markers, linkage mapping and a candidate gene approach based on resistance gene analogs (RGAs) using Finnish line Bor4109 as resistance source. The reaction against white rust races 7a and 7v was scored in 20 seedlings in F₂ The

proportion of resistant plants among F_3 families varied from 0 to 67 per cent. Bulk segregant analysis did not reveal any markers linked with resistance, thus a linkage map with 81 markers was created. A locus accounting for 18.4 per cent of the variation in resistance for white rust was mapped to linkage group (LG) 2 near the RAPD marker Z19a. During the study, a bacterial resistance gene homologous to *Arabidopsis* RPS2 and six different RGAs were sequenced. RPS2 and five of the RGAs were mapped to linkage groups LG1, LG4 and LG9. Unfortunately, none of the RGAs could be shown to be associated with white rust resistance. Singh *et al.* (2015) effectively applied the already identified *Arabidopsis*-derived intron polymorphic (IP) markers At5g41560 and At2g36360, which were highly linked with AcB1-A4.1 and AcB1-A5.1, respectively and validated in a set of 25 genotypes of Indian Mustard and three F_2 populations. The relationships between the variation of PCR products of the two markers with the percent disease index (PDI) of the tested genotypes, and the co-segregation analysis of the markers with disease phenotype in F_2 populations clearly indicated that At5g41560 and At2g36360 are genotype-nonspecific markers and are closely linked to white rust resistance loci AcB1-A4.1 and AcB1-A5.1, respectively. It also became evident from the study that AcB1-A4.1 and another white rust resistance locus Ac(2) are likely the same gene locus. These markers can further be used in marker assisted breeding for gene pyramiding.

Screening Techniques : Various screening techniques have been used by various workers for particular disease. However standard methods adopted in All India Coordinated Research Project (rapeseed and mustard) for screening of resistant/ tolerant genotypes against white rust is detailed below

Method of Artificial Inoculation for White Rust : Test plants (including checks) should be inoculated twice *i.e.* at initiation of flowering and pod formation stage. Inoculum may be prepared by collecting fresh zoosporangia from naturally infected leaves with *Albugo candida*. Petri plates containing zoosporangia suspended in distilled water be kept at 4°C for 2 h to facilitate germination of zoosporangia. To assure germination of the sporangia, the plates may be examined under the low power microscope. Germinating zoosporangia would be emptied and zoospores will be visible in the suspension. Suspension containing zoospores be filtered through double layered muslin cloth and further diluted with distilled water for spraying on leaves of test plants. This may be done with the help of atomizer/ small sprayer in the afternoon (after 1500 hrs). Data for disease severity may be recorded 75 DAS/at maximum disease pressure on leaves and 15 days before harvest for staghead.

Observations to be Recorded

1. Date of first appearance of each disease including bacterial rot.

2. Data as percent disease severity /percent disease incidence for WR (75 DAS/at maximum disease pressure), on leaves and pods and number of staghead (15 days before harvest) should be recorded on 10 randomly selected plants from each plot using 0-9 scale.

Staghead formation should be recorded as percent incidence and percent twigs infected. Staghead (per cent twigs affected) = (number of twigs infected/total number of twigs) x 100.

3. Data for WR disease may be recorded as percent disease severity (WR) on leaves/pods

4. Date of each observation should be provided in the data sheet.

5. Data should be statistically analysed as per the design using ANOVA after arc sin transformation. Actual and transformed (in parenthesis) values along with mean, CD ($P < 0.05$) and CV (per cent) are to be submitted for report preparation.

Scale (0-9) for rating of entries for reaction to white rust should be used.

0 (Immune for WR) = No lesion

1 (HR) = Non-sporulating pinpoint size or small brown necrotic spots, less than 5 per cent leaf area covered by lesion

3 (R) = Small roundish slightly sporulating larger brown necrotic spots, about 1-2 mm in diameter with a distinct margin or yellow halo, 5-10 per cent leaf area covered by lesions

5 (MR) = Moderately sporulating, non-coalescing larger brown spots, about 2-4 mm in diameter with a distinct margin or yellow halo, 11-25 per cent leaf area covered by the spots

7 (S) = Moderately sporulating, coalescing larger brown spots about 4-5 mm in diameter, 26-50 per cent leaf area covered by the lesions

9 (HS) = Profusely sporulating, rapidly coalescing brown to black spots measuring more than 6mm diameter without margins covering more than 50 per cent leaf area.

Conclusion

These are exciting times for plant and pathogen research as new tools, particularly at the genomic level, become available and more affordable. Combinations of strategies and collaborative efforts from scientists around the world are required to effectively breed for resistance to *Albugo*

candida. Progress in understanding and manipulating the Brassica-*Albugo candida* system is likely to be useful in other host-pathogen systems and increase our odds to develop durable management strategies.

References

- Adhikari, T.B., Liu, J.Q., Mathur, S., Wu, C.X., and Rimmer, S.R. (2003). Genetic and molecular analyses in crosses of race 2 and race 7 of *Albugo candida*. *Phytopathology*, 93: 959-965.
- Chauhan, Y.S.R. and Kumar, K. (1991) Natural cross pollination in Indian mustard. *Cruciferae Newslett.*, 14/15: 24-25.
- Cheung, W.Y., Gugel, R.K. and Landry, B.S. (1998). Identification of RFLP markers linked to the white rust resistance gene (Acr) in mustard (*Brassica juncea* (L.) Czern. and Coss). *Genome*, 41: 626-628.
- Delwiche, P.A. and Williams, P.H. (1974). Resistance to *Albugo candida* race 2 in *Brassica* Spp. *Proc. Am. Phytopathol. Soc.*, 1: 66.
- Delwiche, P.A. and Williams, P.H. (1981). Thirteen marker genes in *Brassica nigra*. *J. Hered.*, 72: 289-290.
- Fan, Z., Rimmer, S.R. and Stefanson, B.R. (1983). Inheritance of resistance to *Albugo candida* in rape (*Brassica napus* L.). *Can. J. Genet. Cytol.*, 25: 420-424.
- Ferreira, M.E., Williams, P.H. and Osborn, T.C. (1995). Molecular Mapping of a Locus Controlling Resistance to *Albugo candida* in *Brassica napus* using molecular markers. *Phytopathology*, 85: 2018-220.
- Gupta, K. and Saharan, G.S. (2002). Identification of pathotype of *Albugo candida* with stable characteristic symptoms on Indian mustard. *J. Mycol. Pl. Pathol.*, 32: 46-51.
- Hemingway, J.S. (1976). Mustard: *Brassica* spp. And *Sinapis alba* (cruciferae). In:
- N.W. Simmonds (ed.), *Evolution of crop plants*. Longmans, London, UK, pp. 56-59.
- Kaur, P., Sivasithamparam, K. and Barbetti, M. J. (2011). Host range and phylogenetic relationships of *Albugo candida* from cruciferous hosts in Western Australia, with special reference to *Brassica juncea*. *Plant Dis.*, 95: 712-718.
- Kole, C., Teutonico, R., Mengistu, A., Williams, P.H. and Osborn, T.C. (1996). Molecular mapping of a locus controlling resistance to *Albugo candida* in *Brassica rapa*. *Phytopathology*, 86: 367-369.
- Lakra, B.S. and Saharan, G.S. (1988). Morphological and pathological variations in *Albugo candida* associated with *Brassica* species. *Indian J. Mycol. Plant Pathol.*, 18: 149-156.
- Lakshmikumaran, M., Das, S. and Srivastava, P.S. (2001). Application of Molecular Markers in Brassica Coenospecies: Comparative Mapping and Tagging.
- Liu, J.Q., Parks, P. and Rimmer, S.R. (1996). Development of monogenic lines for resistance to *Albugo candida* from a Canadian *Brassica napus* cultivar. *Phytopathol.*, 86: 1000-1004.
- Love, C.G., Robinson, A.J., Lim, G.A.C., Hopkins, C.J., Batley, J., Barker, G., Spangenberg, G.C., Edwards, D. (2005). Brassica ASTRA: an integrated database for Brassica genomic research. *Nucleic Acids Res.*, 33: D656-D659.
- Mukherjee, A.K., Mahapatra, T., Varshney, A., Sharma, R. and Sharma, R.P. (2001). Molecular mapping of a locus controlling resistance to *Albugo candida* in Indian mustard. *Plant Breeding*, 120(6): 483-497.
- Panjabi-Massand, P., Yadava, S.K., Sharma, P., Kaur, A., Kumar, A., Arumugam, N., Sodhi, Y.S., Mukhopadhyay, A., Gupta, V., Pradhan, A.K. and Pental, D. (2010). Molecular mapping reveals two independent loci conferring resistance to *Albugo candida* in the east European germplasm of oilseed mustard *Brassica juncea*. *Theor. Appl. Genet.*, 121: 137-145.
- Petrie, G.A. (1988). Races of *Albugo candida* (white rust and staghead) on cultivated Cruciferae in Saskatchewan. *Can. J. Plant Pathol.*, 10: 142-150.
- Pound, G.S. and Williams P.H. (1963). Biological races of *Albugo candida*. *Phytopathol.*, 53: 1146-1149.
- Prabhu, K.V., Somers, D.J., Rakow, G. and Gugel, R.K. (1998). Molecular markers linked to white rust resistance in mustard *Brassica juncea*. *Theor. Appl. Genet.*, 97: 865-870.
- Quiros, C. F., Grellet, F., Sadowski, J., Suzuki, T., Li, G. and Wroblewski, T. (2001). Arabidopsis and Brassica Comparative Genomics: Sequence, Structure and Gene Content in the *ABI1-Rps2-Ckl* Chromosomal Segment and Related Regions. *Genetics*, 157 (3): 1321-1330.
- Rai, B. and Singh, A. (1976). Commercial seed production in rapeseed. *Ind. Farm* 26: 15-17.
- Rakow, G. and Woods, D.L. (1987) Outcrossing in rape and mustard under Saskatchewan prairie conditions. *Canadian J. Plant Sci.*, 67: 147-151.
- Sachan, J.N., Kolte, S.J. and Singh, B. (2000). Inheritance of white rust (*Albugo candida* race 2) in *Brassica juncea*. *Indian Phytopathol.*, 53: 206-209.
- Saharan, G.S. and Kadian, A.K. (1983). Analysis of components of horizontal resistance in rapeseed and mustard cultivars against *Alternaria brassicae*. *Indian Phytopathol.*, 36: 503-507.
- Singh, B.K., Nandan, D., Supriya, A., Ram, B., Kumar, A., Singh, T., Meena, H.S., Kumar, V., Singh, V.V., Rai, P.K. and Singh, D. (2015). Validation of molecular markers for marker-assisted pyramiding of white rust resistance loci in Indian Mustard (*Brassica juncea* L.). *Can. J. Plant Sci.*, 95: 939-945.
- Somers, D.J., Rakow, G. and Rimmer, S.R. (2002). *Brassica napus* DNA markers linked to white rust resistance in *Brassica juncea*. *Theor. Appl. Genet.*, 104: 1121-1124.
- Spect, C.E. and Diederichsen, A. (2001). Brassica. In: Hanelt, P. (ed) *Mansfeld's Encyclopedia of Agricultural and Horticultural Crops*. 6 vols. Springer-Verlag, Berlin, Heidelberg, New York vol. 3. pp. 1453-1456.
- Tanhuanpaa, P. (2004). Identification and mapping of resistance gene analogs and a white rust resistance locus

- in *Brassica rapa* ssp. *oleifera*. *Theor. Appl. Genet.*, 108: 1039-1046.
31. Tiwari, A.S., Petrie, G.A. and Downey, R.K. (1988). Inheritance of resistance to *Albugo candida* race 2 in mustard [*Brassica juncea* (L.) Czern.]. *Can. J. Plant Sci.*, 68: 297-300.
 32. Varshney, A., Mahapatra, T. and Sharma, R.P. (2004). Development and validation of CAPS and AFLP markers for white rust resistance gene in *Brassica juncea*. *Theor. Appl. Genet.*, 109: 153-159.
 33. Verma, P.R., Saharan, G.S., Bartaria, A.M. and Shivpuri, A. (1999). Biological races of *Albugo candida* on *Brassica juncea* and *B. rapa* var. *toria* in India. *J. Mycol. Pl. Pathol.*, 29: 75-82.
 34. Verma, V. and Bhowmik, T.P. (1989). Inheritance of resistance to a *Brassica juncea* pathotype of *Albugo candida* in *Brassica napus*. *Can. J. Plant Pathol.*, 11: 443-444.
 35. Vignesh, M., Yadava, D.K., Sujata, V., Mahapatra, T., Jain, N., Yadav, A.K., Malik, D., Yadav, M.S. and Prabhu, K.V. (2009). Genetics of white rust resistance in [*Brassica juncea* (L.) Czern. and Coss.] and allelic relationship between interspecific sources of resistance. *Indian J. Genet.*, 69(3): 205-208.
 36. Warwick, S.I., Francis, A. and Al-Shehbaz, I.A. (2006). Brassicaceae: species checklist and database on CD-Rom. *Pl. Syst. Evol.*, 259: 249-258.



Impact of Modern Agro-Techniques on Growth and Yield of Wheat

B.L. Meena¹, R.S. Meena², M.L. Meena¹ and Y.K. Sharma¹

¹College of Agriculture, SKNAU, Lalsot, Dausa, Rajasthan

²Agriculture Research Station, Ganganagar, Rajasthan

Corresponding Author Email : agromeena@gmail.com

Abstract

Modern agro techniques along with rice residue and chemical weed management is the need of hour in the era of 21st century. So, to evaluate the efficiency of herbicides under different rice residue management practices in wheat crop was practiced during the years of 2009-10 and 2010-11. The herbicide treatments included application of sulfosulfuron alone and tank mix Sulfosulfuron 25 g/ha + metsulfuron 4 g/ha and isoproturon 1.0 kg/ha + metsulfuron 4 g/ha. Residue mulching reduced weed density, resulting in improvement of growth and yield attributing characters of wheat followed by residue incorporated and residue retained treatments. Among the different herbicide application, Sulfosulfuron 25 (g/ha) + metsulfuron 4 g/ha was recorded higher, growth, yield attributes and wheat yield; and harvest index followed by isoproturon 1.0 kg/ha + metsulfuron 4 g/ha and sulfosulfuron 25 g/ha. It was concluded that rice residue mulching management was best among the given residue management practices and tank mix application of Sulfosulfuron 25 g/ha + metsulfuron 4 g/ha was best among other treatments in terms of increased wheat yield.

Key words : Modern agro-techniques, rice residue, weed management, wheat crop.

Introduction

Crop production under climate change era is very challenging task to farming community in the country. The rice residue management is most important in present time to protect the natural environment from pollution cause due to burning of straw. Sustainable use of natural resources by utilizing crop residue and managing weeds in wheat crop is critical for farmers because weeds are the most important and crucial factor in agro-eco-system. Modern crop production not only challenging but also the lots of weeds already developed resistance towards chemical management practices. So, an attempt was taken towards sustainability to improve in wheat yield by managing crop residues along with application of modern chemicals. Wheat (*Triticum aestivum* L.) stands second in grain production in the world and most widely cultivated food crop (Maurya *et al.*, 2014). In India, it is second important staple food crop cultivated over an area of 30.54 million hectares with a total production of 94.57 million tones and total productivity of 3370 kg per hectare. Uttar Pradesh has largest share in area with 9.75 million hectare (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%). However, a major expansion in wheat area was observed in the states such as Jharkhand (51%), Madhya Pradesh (27%) and Rajasthan (13%) to all India production of wheat (Ramadas *et al.*, 2019). Rice-wheat cropping system is the predominant cropping system in India. About 400 million tons of crop residues are produced in India alone. In areas where mechanical

harvesting is practiced, a large quantity of crop residues is left in the field which necessitates proper management and utilization of crop residue which can be reused as a source of nutrient supply. Further the burning of crop residue which is a cost-effective method of disposal of residue but it causes harmful effect on the environment which calls for exploring the residue as a means of compost or mulch and eco-friendly options to manage the residues. Crop residues left on the surface can suppress weed seed germination and or seedling growth and complement the effects of herbicide (Crutchfield *et al.*, 1986). Brar *et al.*, (1998) however, observed that there was no significant effect of burning or incorporation of crop residue on the efficiency of butachlor applied to rice and isoproturon applied to wheat in rice-wheat cropping systems (Kumar *et al.*, 2017 and Kumawat *et al.*, 2018).

Weed infestation is also a serious factor in rice-wheat cropping system. Besides the crop rotation (Anderson and Beck, 2007), tillage also influences the type of weed flora. Among grassy weeds, *Phalaris minor* (L.) Retz. and among broad leaved weeds *Rumex detasus* (L.) are of major concern in irrigated wheat under rice-wheat cropping system in India (Balyan and Malik, 2000). Under such situation, combination of grassy and non- grassy herbicides effectively controls the weeds and improve crop yield. Tank mix application of both grassy and broad leaf herbicides such as isoproturon + metsulfuron, sulfosulfuron + metsulfuron and many others have been reported promising to control complex weed flora and resulted in significant increase in wheat yield

when compared with alone application of component herbicides (Meena and Singh, 2011 and Paswan *et al.*, 2017). In addition to influencing the weed growth and population, crop residues management and tillage practices also influence the efficiency of herbicides (Kumar and Goh, 2004 and Yadav *et al.*, 2018). Keeping in the view the above facts, an investigation was planned to study on the response of herbicides under different rice residue management practices in wheat.

Materials and Methods

A research trial was led during winter (*rabi*) of 2009-10 and 2010-11 at the Agricultural Research Farm, Institute of Agricultural Sciences Banaras Hindu University, Varanasi. The eastern indo-gangetic soil was sandy clay loam in texture having pH 7.8 and moderately fertile, organic carbon 0.43 % and available N, P₂O₅ and K₂O was 205.14, 17.46 and 237.34 kg/ha, respectively. The treatment comprised of three rice residue management practices (retained, mulching and incorporation) in main plots and five weed control treatments, viz., weedy, weed free, sulfosulfuron 25 g/ha alone, tank mix Sulfosulfuron 25 g/ha + metsulfuron 4 g/ha and isoproturon 1.0 kg/ha + metsulfuron 4 g/ha in sub plots. The experiment was laid-out in split plot design with four replications. After harvesting of rice, anchored residue to the height of 30 cm were retained and incorporated before sowing of wheat crop. Whereas, the harvested rice residue at the rate of 4.0 tonnes were uniformly spread between crop rows after germination of crop. Wheat cultivar HUW 234 was sown with the help of zero-till seed cum ferti-drill on December during 2009-10 and 2010-11. A uniform fertilizer dose of 120-60-60 Kg N-P-K/ha was applied in the form of urea, single super phosphate and muriate of potash in all the plots. One third nitrogen and full dose of phosphorus and potassium was applied as basal and remaining two thirds was applied in two equal splits at crown root initiation and panicle initiation stages. Existing weed species were destroyed by application of glyphosate at 2 kg/ha (3 days before sowing). In weed free treatment weeds were manually removed with the help of hand hoe (*khurpi*) when appears in crop till the harvest of the crops. Herbicides were applied as post emergence at 32 DAS with the help of hand operated knapsack sprayer, fitted with flat fan nozzle with water as carrier at 600 liters/ha. The heights of ten randomly tagged plants were measured at different successive stages of crop growth with the help of meter scale from base of the plant to the tip of uppermost leaf of the plant before ear emergence and up to the tip of ear head after heading, averaged and expressed in cm starting from 30, 60, 90 DAS and at harvest. The number of tillers were recorded randomly from three places per running meter in each plot at 30, 60, 90 days after sowing

Table-1 : Effect of rice residue management and herbicides on growth attributes at 60 DAS, yield attributes and yield of wheat.

Treatments	Plant height (cm)		Dry matter accumulation (g/plant)		Ear heads/m ²		Test weight (g)		Grain yield (kg/ha)		Biological yield (kg/ha)		Harvest index (%)	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Residue management														
Rice residue retained	69.99	71.06	361.01	362.01	318.25	320.30	40.21	41.11	3630	3835	9243	9650	39.19	39.67
Rice residue mulches	73.76	74.80	364.48	365.51	325.55	327.65	42.06	43.31	4341	4574	10725	11163	40.16	40.68
Rice residue incorporated	73.03	74.07	362.99	364.10	324.00	326.20	41.24	42.22	3919	4107	9857	10250	39.68	40.00
SEM±	0.43	0.43	0.527	0.52	1.10	1.06	0.29	0.31	70	74	119	123	0.51	0.50
CD (P=0.05)	1.50	1.49	1.823	1.81	3.78	3.66	0.99	1.08	243	255	413	424	NS	NS
Weed management														
Weedy check	71.07	72.13	359.38	360.51	315.83	317.92	40.04	40.91	2835	3043	7669	8082	37.07	37.74
Weed free	74.03	75.09	366.10	367.07	327.25	329.17	42.09	43.43	4563	4775	11130	11547	40.9	41.27
Sulfosulfuron	71.43	72.44	361.01	362.08	319.67	322.08	40.72	41.74	3922	4126	9823	10231	39.93	40.33
Sulfosulfuron + metsulfuron	72.82	73.89	364.47	365.52	326.17	328.25	41.66	42.66	4307	4515	10651	11063	40.38	40.74
Isoproturon + metsulfuron	71.94	72.99	363.18	364.19	324.08	326.17	41.33	42.34	4191	4399	10435	10848	40.11	40.51
SEM±	0.38	0.38	0.502	0.51	0.77	0.78	0.21	0.23	50	50	69	69	0.46	0.43
CD (P=0.05)	1.08	1.10	1.441	1.45	2.21	2.22	0.61	0.66	145	144	199	197	1.31	1.24

and at harvest stage and average value was expressed in terms of tillers per metre row length.

Plant samples of half-running meter were taken randomly from sample row in each plot at 30, 60, 90 days after sowing and at harvest stage of crop. Samples were dried in oven at 65°C temperature for 24 hours till the constant weight obtained, the weight of dry sample was expressed in terms of gm per row length. Ear heads were counted randomly at two places in net plot from an area of one meter square in each plot and expressed as average number of ear heads per meter square. Twenty ear-head were randomly selected from tagged plants in each plot and their length (cm) was measured from neck node to tip of the top most spikes and average length was calculated. The grains of twenty selected ear-heads were counted and averaged to get the number of grains/ear heads. One thousand grains were counted from representative sample of each treatment drawn from winnowed and cleaned produce, and their weight expressed in gram. After threshing of net plot area of each treatment, the grain was separated from the straw and cleaned. The grain yield was recorded plot wise, adjusted at 14% moisture level and there after expressed in kg/ha. After threshing of net plot area of each treatment, straw yield was recorded plot wise by subtracting grain yield from bundle weight and thereafter expressed in kg/ha. All above ground plant parts harvested from net plot area were carefully bundled, tagged and taken to the threshing floor separately. The individual bundle was weighed after complete drying in the sun and the biological yield per plot was then converted into kg/ha. The harvest index was computed in term of grain yield expressed as percentage of biological yield (grain + straw) based on the per hectare yields. Harvest index was calculated by dividing economic yield (grain) by biological yield (grain + straw) and multiplied with 100 to express in percent through the following formula

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg / ha)}}{\text{Biological yield (kg / ha)}} \times 100$$

Results and Discussion

Growth parameters : Crop growth attributes data revealed that the plant height and dry matter accumulation were highest in plots having rice residue mulch which was at par with rice residue incorporated and significantly superior to rice residue retained in both years (Table-1). The superiority of rice residue mulch in respect of crop growth parameters can be discussed in light of the fact that this treatment caused maximum reduction in weeds growth resulting in more availability of light, moisture and nutrients than treatments. It is also evident that all the competitive features in crop against weeds were more

prominent in rice residue mulch but least prominent in rice residue retained (Kumar *et al.*, 2017). Among the different weed control treatments, weed free recorded the higher plant height and dry matter in comparisons to other herbicidal treatment in both the years. Combination of sulfosulfuron 25 g/ha + metsulfuron methyl 4 g/ha had recorded more plant dry matter which was at par with isoproturon 1.0 kg/ha + metsulfuron methyl 4 g/ha and significantly superior to sulfosulfuron 25 g/ha which had the lowest dry matter amongst herbicidal treatments. The reason for higher values of growth parameters can be discussed in light of fact that crop under this treatment had comparatively less weed competition for resources which led to more crop growth than other treatments (Kumar *et al.*, 2013 and Kumar *et al.*, 2017).

Yield parameters : Rice residue mulches showed better performance in improving yield attributes viz., number of ear head/m² and test weight that was significantly different from rice residue incorporated and rice residue retained. Grain and biological yield were also found to be highest with rice residue mulch application and significantly different from rice residue retained which was at par with rice residue incorporated. The better performance of yield and yield attributing characters was also reflected in the performance of harvest index, where Rice residue mulches recorded the highest harvest index and it was significantly superior than rice residue retained and statistically similar to rice residue incorporated in both the years. The development of growth attributes is a function of dry matter accumulation by crop and its translocation is important for the formation of yield attributing characters of crop. Similar results were observed by Walia (2002) and Singh *et al.*, (2006). All the weed control treatments significantly outperformed the weedy in respect of yield attributes viz., ear head/m² and test weight and yield. An increase of 61% and 57% in grain yield in first year and 45% 43 in biological yield in second year with weed free over the weedy was observed mainly owing to manual removal of associated weed flora and keeping the plots weed free in first and second years, respectively. Combination of sulfosulfuron 25 g/ha + metsulfuron methyl 4 g/ha showed better performance in improving yield attributes in comparison to sulfosulfuron 25 g/ha and it was at par with isoproturon 1.0 kg/ha + metsulfuron methyl 4 g/ha with respect to yield attributing characters viz., number of ear head/m², ear head length, number of grains/ear head, test weight. Similarly, the maximum harvest index was also recorded with the application of sulfosulfuron 25 g/ha + metsulfuron methyl 4 g/ha. Chhokar and Malik (2002) reported that metsulfuron methyl controls mostly broad-leaved weed species, whereas sulfosulfuron controls grasses and some broad-leaved species. In the present investigation,

application of sulfosulfuron and metsulfuron methyl provided broad spectrum weed control. Therefore, after weeding, minimum weed density and dry weight and maximum grain yield was observed in this treatment. Similar findings have been also reported by Chhokar *et al.*, (2007), Meena and Singh (2011) and Singh *et al.*, (2012). Use of Rice residue mulches and control of weeds through application of Sulfosulfuron 25 g/ha + metsulfuron methyl 4 g/ha was found to result in better performance of wheat in terms of improvement in yield attributing character and increase in yield. It might be due to the result of better weed control facilitating the competitive ability of plants in using the resources efficiently.

References

1. Anderson R.L. and Beck D.L. 2007. Characterizing in central Dakota. *Weed tech.*, 21: 76-79.
2. Balyan R.S. and Malik R.K. 2000. New herbicides for *jagali palak* (*Rumex retroflexus* L.). *Indian J. Weed Sci.*, 32: 86-88.
3. Brar S.S., Kumar S., Brar L.S. and Walia S.S. 1998. Effect of crop residue management systems on the grain yield and efficacy of herbicides in rice-wheat sequence. *Indian J. Weed Sci.*, 30: 39- 43.
4. Chhokar R.S. and Malik R.K. 2002. Isoproturon resistant *Phalaris minor* and its response to alternate herbicides. *Weed Techno.* 16: 116-123.
5. Chhokar R.S., Sharma R.K., Jat G.R., Pundir A.K. and Gathala M.K. 2007. Effect of tillage and herbicides on weeds and productivity of wheat under rice-wheat growing system. *Crop Protec.* 26 (11): 1689-1696.
6. Crutchfield D.A. 1986. The effect of wheat straw mulch on weed control and corn growth. *Diss. Abstr. Int.*, 45: 2741.
7. Kumar K. and Goh K.M. 2004. Crop residues and management practices: Effect on soil quality, soil nitrogen dynamics crop yields and nitrogen recovery. *Adv. Agro.*, 68: 197-329.
8. Kumar R., Kumawat N., Kumar S., Kumar R., Kumar M., Sah R.P. and Kumar A. 2017. Direct seeded rice: research strategies and opportunities for water and weed management. *Oryza*, 53 (4):354-365.
9. Kumar R., Singh U.P. and Mahajan G. 2017. Influence of residue and weed management practices on no-till wheat (*Triticum aestivum* L.) under rice-wheat cropping system. *Indian J. Soil Conserv.*, 45 (2): 198-202.
10. Kumar V., Singh S., Chhokar R.S., Malik R.K., Brainard D.C. and Ladha J.K. 2013. Weed management strategies to reduce herbicide use in zero-till rice- wheat cropping systems of the Indo- Gangetic Plains. *Weed Tech.*, 27: 241-254.
11. Kumawat N., Kumar R., Singh M., Tomar I.S. Morya J., Yadav R.K. Sahu, Y.K. and Singh A. K. 2018. A study on chemical weed management in boro rice: A Review. *Agric. Reviews*, 39(1): 69-75.
12. Maurya P., Kumar V., Maurya K.K., Kumawat N., Kumar R. and Yadav M.P. 2014. Effect of potassium application on growth, yield and economics of wheat varieties. *The Bioscience*, 9 (4): 1371-1373.
13. Meena R.S. and Singh M.K. 2011. Weed management in late-sown zero-till wheat (*Triticum aestivum*) with varying seed rate. *Indian J. Agron.*, 56 (2): 127-132.
14. Paswan A.K., Mandal D., Kumawat N., Kumar J., Kumar R., Singh A.K. and Kumar A. 2017. Efficacy of separate and premix formulation of metsulfuron- methyl and carfentrazone-ethyl on weeds in wheat: A Review. *J. Curr. Microbio. Appl. Sci.*, 6(7): 2439-2453.
15. Ramadas S., Kumar T. M. K. and Singh G. P. 2019. Wheat Production in India: Trends and Prospects. DOI: <http://dx.doi.org/10.5772/intechopen.86341>
16. Singh A., Kaur R., Kang J.S. and Singh G. 2012. Weed dynamic in rice-wheat cropping system. *Global J. Bio. Agric. Health Sci.*, 1 (1): 7-16.
17. Singh R. and Yadav D.S. 2006. Effect of rice (*Oryza sativa*) residue and nitrogen on performance of wheat (*Triticum aestivum*) under rice wheat cropping system. *Indian J. Agron.*, 55(2): 83-88.
18. Walia S.S., Brar S.S. and Klar D.S. 1995. Effect of management of crop residue on soil properties in rice-wheat cropping systems. *Environ. Sci.*, 13: 5.
19. Yadav R.K., Kumawat N., Singh A., Tomar, I.S., Singh M. and Morya J. 2018. Bio- efficacy of new herbicides in mixture and alone on weed dynamic, yields and nutrient uptake of maize (*Zea mays* L.) under rainfed conditions. *Indian J. Agric. Sci.*, 88 (7): 1123-1128.



Problems Faced by the Households in Existing Crop Production in Dausa District of Rajasthan

B.L. Meena¹, Nisha Meena², M.L. Meena¹ and Y.K. Sharma⁴

¹College of Agriculture, Lalsot, Dausa, Rajasthan

²College of Agriculture, SKNAU, Jobner, Rajasthan

Corresponding Author Email : agromeena@gmail.com

Abstract

The present investigation was carried out in two blocks of Dausa district viz., Lalsot and Dausa on constraints faced by farmers in adoption of crop production activities. Multi stage random sampling plan was used in six villages of two different tehsil from dausa district in such a way that Lalsot tehsil has highest proportion of high productive area and other Dausa tehsil have highest share of low productive area to total net sown area. Ten households from each village were selected. Thus a total sample of 60 households was selected, representing 30 households from high productive and 30 households from low productive farming systems. There were four farming systems prevalent in the low productive and high productive condition of Dausa districts. Farming system (FS-I) describes crops + dairy and crops + dairy, crop + dairy + horticulture and crop + dairy + goat forms FS-II. Crops + dairy and Crops + dairy + goats constituted the FS-III. Crops either supported by goat or kitchen gardening were the part of FS-III in both the situations of the selected tehsils from dausa district. In both conditions (low productive and high productive area) the major problems faced by farmers were high cost of quality seeds, followed by lack of availability of quality seed, shortage of agriculture labour in peak and Lack of loan availability.

Key words : Cost, household, integrated farming system, problems.

Introduction

At the beginning of the new millennium, agriculture in India is facing the challenge to achieve sustainable food security with shrinking land resources by producing an additional 275 million tones (MT) of food to meet the requirement of the prognosticated population of 1.39 billion in the country. Because of declining per capita availability of land in India, there is hardly any scope for horizontal expansion of land for food production. Only vertical expansion is possible by integrating appropriate farming components that require lesser space and time to ensure periodic income to the farmer. Further, modest increments in land productivity are no longer sufficient for the resource-poor farmers. Hence, intelligent management of available resources, including optimum allocation of resources, is important to alleviate the risk related to land sustainability. Moreover, proper understanding of interactions and linkages between the components would improve food security, employment generation as well as nutritional security. This approach can be transformed into a farming system that integrates crops with enterprises such as– agroforestry; horticulture; cow, sheep and goat rearing; fishery; poultry and pigeon rearing; mushroom production; sericulture; and biogas production – to increase the income and improve the standard of living of small and marginal farmers. Integrated farming system (IFS) seems to be the possible solution to meet the continuous increase in demand for

food, stability of income and diverse requirements of food grains, vegetable, milk egg, meat, etc. there by improving the nutrition status of the small scale farmers with limited resources. The farm is viewed in holistic manner and farmers are subjected to many socio-economic, biophysical, institutional, administrative and technological constraints. Producer farmers face problems of production, protection, marketing, feeding and health management related to integrated farming systems. Therefore, it was also thought worthwhile to identify various constraints in integrated farming systems. Thus, the present study attempts to examine the constraints of prevailing farming systems in eastern Rajasthan with special reference to Low and High productive conditions in dausa district.

Materials and Methods

In Eastern Rajasthan, Dausa districts comprises of two tehsil viz., Dausa and Lalsot. Dausa districts fall in agro-climatic region III B. These districts fall in semi-arid eastern plain (III-A) agro-climatic region. Among these tehsil Dausa and Lalsot is tribal dominated tehsil of dausa district. Dausa district from III-B was purposively selected for the study of integrated farming systems, as this district have high potential for development of agriculture, horticulture livestock and goat farming. Multi stage random sampling plan was used. Two tehsils from district were selected in such a way that one having highest proportion of high productive or irrigated area and other

Table-1 : Existing farming systems in study area.

Farming systems	Dausa District	
	Low productive (Dausa)	High productive (Lalsot)
FS-I	Crop + Dairy (C+D)	Crop + Dairy (C+D)
FS-II	Crop + Dairy + Horticulture (C+L+H)	Crop + Dairy + Horticulture (C+L+H)
FS-III	Crop + Dairy + Goat (C+D+G)	Crop + Dairy + Goat (C+D+G)
FS-IV	Crop + Dairy + Vegetable (C+D+V)	Crop + Dairy + Vegetable (C+D+V)

Table-2 : Constraints faced by households in crop production.

S. No.	Constraints	Dausa District			
		Low productive (Dausa)		High productive (Lalsot)	
		Garret score	Rank	Garret score	Rank
1.	High cost of quality seeds	58.33	1	55.33	1
2.	Lack of availability of quality seeds	54.14	2	52.14	2
3.	Shortage of agricultural labor in peak season	41.67	3	40.67	3
4.	Lack of loan availability	37.50	4	35.50	4
5.	Lack of marketing facilities	33.33	5	31.33	5
6.	Lack of knowledge about recommended package practice	29.17	6	28.17	6
7.	Low price of farm produce at the time of harvest	25.00	7	24.20	7
8.	Inadequate power supply	20.83	8	20.50	8
9.	Lack of storage facilities	16.67	9	15.57	9
10.	inadequate Irrigation facilities	12.50	10	12.80	10
11.	High incidence of disease and pest	8.33	11	8.15	11
12.	Damage caused by birds and animals	4.17	12	4.00	12

one having highest share of low productive or rainfed area to total net sown area so that selected tehsils represented irrigated and rainfed farming systems in tribal areas. There after ten households from each village were randomly selected. Thus a total sample of 60 households was selected from Dausa districts, representing 30 households from low productive or rainfed and 30 households from high productive or irrigated farming systems. Both primary and secondary data were collected during the year 2016-17. Garret's ranking technique was used to analyze the constraints as perceived by the respondents in crop production activities. The respondents were asked to rank the factors that limit in the integrated farming systems. These orders of merit were transformed into units of scores by using the following formula:

$$\text{Per cent position} = 100 (R_{ij} - .50) / N_j$$

Where, R_{ij} - Rank given for the i th factor by the j th individual.

N_j - Number of factors ranked by the j th individual.

The percent position was converted into scores by referring to the Table suggested by Garret and Woodworth (1969). Then for each factor the scores of the individual respondents were added together and divided by the total number of respondents for whom scores were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified through the ranks assigned.

Results and Discussion

Existing farming systems in the study area mainly there were four farming systems prevalent in the low productive or rainfed and high productive or irrigated condition of dausa districts as shown in Table-1. Farming system (FS-I) describes crops + Livestock and crops + Livestock + horticulture forms FS-II. Crops + dairy + goats constituted the FS-III. Crops either supported by vegetables were the part of FS-IV in both the situations of the selected districts.

Constraints : The constraints faced by the farmers in crop activities discussed below sections.

It is evident from the table that twelve constraints were faced by households in crop production. The problems vary from area to area as well as low productive and high productive situations in Dausa district of Rajasthan. In low productive area of dausa block of Dausa district 58.33 score were reported by households as high cost of quality seeds, gave first rank it was followed by lack of availability of quality seed (54.14 score), shortage of agriculture labour in peak (41.67 score), Lack of loan availability (37.50) and least were found in case of damage caused by bird and animals (4.17). While in case of high productive area of lalsot block of dausa district major problem faced by farmers were high cost of quality seeds (55.33), followed by lack of availability of quality seed (52.14 score),

shortage of agriculture labour in peak (40.67 score), Lack of loan availability (35.50) and least were found in case of damage caused by bird and animals (4.00). In all 12 constraints were reported by the respondent households in both the districts under crop activities. Singh et al. (2016), Kadam *et al.* (2003), Singh and Singh (2005) and Choudhary *et al.* (2007) also reported similar findings.

Conclusions

It concluded from the study that four farming systems were prevalent in the low productive and high productive areas of Dausa districts. Farming system (FS-I) describes crops + dairy and crops + dairy, crop + dairy + horticulture and crop + dairy + goat forms FS-II. Crops + dairy and Crops + dairy + goats constituted the FS-III. Crops either supported by goat or kitchen gardening were the part of FS-III in both the situations of the selected tehsils from dausa district. The crop activities of Dausa district in either low productive and high productive conditions the major constraints or problems faced by farmers were high cost of quality seeds (55.33), followed by lack of availability of quality seed (52.14 score), shortage of agriculture labour in peak (40.67 score), Lack of loan availability (35.50) and least were found in case of damage caused by bird and animals (4.00).

Acknowledgments

The authors avail the opportunity to express their deep sense of gratitude to ECF Scheme, College of Agriculture, Lalsot, SKNAU, Jobner for providing the necessary facilities and support for research work.

References

1. Singh, Hari, Burark, S.S., Meena G.L., Bhushan Bharat and Meena Kamallesh. 2016 Constraints Faced by the Households in Existing Farming Systems in Chittorgarh and Banaswara Districts of Southern Rajasthan. *Journal of Animal Research*, 6(6) : 1031-1035.
2. Chandel, B.S. and Malhotra, R. 2006. Livestock systems and their performance in poor endowment regions. *Agr. Econ. Res. Rev.*, 19(2): 311-326.
3. Chandrashekar, S., Vasterlaliitha, K.C., Lakshmi Narayana, M.T. and Ranganatha, A.D. 2001. Production constraints faced by potato growers. *Rural India*, 64(2-3): 33-34.
4. Chitnis, D.H. and Bhikgaonkar, M.G. 1987. Constraints causing technological gap in dry farming systems. *J. Maha. Agr. Univ.*, 12(1): 84-88.
5. Choudhary, N.K, Roy, D.K. and Sinha, K.K. 2007. Characterization and constraint analysis of farming system of Nalanda district (Bihar). *J. Farm. Syst. Res. Devp.*, 13(1): 38-45.
6. Kadam, R.P., Wangikar, S.D. and Panwar, G.S. 2003. Constraints in adoption of improved soybean cultivation practices in Marathwada region. *Maha. J. Exten. Educat.*, 22(2): 212-214.



Proteolytic Activity of Ginger Extract, Kachri (*Cucumis melo* Var. *Agrestis*) Extract, Kiwi Fruit Extract and Papaya Peel Extract against Casein as Substrate

Praneeta Singh* and P. Prabhakaran

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, GBPUAT, Pantnagar-263145, Uttarakhand, India

*Email : vet_praneeta12@rediffmail.com

Abstract

Plant enzymes such as proteases have varied applications in medicine and food industry. Several proteases obtained from fruits and vegetables like papain, bromelain, ficin, zinzibain, actinidain and cucumisin are commonly used in food industry for brewing, meat tenderization, milk processing etc. The present study was undertaken to assess the proteolytic activity of four plant extracts against 1% casein as substrate. The proteolytic activity of ginger, *kachri*, kiwi and papaya peel extracts were found to be 0.087 ± 0.00 , 0.136 ± 0.01 , 0.053 ± 0.01 and 0.085 ± 0.02 , respectively. *Kachri* extract showed significantly ($P < 0.01$) higher proteolytic activity. SDS PAGE of these extracts was carried out. Kiwi fruit extract showed bands at approximately 20-30 k Da and bands for *kachri* extract appeared at about 60-67 k Da. It can be concluded that these plant extracts have good proteolytic activity and can be explored for application in food industry.

Key words : *Ginger, kachri, kiwi, papaya, casein.*

Introduction

Increasing awareness among consumers has veered interest towards natural plant products. Industries are exploiting enzymes of plant origin for innovative purposes at a rapid rate. Plant derived enzymes have varied application in food, pharmaceuticals and detergent industries. They are also used in processing of hides into leather and wool processing (7).

Proteolytic enzymes belongs to class of enzymes known as hydrolases, which are further subdivided into subclass viz. peptide hydrolases or peptidases or proteases. Proteases (EC 3.4) are further divided into sub-subclasses viz. serine proteases (EC 3.4.21) having a Ser residue in the active site, cysteine proteases (EC 3.4.22) possessing a Cys residue in the active site, aspartic proteases (EC 3.4.23) which depend on Asp residue for their catalytic activity and metallo proteases (EC 3.4.24) that employ metal ion (normally Zn^{++}) for their catalytic activity (13). Serine and cysteine proteases form covalent enzyme substrate complexes. Strong nucleophilic amino residue in their active site attacks the carbonyl group of peptide bond and catalyses it (8).

Fruits and vegetables are natural source of number of enzymes which are useful for food industry specifically proteases such as papain (papaya- *Carica papaya* L.), bromelain (pineapple- *Ananas comosus*), ficin (fig- *Ficus carica*), zinzibain (ginger- *Zingiber officinale roscoe*), actinidain (kiwifruit- *Actinidia deliciosa*) and cucumisin (*Kachri- Cucumis melo* var. *agrestis*). These proteases have their commercial importance in food processing

such as brewing, meat tenderization and processing of milk to form products like cheese. Most of the proteases obtained from fruits and vegetables viz. papaya, fig, ginger, pineapple and kiwi belong to the category of cysteine proteases, also known as thiol proteases. Ginger contains a cysteine protease and was named as Zingibain (24). This protease preferentially acts on proline containing substrates (4). Actinidain enzyme present in kiwi fruit juice is a sulfhydryl (thiol) protease belonging to cysteine protease category (1). Kiwi fruit-based solution was tried successfully to improve tenderness in beef m. *semimembranosus* (25). The mature unripe fruit of papaya contains an important proteolytic enzyme called papain. Papain belongs to cysteine protease category (3). It possesses good hydrolytic activity against myofibrillar proteins as well as collagen. *Kachri* (*Cucumis melo* var. *agrestis*) fruit is amongst the commonly used meat tenderizers in India traditionally (2). *Kachri* contains an extracellular thermostable protease cucumisin, which is alkaline in nature (26).

Several research works have been carried out to assess the proteolytic activity of plant extracts after purification steps like phase partitioning, precipitation, dialysis etc. using a number of chemicals (9, 15). However, such purified extracts may contain stabilizing or protective agents that may not be preferable in food applications especially in the current era of heightened consumer health awareness. Few works have been conducted to compare proteolytic activity of natural plant extracts of ginger, kiwi and papaya (6, 23).

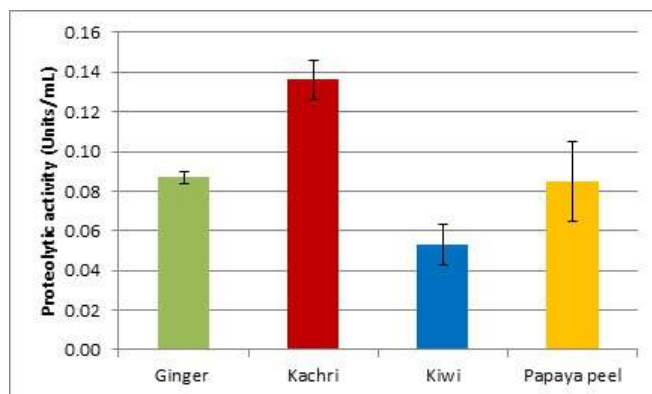
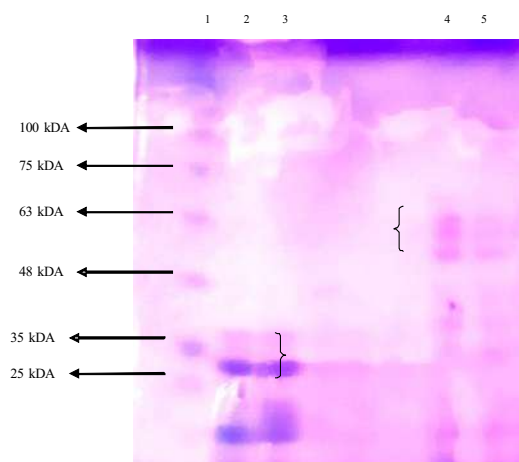
Therefore, the present study was envisaged to

Table-1 : Mean $\pm$ S.E. proteolytic activity (units*/ml) of plant extracts against 1% casein as substrate.

Plant Extract	Proteolytic activity (units/ml)
Ginger	0.087 $\pm$ 0.003 ^b
Kachri	0.136 $\pm$ 0.01 ^c
Kiwi	0.053 $\pm$ 0.01 ^a
Papaya peel	0.085 $\pm$ 0.02 ^b

Means bearing different superscripts (a,b) between rows differ significantly ($P < 0.05$) $n=9$

* One unit of enzyme will hydrolyze casein to produce color equivalent to 1.0 μ mole (181 μ g) of tyrosine per minute at pH 7.5 at 37°C (color by Folin & Ciocalteu's reagent).

**Fig.-1 : Proteolytic activity of plant extracts against 1% casein as substrate.****Fig.-2 : Enzyme extracts protein profiles displayed by 1D SDS PAGE Lane 1. Molecular marker, Lane 2 and 3. Kiwi fruit extract, Lane 4 and 5. Kachri extract.**

compare the proteolytic activity of natural plant extracts viz. ginger rhizome extract, *kachri* fruit extract, kiwi fruit extract, papaya peel extract from unripened fruit.

Materials and Methods

Materials : Fruits (for extraction of natural proteases) were procured from local market. Chemicals (analytical grade) like casein, trichloroacetic acid, tyrosine, SDS PAGE

related chemicals were procured from standard firms like Himedia®, Merck® and Qualigens® etc.

Preparation of natural plant extracts to assess their proteolytic activity : The procedure of (20) with minor modifications was followed for preparation of plant extracts. Ginger (peeled and chopped) or *kachri* (sarcocarp chopped) or kiwi (pulp chopped) or papaya peel from unripened mature fruit were mixed with 0.02 M sodium phosphate buffer pH 7.2 in the ratio of 1:1 w/v; homogenized in a homogenizer (Remi®RQ-127) and centrifuged at 5000 xg for 30 min at 4 °C . Supernatant obtained was filtered through muslin cloth and used for assessing proteolytic activity.

Determination of proteolytic activity : Proteolytic activity was determined by the method of (16) with slight modifications as per procedure given by Sigma ® using 1% casein as substrate. Casein solution 1% was prepared with 0.1 M Phosphate buffer of pH 7.0. Nine hundred L of this 1% casein solution was mixed with 100 L of the plant extracts containing protease in an eppendorf tube. This suspension was incubated at 50°C for exactly 60 min, then 1 mL of 5% TCA was added immediately to cease the reaction. A blank solution was also prepared by incubating 900 iL of 1% casein (without plant extract) at 50°C for 60 min, then one mL of 5% TCA was added, finally 100 mL of plant extract was added and mixed well. The eppendorf tubes were vortexed for 5 min; then kept in ice for 30 min; followed by centrifugation at 17000 xg for 20 min at 4 °C. To measure solubilised nitrogen, 1 mL of the supernatant was transferred to a clean and dry test tube. It was diluted with equal quantity of distilled water (DW) and 5 mL of 500 mM Sodium carbonate was added to it, followed by 1 mL of Folin-Ciocalteu's phenol reagent (diluted 1:2 with distilled water) and incubated at 37°C for 20 min. At the end of incubation the test tubes were cooled to room temperature for 15 min. The optical density was measured at 660 nm. Standard curve was prepared by serially diluting stock solution of 1.1 mM tyrosine to 0.05, 0.1, 0.2, 0.4 mM concentration treated in the same manner as test solution (for measuring solubilised nitrogen). One unit of enzyme activity (U) was defined as the amount of enzyme that hydrolyzed casein to produce color equivalent to 1.0 μ mole (181 μ g) of tyrosine per minute at 37 °C and pH 7.5.

SDS PAGE : SDS PAGE of plant extracts of ginger, *kachri*, kiwi fruit and papaya peel extracts (prepared as in 2.2) was carried out as per the procedure of (17) using 10% separating gel and 4% stacking gel. These extracts were taken in eppendorf tube and centrifuged at 12500 xg for 10 min at 4°C. The supernatant solution 25 iL was taken in an eppendorf tube and mixed with 2X Laemmli

buffer (Himedia®) in the ratio of 1:1. The tubes, kept in a stand, were immersed in a water bath maintained at 90 °C for 90 sec. From each of the tubes, 40 µl was loaded into the wells of precasted gel along with prestained protein ladder (Himedia®) in side well. The migration in the electrophoresis assembly (GeNei®-midi gel system, India) was commenced at 80 V until the loaded samples passed through the stacking gel (traced by the blue coloured bromo phenol blue dye present in the laemmli buffer). Then the voltage was increased to 150 V until the migrating samples reached the end of separating gel. The gel was carefully taken out from the glass plates of the assembly and washed 2-3 times in deionized water to remove electrophoresis buffer. For staining the gels were kept submerged with Coomassie blue R-250 staining solution (containing 0.1% Coomassie R-250 w/v, 10% acetic acid v/v, 40% methanol v/v in distilled water) for 4-5 h in a staining box. Then the stain was drained and the gel was washed with deionised water 2-3 times and destaining solution (containing 10% acetic acid v/v, 20% methanol v/v in distilled water) was poured on the gel to keep it submerged. Destaining was carried out for 12-24 h with intermittent shaking, till bands were clearly visualised or the background was clear.

Results and Discussion

Proteolytic activity of the plant extracts : Mean±S.E. values for proteolytic activity of the above plant extracts are shown in Table 1 and Fig. 1. The mean proteolytic activity of ginger, *kachri*, kiwi and papaya peel extracts were found to be 0.087 ± 0.00 , 0.136 ± 0.01 , 0.053 ± 0.01 and 0.085 ± 0.02 , respectively.

Analysis of variance showed highly significant ($P < 0.01$) difference in the proteolytic activity amongst the extracts. *Kachri* extract showed the highest ($P < 0.01$) proteolytic activity among plant extracts. Kiwi extract exhibited the lowest ($P < 0.01$) activity. No significant difference in proteolytic activity between ginger and papaya peel extract was observed. However, they possessed superior ($P < 0.05$) proteolytic activity than kiwi fruit extract.

Proteolytic activity of different fruits and vegetable extracts at varying pH was studied by (23) and they found that ginger extract, kiwi fruit extract and papaya extract showed proteolytic activity ranging between 0.003-0.083, 0.043-0.116 and 0.020-0.103 Units (moles of tyrosine released)/g, respectively. Ginger proteases showed higher relative caseinolytic activity than papain (15). Proteolytic activity of purified ginger extract was found to be 0.630 units/mg of protein (6). Specific activity of purified ginger extract was observed as 27.6 units/mg of protein (21). Proteolytic activity of kiwi, ginger and melon

extract was found to be 0.55, 0.73 and 0.90 units/mg (20). Specific activity of crude extract of *Cucumis melo* was observed at 0.71 units/mg (9).

Protease activity is also affected by degree of ripening of fruit (18) observed a threefold rise in the protease activity of kiwifruit three weeks post harvest. Proteolytic activity of kiwifruit juice was assessed against myoglobin as substrate and recorded as 4.65 units/ml of kiwifruit juice (19). Caseinolytic activity of commercial papain and zingibain was observed as 2.3×10^5 and 1.3×10^5 fluorescence $\text{min}^{-1} \text{mg}^{-1}$ protein respectively (11). A papaya peel based meat tenderizer was developed and its proteolytic activity was recorded as 6.07 to 8.883×10^{-8} moles of p-nitroaniline hydrolyzed/mg papaya peel (12). Proteolytic activity of purified papain from papaya latex was found as 0.022 Abs/min by (22). The results of present study were broadly in agreement with (23), (15) and (18) but not with (6), (21), (20), (9), (19), (11), (12) and (22). The differences observed in the present study were due to the differences in the definition of enzyme unit; substrate used and level of purity of the enzyme used.

SDS PAGE : SDS PAGE pattern plant extracts are presented in Fig.-2. Kiwi fruit extract (lane 1 and 2) showed distinctive bands at approximately 20-30 kDa. As reported by (14) that the enzyme actinidain contains 220 amino acids and its molecular weight is 23 kDa. Kiwifruit extract was purified by precipitation with ammonium sulphate (1) and dialysed against 0.05 M citrate buffer (pH 5.5). This dialysed extract when mobilized in SDS PAGE showed protein bands of approximately 23 kDa molecular weight. Evaluation of purified kiwi fruit extract using SDS PAGE revealed protein bands at 23-25 kDa (5, 11). The results of present study are in agreement with (1), (5) and (11). The longer band size observed may be due to the crude extract used. Bands in the range of 20-25 kDa were observed (Fig.-2). Crude kiwi fruit extract was studied by SDS PAGE, in addition to actinidin, thaumatin-like protein, kiwellin and kirola were observed by mass spectroscopy with molecular weight of 24 kDa, 20 kDa and 17.4 kDa, respectively (10). The results of present study are in agreement with (10).

Kachri extract (lane-3 and 4, Fig.-2) showed diffused band at the level of approximately 60-67 kDa. Cucumisin in its native form possessed a molecular mass of 67kDa (26). *Kachri* fruit extract was purified using two ion exchange chromatographic steps (2) and ammonium sulphate precipitation, on viewing the migration pattern of this extract on SDS PAGE they also showed a thick band at level of 67 kDa. In the present study, crude extract was used and may have resulted in longer diffused band. However, the molecular weight was broadly in agreement

with (26) and (2). Bands for ginger extract and papaya peel extract were not visible.

Conclusion

This can be concluded that the extracts obtained from ginger, *kachri*, kiwi fruit and papaya peel possessed good proteolytic activity in their crude forms that may be easily used in food industry. *Kachri* extract showed highest proteolytic activity, therefore it will be more effective in its natural form.

Acknowledgement

We thank Uttarakhand Council of Biotechnology for providing research grants to conduct this study.

References

- Aminlari, M., Shekarforoush, S.S., Gheisari, H.R. and Golestan, L. (2009). Effect of actinidin on the protein solubility, water holding capacity, texture, electrophoretic pattern of beef, and on the quality attributes of a sausage product. *Journal of food science*. 74(3): C221-C226.
- Asif-Ullah, M., Kim, K.S. and Yu, Y.G. (2006). Purification and characterization of a serine protease from *Cucumis trigonus* Roxburghii. *Phytochemistry*. 67(9): 870-875.
- Brocklehurst, K., Baines, B.S. and Malthouse, J.P. (1981). Differences in the interaction of the catalytic groups of the active centres of actinidin and papain Rapid purification of fully active actinidin by covalent chromatography and characterization of its active centre by use of two-protonic-state reactivity probes. *Biochemical Journal*. 197(3): 739-746.
- Choi, K.H., Laursen, R.A. and Allen, K.N. (1999). The 2.1 Å structure of a cysteine protease with proline specificity from ginger rhizome, *Zingiber officinale*. *Biochemistry*. 38(36): 11624-11633.
- Christensen, M., Tørngren, M.A., Gunvig, A., Rozlosnik, N., Lametsch, R., Karlsson, A.H. and Ertbjerg, P. (2009). Injection of marinade with actinidin increases tenderness of porcine *M. biceps femoris* and affects myofibrils and connective tissue. *Journal of the Science of Food and Agriculture*. 89(9): 1607-1614.
- Cruz, P.L., Panno, P.H.C., Giannotti, J.D.G., de Carvalho, R.V. and Roberto, C.D. (2020). Effect of proteases from ginger rhizome on the fragmentation of myofibrils and tenderness of chicken breast. *LWT*. 120:108921.
- Doran, P.M. (2002). Properties and applications of hairy root cultures. In *Plant biotechnology and transgenic plants* (pp. 134-151). CRC Press.
- Dunn, B.M. (2001). Determination of protease mechanism In: R. Beynon, J.S. Bond (Eds.). *Plant proteolytic enzymes – a practical approach*, Oxford University Press, New York, 2001, pp 77-79.
- Gagaoua, M., Ziane, F., Rabah, S.N., Boucherba, N., El, A.A.K.E.H., Bouanane-Darenfed, A. and Hafid, K. (2017). Three phase partitioning, a scalable method for the purification and recovery of cucumisin, a milk-clotting enzyme, from the juice of *Cucumis melo* var. *reticulatus*. *International journal of biological macromolecules*. 102: 515-525.
- Ha, M., Bekhit, A.E.D., Carne, A. and Hopkins, D.L. (2013). Characterisation of kiwifruit and asparagus enzyme extracts, and their activities toward meat proteins. *Food chemistry*. 136(2): 989-998.
- Ha, M., Bekhit, A.E.D.A., Carne, A. and Hopkins, D.L. (2012). Characterisation of commercial papain, bromelain, actinidin and zingibain protease preparations and their activities toward meat proteins. *Food Chemistry*. 134(1): 95-105.
- Islam, M.N. and Molinar-Toribio, E.M. (2013). Development of a meat tenderizer based on papaya peel. *Observación por Pares Basada en Mapas Conceptuales: Una Estrategia para Fomentar el "Scholarship of Teaching and Learning" en la Universidad Tecnológica de Panamá*: 24-29.
- IUBMB 1992. Enzyme nomenclature, Recommendations of the nomenclature committee of the IUBMB, Academic press, San Diego.
- Kamphuis, I.G., Drenth, J. and Baker, E.N. (1985). Thiol proteases: comparative studies based on the high-resolution structures of papain and actinidin, and on amino acid sequence information for cathepsins B and H, and stem bromelain. *Journal of molecular biology*. 182(2): 317-329.
- Kim, M., Hamilton, S.E., Guddat, L.W. and Overall, C.M. (2007). Plant collagenase: unique collagenolytic activity of cysteine proteases from ginger. *Biochimica et Biophysica Acta (BBA)-General Subjects*. 1770(12): 1627-1635.
- Kunitz, M. (1947). Crystalline soybean trypsin inhibitor II. General properties. *Journal of General Physiology*. 30(4): 291-310.
- Laemmli, U.K. (1970). Cleavage of structural proteins during the assembly of head of bacteriophage T4. *Nature*. 227: 680-685.
- Lewis, D.A. and Luh, B.S. (1988). Application of actinidin from kiwifruit to meat tenderization and characterization of beef muscle protein hydrolysis. *Journal of Food Biochemistry*. 12(3): 147-158.
- Liu, C., Xiong, Y.L. and Rentfrow, G.K. (2011). Kiwifruit protease extract injection reduces toughness of pork loin muscle induced by freeze-thaw abuse. *LWT-Food Science and Technology*. 44(10): 2026-2031.
- Mazorra-Manzano, M.A., Perea-Gutiérrez, T.C., Lugo-Sánchez, M.E., Ramírez-Suarez, J.C., Torres-Llanez, M.J., González-Córdova, A.F. and Vallejo-Cordoba, B. (2013). Comparison of the milk-clotting properties of three plant extracts. *Food chemistry*. 141(3): 1902-1907.
- Nafi, A., Foo, H.L., Jamilah, B. and Ghazali, H.M. (2013). Properties of proteolytic enzyme from ginger (*Zingiber officinale* Roscoe). *International Food Research Journal*, 20(1).
- Paul, B., Nasreen, M., Sarker, A. and Islam, M. (2013). Isolation, purification and modification of papain enzyme to ascertain industrially valuable nature. *International Journal of Bio-Technology and Research*. 3(5): 11-22.
- Sun, Q., Zhang, B., Yan, Q.J. and Jiang, Z.Q. (2016).

- Comparative analysis on the distribution of protease activities among fruits and vegetable resources. *Food chemistry*. 213: 708-713.
24. Thompson, E.H., Wolf, I.D. and Allen, C.E. (1973). Ginger rhizome: A new source of proteolytic enzyme. *Journal of Food Science*. 38(4): 652-655.
25. Toohey, E.S., Kerr, M.J., Van de Ven, R. and Hopkins, D.L. (2011). The effect of a kiwi fruit based solution on meat traits in beef m. semimembranosus (topside). *Meat Science*. 88(3): 468-471.
26. Yamagata, H., Masuzawa, T., Nagaoka, Y., Ohnishi, T. and Iwasaki, T. (1994). Cucumisin, a serine protease from melon fruits, shares structural homology with subtilisin and is generated from a large precursor. *Journal of Biological Chemistry*, 269(52): 32725-32731.



Survey of Soft Rot Causing Bacterium *Pectobacterium carotovorum* sp. *carotovorum* from Daurala Block of Meerut District

Ajay Kumar Mishra¹, Ramesh Singh^{1*}, Kamal Khilari¹, Gopal Singh¹, Amit Kumar² and Hem Singh³

¹Department of Plant Pathology, College of Agriculture, SVPUAT, Meerut, U.P. India

²Division of Animal Biotechnology, College of Biotechnology, SVPUAT, Meerut, U.P. India

³Department of Entomology, College of Agriculture, SVPUAT, Meerut, U.P. India

*Corresponding Author Email : spsfundingagency@gmail.com

Abstract

Soft rot disease of potato is one of the most destructive diseases causing heavy post-harvest losses. In the present study, samples were collected from fifty potato fields based on the gross examination (visual symptoms) by drawing 25 tuber samples from the farmer's fields and cold storages. Out of 25 samples, 14 isolates revealed cultural characters resembling to *Pectobacterium* spp. Morphological examination of these 14 presumptive isolates showed 13 Gram negative isolates. Further examination of these 13 isolates by flagella and negative staining, 09 isolates revealed morphological characters resembling to *Pectobacterium carotovorum* var. *carotovorum*. Out of 09 presumptive isolates of *Pectobacterium* spp. biochemical tests showed only 6 isolate with biochemical reactions comparable to positive control. Pathogenicity test was of all the 6 isolates showed soft rot symptoms on potato slice. However, PCR based confirmation of the presumptive 06 isolates of *Pectobacterium* spp. with species specific primers for *Pectobacterium* spp. *carotovorum* subsp. *carotovorum* revealed absence of amplicon of desired size with 550bp in all the isolate. The study suggested the presence of related pathogenic species of genus *Pectobacterium* Daurala block potato crops.

Key words : Biochemical, CVP, *Pectobacterium carotovorum* subsp. *carotovorum* and Potato.

Introduction

Potato (*Solanum tuberosum* L.) is the most important food crop worldwide and represents a valuable source of nutrients in a balanced diet. For a number of reasons, potato stands out among the world's major food crops. Potato plays multiple and important roles in local food systems and for food security. Out of 1500 solanum species only 90 are tuber producers and very few are cultivated. The total potato production in the world is estimated at 388.20 million tonnes in 2017 (FAOSTAT, 2019). India contributes approximately 7.5 percent of the world's total potato production (Indian Horticulture, 2020) on 2.17 million ha area with total production of 48.60 million tonnes in 2017 (Annual report, 2019-20).

Keeping in view the shrinking cultivable land and burgeoning population in India, the potato is a better alternative to deal with the situation. The yield and quality of potato are both, affected by a number of fungal, bacterial and viral diseases which cause heavy losses to the crop annually. It is imperative to avoid losses due to diseases in the field and equally important to prevent losses due to rots during storage and transit. Post-Harvest Soft rot is one of the destructive diseases of vegetables including potato. It occurs worldwide wherever vegetables and ornamentals having fleshy storage tissues are found. The disease can be found on crops in the field, in transit and in storage or during marketing. The

ideal harvest temperature for potatoes is between 10 to 15°C. Potatoes should not be harvested when tuber pulp temperatures are less than 5°C, as the cold tubers are prone to shatter bruising. Any type of bruise reduces marketability (Schaupmeyer, 1992) and renders the tubers more susceptible to attack by pathogens such as *Erwinia* soft rot. Tubers harvested in excessively high temperatures are prone to storage breakdown caused by bacterial soft rot. In storage, decaying tubers infected with bacterial soft rot break down, releasing bacteria-laden ooze onto adjacent tubers in the storage. In storage, the development of films of water on the tubers produces the anaerobic conditions ideal for the development of this disease. Given suitable conditions and adequate initial infection levels, both the incidence and severity of soft rot increase as time in storage increases. After invading host tissue, the bacterial population increases to a critical density, above which a large amount of cell wall degraded by releasing pectolytic enzymes, resulting in tissue maceration and granular rot of infected tubers. Rotted tissue is initially white or cream coloured, but brown pigments subsequently appear due to the oxidation of diseased tissue (Thipathi *et al.*, 1975). Post-harvest bacterial soft rot losses have been estimated to vary between 15-30% of the harvested crop (Agrios, 2006). Approximately 22% of potatoes are lost per year due to viral, bacterial, fungal, and pests attack to potato tuber and potato plant, incurring an annual loss of over 65

million tonnes and bacterial soft rot alone accounts for 30–50% of this huge loss (Czajkowski *et al.*, 2011b).

Materials and Methods

In the present investigation, survey of soft rot of potato were carried out from farmer's field of Daurala block, district Meerut. Identification was done based on cultural, morphological, biochemical and molecular characterization of isolated bacterial pathogens. The experiments were carried out in the laboratory of Centre of excellence for Sanitary and Phytosanitary (SPS), Department of Plant Pathology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut.

Survey and collection of samples : Potato fields were surveyed during 2019-20 and 2020-21. A survey methodology (James, 1974) was followed for monitoring the diseases and collection of samples. Samples were collected from fifty potato fields on the basis of grass examination (visual symptoms). 25 tubers samples were randomly drawn from the farmer's fields and cold storages. Sampling was done using random simple technique as well as with convenient sampling where symptomatic samples were observed. The typical soft rotted symptoms of potato were collected in sterilized polythene bags and labelled properly. The specimens were brought to laboratory where these were washed and dried at room temperature (25-27°C). These were stored in a refrigerator at 4°C until processed for isolation and were sorted out as per key (Turkensteen, 1986). Tubers were washed thoroughly in running tap water for 5 to 7 minutes to remove soil adhered from their surfaces and air dried. A descriptive questionnaire was used to obtain information of farmer's detail, symptoms of bacterial soft rot and crop details.

Isolation of pathogen : Infected samples of potato tubers were cleaned; surface sterilized with 1% sodium hypochlorite solution for 30 seconds, washed with sterile distilled water and then grinds in sterile 0.85% saline solution using sterile mortar under aseptic condition. The resulting bacterial suspension was left undisturbed for a few minutes. This suspension was then streaked on the surface of plates containing Crystal Violet Pectate (CVP) medium and the plates were incubated at 30°C for 24 hours. Individual colonies growing on CVP (Solution A containing : Tryptone (Oxoid L42) 1.0 g, Tri sodium citrate 5.0g, Sodium nitrite 2.0 ml, 10% w/Calcium chloride hydrated (CaCl₂.H₂O), 10.2 ml, 0.075% Crystal Violet 2.0 ml, Bacteriological Agar 4.0g Distilled water, 500 ml and solution B containing: 5M sodium hydroxide, 2.5ml, Polygalacturonic acid sodium salt, 18.0g, Distilled water 1000ml) were picked up and streaked on nutrient agar (NA) plates again and then incubated at 30°C for another 24 hours. This was repeated several times to obtain pure cultures. Purification of bacterial colony was done by

re-streaking of single colony in sterile nutrient agar plates and about 10⁷ cells/μl of each isolate was stored at -20°C in phosphate buffer saline with 10% glycerol.

Cultural characterization of *Pectobacterium* spp :

The morphology (size, shape, colour and growth patterns) of colonies was recorded after 24–48 hours of growth on a dish with a potato agar at ±28°C. The mobility of bacteria was determined by the “crushed drop” method on the one-day culture.

Morphological characterization of *Pectobacterium*

spp : The prepared slide was examined under binocular microscope Olympus CH₂Oi (Japan) using immersion oil. For morphological characteristics of the bacteria Gram, flagella and negative staining were performed according to the protocol given by Kelman (1954), Anonymous (1957). Manual of Microbial Methods: (Ed.). Society of American Bacteriologists, McGraw, New (1957), Bradbury (1970) and Schaad (1992).

Potassium hydroxide (KOH) solubility test : On glass slide a loop full of bacteria from a well grown colony was mixed with a drop of 3% KOH aqueous. Mixing was continued for less than 10 seconds. A toothpick was used for picking bacteria from a colony as well as for mixing it. The toothpick was raised a few centimetres from the glass side.

Biochemical tests of suspected bacterial isolates :

Various biochemical tests like Kovac's oxidase test, Catalase test, Indole production test, Methyl red test, Voges Proskauer Test (VP test), Citrate utilization test, Nitrate reduction test and Urease test were performed by standard procedures described in (Kolomiiets *et al.*, 2020; Czajkowski *et al.* 2015a; Rahman *et al.*, 2010)

Molecular identification of *Pectobacterium carotovorum* ssp. *carotovorum* using subspecies specific gene based PCR :

For the PCR based confirmation the genomic DNA was extracted from bacterial cells using standard DNA extraction method as described by Sambrook and Russell, (2001). PCR amplification was performed using primer pair EXPCCF 5'-GAACTTCGCACCGCCGACCTTCTA-3' and EXPCCR 5'-GCCGTAATTGCCTACCTG CTTAAG-3' following the protocols previously described (De Boer and Ward 1995; Kang *et al.* 2003; Duarte *et al.* 2004) to detect *Pectobacterium carotovorum* subsp. *carotovorum*.

PCR amplification was carried out in a T100 PCR thermal cycler (BioRad) with initial denaturation at 94 °C for 4 min and then 30 cycles of denaturation at 94 °C for 1 min, annealing at 60 °C for 1 min, extension at 72 °C for 2 min followed by the final extension at 72 °C for 7 min with the reaction mixture detailed in Table-1.

Table-1 : Details of the samples collected for the isolation of *Pectobacterium carotovorum* subsp. *Carotovorum*.

Isolates	Potato Cultivar	Location of Sampling
PC01	K. Khyati	Modipuram
PC02	K. Pukhraj	Mahal
PC03	Kufri Bahar	Lawar
PC04	S4	Pavli Khas
PC05	Kufri Seetman	Rajpura
PC06	S4	Jan Shakti Cold Store Daurala
PC07	Kufri Bahar	Mahel Cold Store
PC08	Kufri Badsah	U.P. State Cold Store Modipuram
PC09	Kufri Chipsona 1	Baparsa
PC10	Kufri Bhahar	Rajpura
PC11	K. Surya	Bharala
PC12	S-1	Modipuram
PC13	K. Bahar	Mavi Meera
PC14	S-4	Baparsa
PC15	Kufri Bahar	Bharala
PC16	S4	Palheda
PC17	Kufri Seetman	Ulkipur
PC18	S4	Danju
PC19	Kufri Bahar	Lawar
PC20	Kufri Bahar	Palheda
PC21	S4	Ulkipur
PC22	S4	Danju
PC23	Kufri Seetman	Lawar

Table-3 : The composition of PCR reaction mixture.

Components	Stock Solution	Volume
Template DNA	25 ng/μl	1.0 μl
Primer (F)	10 μM	0.6 μl
Primer (R)	10 μM	0.6 μl
GoTaq™ DNA polymerase (Promega Inc.)	5 units/μl	0.5 μl
Go Taq™ buffer (Promega Inc.)	5X	5.0 μl
MgCl ₂ (Promega Inc.)	25 mM	1.5 μl
dNTPs (Promega Inc.)	10 mM	0.2 μl
Nuclease free Water (Promega Inc.)	-	12.6 μl
Dimethyl sulfoxide (DMSO)	-	3.0 μl
Total		25.0 μl

Pathogenicity Test

Soft Rot on Slice method : To test the pathogenicity of all the isolates test was carried out by introducing the soft rot pathogen (*Pectobacterium carotovorum* subsp. *carotovorum*) in healthy tuber slices. A total of approximately 10^8 cells were inoculated in the form of a thick paste onto the surface of healthy tuber slices. The inoculated tuber slices were incubated for 24-48 h at $28 \pm 2^\circ\text{C}$, in two petri plates having 5ml of sterile water, kept in such a way that the tuber slices should not come in direct contact with the water. Tuber slices without inoculating the pathogen in one petri plate were kept as control. Softening of the inoculated tuber slices, accompanied by the

production of the characteristic odour was taken as a positive reaction. From the experimentally induced bacterial pathogen, bacteria was re-isolated and compared with the original isolate of *Pectobacterium carotovorum* (Shashirekha et al., 1987).

Results and Discussion

Isolation and identification of *Pectobacterium carotovorum* subsp. *Carotovorum* : During the survey, it was observed that out of 50 fields, 25 samples were taken based on the gross examination. Out of 25 samples collected, 14 samples produced the discrete colonies resembling to *Pectobacterium* spp. over specific CVP medium. These resembling single colonies were further purified on Nutrient Agar medium and stored for further investigation. The details of the 14 samples are provided in Table-3.

Morphological characterization of presumptive *Pectobacterium* spp. : Strands of viscid materials were noticed in 13 out of 14 presumptive isolates of *Pectobacterium* spp. using KOH test indicating that the test isolates were found to be Gram negative. Which were also confirmed by using Gram staining method. On further examination for flagella and negative staining 09 isolates revealed morphological character resembles to *Pectobacterium carotovorum* var. *carotovorum*.

Biochemical characterization of presumptive

Table-4 : Morphological characterization of presumptive *Pectobacterium carotovorum* subsp. *Carotovorum*.

Name of Isolates	KOH test	Gram's stain	Flagella staining	Negative staining	Pits on CVP
PC01	+	-	-	+	-
PC03	+	-	+	+	+
PC07	+	-	+	+	+
PC08	+	-	-	+	+
PC11	+	-	+	+	+
PC12	+	-	+	+	+
PC13	+	-	+	+	+
PC17	+	-	+	+	-
PC18	-	+	-	+	+
PC19	+	-	+	+	+
PC20	+	-	+	+	+
PC22	+	-	+	+	+
PC23	+	-	-	+	+
PC24	+	-	+	+	+
+ve control (Pcc)	+	-	+	+	+

Table-5 : Biochemical characterization of presumptive *Pectobacterium* spp. Isolates.

Name of Isolates	Kovac's oxidase	Catalase	Indole production	Methyl red	Voge's Proskauer	Citrate utilization	Nitrate reduction	Urease
PC03	+	+	-	+	-	+	-	-
PC07	+	+	+	+	-	+	+	-
PC11	+	+	-	+	-	+	-	-
PC12	+	+	-	+	-	+	-	-
PC17	+	+	-	+	-	+	-	-
PC19	+	+	-	+	-	+	+	-
PC20	+	+	+	+	-	+	-	-
PC22	+	+	-	+	-	+	-	-
PC24	+	+	-	+	-	+	-	-
+ve control (Pcc)	+	+	-	+	-	+	-	-

“+” Showed positive reaction, ‘-’ showed negative reaction and ‘±’ not confirmed.

***Pectobacterium* spp. Isolates :** All the 09 isolates showing resemblance with *Pectobacterium carotovorum* var. *carotovorum* during cultural and morphological examination were subjected to biochemical characterization for their further confirmation.

Though biochemical and phenotypic traits are not accurate in differentiating closely related *Pectobacterium* spp. in this case among 09 isolates, 06 isolates were identified as *P. carotovorum* subsp. *carotovorum* in biochemical and physiological tests. However, for the further confirmation of the preliminary findings of cultural, morphological and biochemical characterization, all the 06 isolates were subjected to *Pectobacterium carotovorum* subsp. *carotovorum* species specific PCR (Figure-1).

Pathogenicity test of *Pectobacterium carotovorum* sub sp. *carotovorum* : All 06 isolates revealing cultural, morphological and biochemical characters of *Pectobacterium* spp. were inoculated over potato slice to assess their pathogenicity. After 48 hrs of incubation,

probing at the site of inoculation on potato slices revealed rotten around and beyond the point of inoculation. The clear discoloration of tissues around the point of inoculation and blackening around the rotten tissue separating rotten tissue from the healthy one suggested the causing pathogen belonging to *Pectobacterium* spp. group in comparison to un-inoculated control potato slice.

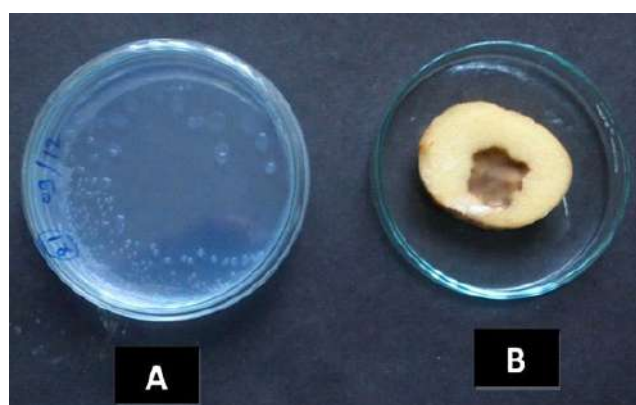


Fig.-1 : *Pectobacteria* spp. A; Colony on CVP Medium, B; Pit formation on potato slice.

Molecular confirmation of the isolates : PCR based confirmation being very specific and sensitive; all the presumptive isolates for all three species were subjected to PCR based confirmation with previously reported custom synthesized primers. All six isolates were subjected to PCR based amplification with EXPCCR and EXPCCF sub species based primers to obtain a unique band of 550bp DNA fragment. The electrophoresis of PCR amplicons revealed the amplification of 550 bp amplicon in positive DNA control of *P. carotovorum* subsp. *carotovorum*. None of the isolate obtained during the study amplified the desired amplicon, suggesting the absence of *P. carotovorum* subsp. *carotovorum*.



Plate : Agarose gel electrophoresis of PCR products produce approximately 550bp. Here Lanes M = 100bp ladder, P= Positive control and 1 to 6 are the presumptive isolates of *P. carotovorum* subsp. *carotovorum*.

Present study conducted a survey for the presence of *P. carotovorum* subsp. *carotovorum* causing soft rot of potato tuber in Daurala block of Meerut, U.P. Different village were surveyed for isolation, identification and molecular confirmation of *P. carotovorum* subsp. *carotovorum*. Total 14 isolates were isolated on specific CVP medium, which produced similar colonies as Pectolytic degrading bacteria. The isolates were further studied for morphological and biochemical confirmation and only 6 isolates were confirm as *Pectobacterium* spp. Molecular confirmation of all the isolates was done with species specific primer. None of the isolate revealed the amplification and desired amplicon. The study suggested the absence of *P. carotovorum* subsp. *carotovorum* in Daurala block similarly Tahir *et al.* (2017) conducted extensive survey of potato growing areas of Punjab. They surveyed several fields from some major district and collected the samples of plants, tubers and soil from field and market. Crystal violet pectate (CVP) selective medium was used for isolation of *E. carotovorum*. The rot suspected samples were streaked on CVP media and the characteristic pit formation was observed. Eight (8) isolates were obtained with pit formation feature and preliminary identification was based on the growth on CVP media at 27, 33.5 and 37 °C. Three strains were found associated to rot as *E. carotovorum* subsp. *atroseptica*, *E. carotovorum* subsp. *carotovorum* and *E.*

chrysanthemi. The isolates were further confirmed using biochemical tests. Pathogenicity was tested on tuber slices which exhibited the rot symptoms.

The absence of *P. carotovorum* subsp. *carotovorum* specific amplification confirmed the absence of *P. carotovorum* subsp. *carotovorum* in the collected samples and area of the sample collection. However, the presence of bacterial isolates with the resembling cultural, morphological and biochemical results suggested the presence of related species of the same genus or closely related bacteria. The previously published reports of Tahir *et al.* (2017) also observed the presence of closely related *E. carotovorum* subsp. *atroseptica*, and *E. chrysanthemi* in Punjab. Similarly Ozturk (2018) isolated 26 Pectinolytic bacteria from 48 potato plants showing the symptoms of blackleg in different fields of commercial potato production areas at Samsun, Amasya, Corum and Yozgat provinces in Turkey in 2015. The pectinolytic strains that belonged to *P. atrosepticum*, *P. carotovorum* subsp. *brasiliense*, *P. carotovorum* subsp. *carotovorum* and *P. parmentieri* species based on molecular identification with species specific PCR and phenotypic characterization.

The presence of pectinolytic strains with positive pathogenicity tests suggested the presence of *P. carotovorum* subsp. *carotovorum* related species like *P. atrosepticum*, *P. carotovorum* subsp. *brasiliense*, and *P. parmentieri* species suggesting the further investigation in the area to confirm the existence of these pathogens in the area.

Conclusions

The study revealed the absence of *P. carotovorum* subsp. *carotovorum* in the study area. However, the findings suggested the presence of other related pathogenic species causing infection and economic losses in the area.

Acknowledgements

Authors are thankful to Dean, College of Agriculture and Hon'ble Vice chancellor of the SVPUAT, Meerut for providing all necessary facilities and support.

References

1. Agrios G.N. (2006). Bacterial Soft Rots. 5th Edn., Academic Press, San Diego Food and Agriculture Organization of the United Nations (FAO). 2011. "FAOSTAT Database."
2. Annual report (2019-20). Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare Directorate of Economics & Statistics. Pp- 38.
3. Anonymous (1957). Manual of Microbial Methods: (Ed.). Society of American Bacteriologists, Mc Graw, New York, 315.

4. Bradbury J.F. (1970). Isolation and preliminary study of bacteria from plants. *Rev.Pl. Pathol.*, 49: 213-218
5. Breakwell D.P., Moyes R.B. and Reynolds J. (2009). Differential Staining of Bacteria: Flagella Stain. *Current Protocols in Microbiology*.
6. Czajkowski R, Pérombelon M.C.M., Jafra S., Lojkowska E., Potrykus M., Vander J.M. Wolf, W. Sledz (2015a). Detection, identification and differentiation of *Pectobacterium* and *Dickeya* species causing potato blackleg and tuber soft rot: a review. *Ann Appl Biol.* 166(1): 18–38.
7. Czajkowski R., Perombelon M.C.M., van Veen J.A., Vander Wolf J.M. (2011b) Control of blackleg and tuber soft rot of potato caused by *Pectobacterium* and *Dickeya* species: a review. *Plant Pathology*, 82(1): 268–278
8. De Boer and Ward (1995) PCR Detection of *Erwinia carotovora* subsp. *atroseptica* Associated with Potato Tissue., *Phytopathology*, 85(6): 854-858
9. Duarte V., De Boer S.H., Ward L.J. and De Oliveira A.M.R. (2004). Characterization of a typical *Erwinia carotovora* strains causing blackleg of potato in Brazil. *Journal of Applied Microbiology*, 96: 535–545
10. Indian Horticulture (2020), Global potato conclave, ICAR-CPRI, Shimla, 6 (64): 125.
11. James WC (1974) Assessment of plant disease and losses. *Annual Review of Phytopathology* 12: 27-48
12. Kang H.W., Park D.S., Go S.J., Eun M.Y., (2002). Fingerprinting of diverse genomes using PCR with universal rice primers generated from repetitive sequence of Korean weedy rice. *Molecules and Cells* 13 (7): 281
13. Kelman A. (1953). The bacterial wilt caused by *Pseudomonas solanacearum*. *N.C. Agr. Exp. Sta. Tech.*, 5. Bull., 99: 194.
14. Kolomiiets Y., Grygoryuk I., Butsenko L., Bohoslavets V., B. Yaroslav and Yemets A. (2020). Identification and biological properties of the pathogen of soft rot of tomatoes in the greenhouse. *The Open Agriculture Journal*, 14, 290-298.
15. Moyes R.B., Reynolds J. and Breakwell D.P. (2009). Preliminary Staining of Bacteria: Negative Stain. *Current Protocols in Microbiology*. pp 1-5
16. Ozturk M., Aksoy H.M., Potrykus M. and Lojkowska E. (2018). Genotypic and phenotypic variability of *Pectobacterium* strains causing blackleg and soft rot on potato in Turkey. *European Journal of Plant Pathology*, 152(1): 143–155.
17. Rahman M.F., Islam M.R., Rahman T. and Meah M.B. (2010). Biochemical characterization of *Ralstonia solanacearum* causing bacterial wilt of brinjal in bangladesh. *Progress. Agric.* 21(1-2): 9–19.
18. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.
19. Schaad N.W. (1992). Laboratory guide for the identification of plant pathogenic bacteria, 2nd ed. *American phytopathol.*, pp 138.
20. Shashirekha M.N., Karanth N.G.K. and N arasimham P. (1987). Surface microflora of seed potatoes (*Solanum tuberosum* L., Kufri Jyoti): Isolation and identification of organisms responsible for spoilage of potatoes grown at Devanahalli, *Journal of Food Science and Technology*, 24: 261-263.
21. Tahir M.I., Inam-ul-Haq M. and Akram Z. (2017) Determination of incidence of potato soft rot in major potato growing areas of Punjab, Pakistan . *Plant Protection*, 1(1): 17-22
22. Thipathi R.K. and Verma M.N. (1975). Phenolic compounds and polyphenol oxidase activity in relation to resistance in potatoes against bacterial soft rot. *Indian J. Exp. Biol.* 13: 414-416.
23. Turkensteen L.J. (1986). Survey on bacterial and fungal diseases of potato in the plains of Pakistan (Punjab province, pabbi area of NWFP and in Baluchistan. PARC, Pak, Swiss Potato Development Project.



Management of Weeds in Rice (*Oryza sativa* L.)

K.V. Singh and U.S. Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab

Abstract

The research experiment was conducted during the *kharif* season of 2019 at Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab to study weed management in rice (*Oryza sativa* L.). The experiment consisted of 8 treatments (T₁ Weedy check, T₂ Weed free, T₃ Hand weeding 15 days after transplanting, T₄ Hand weeding 15 and 30 days after transplanting, T₅ Butachlor 1.5 kg a.i./ha Pre-emergence, T₆ Bispyribac 0.025 kg a.i./ha post-emergence 20 days after transplanting, T₇ Butachlor 1.5 kg a.i./ha pre-emergence followed by hand weeding at 30 day after transplanting, T₈ Butachlor 1.5 kg a.i./ha pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence) was laid out in randomized complete block design (RCBD) with three replications. The weed studies, growth parameters and yield attributes were significantly influenced with management of weeds. The minimum weed density (3.8 m⁻²), weed dry weight (2.9 m⁻²) and higher weed control efficiency (87.1 %) was obtained with butachlor 1.5 kg a.i./ha pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence. The highest plant population (28.8 m⁻²), plant height (95.2 cm), tillers hill (16.2), panicles/hill (15.6), 1000-grains weight (22.6 g), grain yield (70.5 q/ha), straw yield (93.3 q/ha) and harvest index (6.59 %) were also obtained with butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence closely followed by butachlor 1.5 kg a.i./ha as pre-emergence followed by hand weeding at 30 days after transplanting.

Key words : Weeds, rice, management, yield.

Introduction

Rice (*Oryza sativa* L.) is one of the most important food crop of India contributing about 40 % of total food grain production. It plays a vital role in food security and livelihood for almost every house hold. The rice production in India during 2019-20 was 112.09 mt (Anonymous 2020). Rice can be grown well on loamy soils with low permeability and over a wide range of soil reaction viz. pH 5 to 9. Weeds are a major impediment to rice production through their ability to compete for resources and their impact on product quality. Weeds are unwanted, prolific, competitive, often harmful to the environment and they occur in every rice field of the world. Weeds reduce the potential production of rice by interfering with agricultural operations (Manhas *et al.*, 2012). Weed management in transplanted rice through herbicide application may be the best suited option. It is practiced by farmers for past several years as it offers selective and economic control of weeds right from the beginning of crop growth and thus, minimize the crop-weed competition. It also save valuable time by covering more area in short period and is also cost effective. Herbicides will help in lowering the cost of production of rice and efficiently control weeds hence higher grain yield. So, weedicides are commonly used to manage rice weeds (Kabdal *et al.*, 2018).

Materials and Methods

The present experiment was carried out during *kharif* season of 2019 at the Agriculture Research Farm of

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh Punjab. The Mandi Gobindgarh is situated at 30.6642° N latitude and 76.2914° E longitudes at an altitude of 268 meters above mean sea level. The experiment was laid out in randomized complete block design (RCBD) with three replications. The soil of the experimental field was medium in organic carbon (0.48 %) and low in available soil nitrogen (144.6 kg N/ha), medium in available soil phosphorus (17.3 P₂O₅/ha) and medium in available soil potassium (220 kg K₂O/ha). The experiment consisted of 8 treatments T₁ Weedy check, T₂ Weed free, T₃ Hand weeding 15 days after transplanting, T₄ Hand weeding 15 and 30 days after transplanting, T₅ Butachlor 1.5 kg a.i./ha Pre-emergence, T₆ Bispyribac 0.025 kg a.i./ha post-emergence 20 days after transplanting, T₇ Butachlor 1.5 kg a.i./ha pre-emergence followed by hand weeding at 30 day after transplanting, T₈ Butachlor 1.5 kg a.i./ha pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence. The twenty kg seed per hectare was used for sowing nursery and crop was transplanted on July 5, 2019 at a spacing of 20 × 15 cm. The gross plot size was 3.5 × 2.5 m and net plot size was 3 × 2 m. The crop was sown on July 1, 2019 and harvested on October 21, 2019. The all-other cultural practices were uniformly applied in all the treatments.

Results and Discussion

Effect on weeds : The major weed species observed in the experimental field were *Echinochloa colona*,

Table-1 : Effect of weed management treatments on the weed density, weed dry weight, and weed control efficiency.

Treatments	Weed density (m ⁻²)	Weed dry weight (g m ⁻²)	Weed control efficiency (%)
T ₁ Weedy check	8.8 (77.3)	8.0 (63.6)	-
T ₂ Weed Free	0.7 (0.00)	0.7 (0.00)	100.0
T ₃ Hand Weeding 15 days after transpalnting	6.9 (46.0)	5.0 (24.6)	61.3
T ₄ Hand Weeding 15 and 30 days after transpalnting	5.3 (28.3)	4.1 (16.1)	74.6
T ₅ Butachlor 1.5 kg a.i./ha pre-emergence	6.3 (40.3)	4.8 (22.1)	65.2
T ₆ Bispyribac 0.025 kg a.i./ha post-emergence 20 days after planting	5.6 (28.3)	3.7 (13.2)	79.2
T ₇ Butachlor 1.5 kg a.i./ha pre-emergence followed by hand weeding at 30 days after planting	5.3 (28.1)	3.3 (10.5)	83.4
T ₈ Butachlor 1.5 kg a.i./ha pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence	3.8 (13.9)	2.9 (8.2)	87.1
C.D at 5%	2.1 (6.62)	1.83 (2.98)	
SE(m)	1.63 (2.16)	1.21 (0.97)	
C.V.	3.42 (11.19)	3.1 (8.58)	

Data were subjected to square root (transformation and the figures in parentheses are the original values.

Table-2 : Effect of weed management treatments on the growth parameters, yield attributes and yield of rice.

Treatment	Plant Population (m ⁻²)	Plant height	Tillers hill ⁻¹	Panicles hill ⁻¹	Test weight (grain/g)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvesting Index (%)
T ₁ Weedy check	25.4	83.2	10.8	8.00	20.6	54.4	77.7	6.44 (41.1)
T ₂ Weed Free	28.8	96.1	16.4	15.7	23.0	79.9	98.3	6.73 (44.8)
T ₃ Hand Weeding 15 days after transpalnting	26.1	85.5	14.6	13.8	21.6	61.6	81.7	6.58 (42.9)
T ₄ Hand Weeding 15 and 30 days after transpalnting	27.6	92.9	15.4	14.8	22.3	64.5	88.2	6.53 (42.2)
T ₅ Butachlor 1.5 kg a.i./ha pre-emergence	27.1	87.2	14.7	14.1	22.0	61.7	81.7	6.60 (43.1)
T ₆ Bispyribac 0.025 kg a.i./ha post-emergence 20 days after planting	27.3	90.7	15.3	14.3	22.2	62.8	83.3	6.58 (42.9)
T ₇ Butachlor 1.5 kg a.i./ha pre-emergence followed by hand weeding at 30 days after planting	27.7	93.2	16.0	15.4	22.5	70.0	88.3	6.68 (44.2)
T ₈ Butachlor 1.5 kg a.i./ha pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence	28.3	95.2	16.2	15.6	22.6	70.5	93.3	6.59 (43.1)
C.D.	NS	8.7	3.12	1.25	NS	10	NS	NS
SE(m)	0.98	4.1	1.16	0.49	0.97	3.66	4.6	1.3 (1.2)
C.V.	6.27	5.43	11.7	5.14	7.63	8.70	9.40	2.3 (4.82)

Data were subjected to square root (transformation and the figures in parentheses are the original values.

Echinochloa crusgalli, *Cynodon dactylon* and *Eleusine indica* under grassy weeds, *Cyperus difformis*, *Cyperus irri*, *Cyperus rotundus* and *Cyperus esculentus* under sedges and *Digeria arvensis* and *Euphorbia hirta* under broad-leaf weeds.

Butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence (Table-1) recorded minimum weed density (3.8 m⁻²) which was significantly lower than butachlor 1.5 kg a.i./ha as pre-emergence (6.3 m⁻²) and one hand weeding at 15 days after sowing (6.9 m⁻²) but was at par with rest of the weed control treatments. Yadav *et al.*, (2018) also found similar

results with butachlor (50 EC) + bispyribac sodium (10% SC).

Minimum dry weight (2.9 g) of weed was noticed (Table1) with butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence which was significantly lower than butachlor 1.5 kg a.i./ha as pre-emergence (4.8 g) and one hand weeding at 15 days after sowing (5.0 g) but was at par with rest of the weed control treatments. Sharma *et al.*, (2020) also observed the lowest dry weight of weeds with butachlor 1.5 kg a.i./ha at 3DAT + bispyribac sodium 10% SC @ 20 g a.i./ha at 21 DAT (3.90 g m⁻²).

The highest weed control efficiency (87.1 %) was found with butachlor 1.5 kg a.i./ha as pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence closely followed by butachlor 1.5 kg a.i./ha as pre-emergence fb hand weeding at 30 days after transplanting (Table-1). Kumar *et al.*, (2018) also found higher weed control efficiency (86 %) with bispyribac sodium 10% SC @ 20 g a.i./ha.

Effect on Growth parameters : Plant population in rice crop was influenced not significantly (Table-2) by different weed control treatments. Yadav *et al.*, (2018) also reported similar results.

Butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence recorded (Table 2) highest plant height (95.2 cm) which was significantly more than one hand weeding at 15 days after transplanting (85.5 cm) and weedy check (83.2 cm) but was at par with rest of the weed control treatments. This might be due to the better weed control throughout growth stages of rice and better availability of all resources viz., light, moisture, space and nutrients to rice. The higher plant height of rice was also reported by Saphi *et al.*, (2018) in weed free treatment.

Significantly higher tillers/hill (16.2) were also obtained with butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence. Which was significantly higher than weedy check (10.8) but was at par with rest of the weed control treatments (Table.2). This might be due to the better weed control throughout growth stages of rice and better availability of all resources viz., light, moisture, space and nutrients to rice. Mustafa *et al.*, (2017) also found increased tillers hill⁻¹ (16) with butachlor + winsta were applied.

Yield attributes and yield : All the weed control treatments recorded significantly higher tillers/hill, panicles/hill, grain and straw yield over weedy check.

Butachlor 1.5 kg a.i./ha as pre-emergence followed by bispyribac 0.025 kg a.i./ha as post-emergence (Table-2) produced maximum panicles hill⁻¹ (15.6) which was significantly higher than butachlor 1.5 kg a.i./ha pre-emergence (14.1) and one hand weeding at 15 days after transplanting (13.8) and bispyribac 0.025 kg a.i./ha post emergence 20 DAT (14.3) but was at par with rest of the weed control treatments. This was due to lesser weed competition and better uptake of nutrients by the crop. Mustafa *et al.*, (2017) also found similar results.

This 1000 grain weight of rice was not affected significantly weed management in rice (Table-2) which is a genetically controlled character and a stable varietal character, thus influenced little by management practices. Singh *et al.*, (2016) also found similar results.

Significantly highest grain yield (79.9 q/ha) was observed in weed free treatment (Table 2) followed by butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence (70.5 q/ha) butachlor 1.5 kg a.i./ha pre-emergence fb one hand weeding at 15 days after transplanting (70. q/ha) than other treatments. This was due to better elimination of weeds, highest weed control effectively during the entire crop growth period and better transfer of photosynthates onto the sink resulting in maximum grain yield. Uma *et al.*, (2014) and Charan *et al.*, (2015) also recorded the highest grain yield with bensulfuron methyl + pretilachlor. Similar results were also observed in straw yield.

Harvesting index (Table 2) was not influenced by different treatments but the weed free treatment recorded highest harvesting index of 6.73 %. Minimum harvest index was observed in weedy check (6.44 %). Kumar *et al.*, (2020) also obtained similar results.

Conclusion

It may be concluded that the butachlor 1.5 kg a.i./ha as pre-emergence fb bispyribac 0.025 kg a.i./ha as post-emergence and butachlor 1.5 kg a.i./ha as post-emergence followed by hand weeding at 30 days after transplanting lead to minimum weed density, weed dry weight and higher weed control efficiency, yield contributing factors and ultimately higher grain yield equivalent to weed free treatment.

Acknowledgement

The authors are very helpful to RIMT University for providing necessary requirement for the conduct of the study.

References

1. Anonymous (2020). Directorate of Economics and Statistics DAC&FW Department of Agriculture Cooperation and Farmers Welfare Ministry of Agriculture and Farmers welfare, Govt. of India.
2. Charan Teja, K.B. Duary and M.K. Bhowmik. (2015). Efficiency of herbicides on weed management in wet season transplanted rice. *Journal of Crop and Weed*, 11: 224-27.
3. Kabdal P., Partap T. and Vimal Raj Yadav (2018) Weed management in transplanted rice. *International Journal of Current Microbiology and Applied Sciences*, 7(4): 1660-69.
4. Kumar Ajay, Kumar Sanjay, Dutta Swaraj Kumar, Shambhavi, Shweta, Ghosh Mainak and Behera Subrat Keshiri (2020). Effect of Sequential Application of Different Pre and Post Emergence Herbicides on Growth and Yield of Rice.
5. Kumar S., Kerkeeta D., Agashe R.D., Chouksey R., (2018). Effect of weed management in transplanted rice (*Oryza*

- sativa* L.). *Journal of Pharmacognosy and Phytochemistry*, 1: 635-36.
6. Manhas S.S. and G. Singh D. Singh and V. Khajuria (2012). Effect of tank-mixed herbicides on weeds and transplanted rice (*Oryza sativa* L.) *Annals Agricultural Research New Series*, 33: 25-31
 7. Mustafa Sohail Rashid, Muhammad Aamer, Akash zafar, Adeel Muktar, Muhammad Makky Javed (2017). Weed management in transplanted rice through different weedicides at Rice Research Station Bahawalnagar. *Asian Journal of Plant Science and Research*. 7(3): 11-13.
 8. Saphi D.K., Yadav Dil Raj., Yadav Rajib Kumar (2018). *International Journal Applied Sciences Biotechnol* 6(4): 428-432.
 9. Sharma Rupan, Gorain Jaladhar, Poddar Parthendu, Maitra Sagar and Pandey Manjil(2020). Chemical weed management in translated rice. *International Research Journal of Pure and Applied Chemistry*, 21(7): 63-72.
 10. Uma G. and M.V. Ramana (2014). Evaluation of low dose herbicides in transplanted rice (*Oryza sativa* L.). *International Journal of Applied Biology and Pharmaceutical Technology*, 5(4): 96-101.
 11. Yadav Vimal Raj, Singh Pratap V. and Kabdal Priyanka (2018). Integrated Weed Management in Transplanted Rice-An Effective Approach. *International Journal of Current Microbiology and Applied Sciences* 7(4): 1670-79.



Assessment of Genetic Variability Among Muskmelon (*Cucumis melo*) Genotypes in the Hot Arid Regions

Priyanka, Santosh Choudhary* and S.K. Moond

Department of Horticulture, College of Agriculture, Agriculture University, Jodhpur 342304, Rajasthan

*Corresponding author's Email : s.choudhary83@yahoo.co.in

Abstract

In the present study, 32 genotypes of muskmelon were evaluated during 2018-19 at the College of Agriculture, Jodhpur Rajasthan, India, to determine genetic variability, heritability, and genetic advance for 15 quantitative characters. Results revealed significant variations for all the characters of muskmelon under study. Among various characters, fruit yield (q/ha) revealed the highest phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV) values, followed by fruit yield per plant, fruit weight, and shelf life. The low PCV and GCV values were reported for fruit set, days to first female flower opening, and days to first fruit harvest. High heritability coupled with high genetic advance was recorded for fruit yield (q/ha). Low heritability with low GAM was recorded for vine length at final harvesting, number of primary branches per vine, number of node at which first female flower appeared, fruit set, and days to first fruit harvest. The study results indicated the preponderance of additive gene action involved in the inheritance of characters like fruit yield (q/ha), fruit weight, and fruit yield per plant. Therefore, breeding through a selection of these characters may be helpful in the improvement of fruit yield.

Key words : Genetic advance, heritability, muskmelon, variability.

Introduction

Muskmelon (*Cucumis melo* L., $2n=2x=24$.) is one of the economically important crops of the Cucurbitaceae family. In India, it is extensively grown in the arid and semi-arid regions. It is one of the most important summer crops due to its high nutritive and medicinal value and sweetness (Reddy *et al.*, 2013). Muskmelons are insect-pollinated and cross-pollinated crops, so high genetic diversity is present within the plant population. Despite its recognized potential and multiple virtues, it is less remunerative for commercial cultivation due to the low productivity of the current open-pollinated varieties with sub-optimal fruit quality. Hence, further genetic improvement in cultivars for yield and quality is needed. The wide genetic diversity within the available genotypes and cultivars offers ample scope for further improvement through a breeding programme to identify farmers' stable and good-yielding varieties. Therefore, the knowledge of genetic variability within the available germplasm is essential for developing superior genotypes in the form of a cultivar. Breeding for desirable traits requires an understanding of the morpho-physiological and biochemical responses of muskmelon to agro-climatic conditions which will help in identifying traits to be used as selection criteria for improving the yield (Kumar *et al.*, 2012). Therefore, the diverse genotypes of muskmelon were evaluated for accessing morpho-physiological biochemical parameters related to fruit yield to derive more helpful information. Therefore, it becomes necessary to partition the observed phenotypic variability of various traits into its heritable and

non-heritable components for exploiting inherent variability and other selection among genotypes with suitable genetic parameters such as phenotypic and genotypic coefficient of variation, heritability, genetic advance, and genetic advance as percent of the mean. Therefore, the present study was undertaken to evaluate the germplasm for various traits and to study the extent of genetic variability in the material of muskmelon in order to develop new varieties to sustain food production under adverse climate conditions.

Materials and Methods

A total of 32 genotypes of muskmelon (Table-1) were evaluated in a randomized block design with three replications at Agricultural Research Station, Mandor, Agriculture University, Jodhpur ($26^{\circ}45''N$ and $73^{\circ}29''E$ at an altitude of 231 meters amsl) during summer 2018 (March-June). The Seeds of each genotype were grown in a double-row plot of 7.0m in length. Rows were spaced 2.0 m apart, while plants were spaced 0.6 m apart, accommodating 10 plants in a row. All the recommended cultural practices were followed during the experiment. Observations were recorded on a total of 17 quantitative characters. The observations on main vine length; the number of primary branches per vine; internodal length; the number of nodes at which the first female flower appeared; percent fruit set; the number of marketable fruit per plant, and days to first fruit harvest were recorded from five randomly selected plants from each plot. The observation related to fruit parameters like fruit diameter; fruit length; fruit weight; fruit yield, rind thickness; flesh

Table-1 : Genotypes of muskmelon used for evaluation.

S. No.	Genotype	Source	S. No.	Genotype	Source
1.	GMM-3	GAU, Anand	17.	VRMM-163	IIVR, Varanasi
2.	MHY-5	RARI, Durgapura	18.	VRMM-313	IIVR, Varanasi
3.	MHY-3	RARI, Durgapura	19.	VRMM-205	IIVR, Varanasi
4.	RM-43	RARI, Durgapura	20.	VRMM-158	IIVR, Varanasi
5.	RM-50	RARI, Durgapura	21.	VRMM-194	IIVR, Varanasi
6.	Durgapura Madhu	RARI, Durgapura	22.	VRMM-196	IIVR, Varanasi
7.	Arka Jeet	IIHR, Bengaluru	23.	VRMM307	IIVR, Varanasi
8.	Pusa Madhuras	IARI, New Delhi	24.	VRMM-315	IIVR, Varanasi
9.	Pusa Sharbati	IARI, New Delhi	25.	VRMM-127	IIVR, Varanasi
10.	Punjab Sunehri	PAU, Ludhiana	26.	VRMM-423	IIVR, Varanasi
11.	Hara Madhu	PAU, Ludhiana	27.	VRMM-402	IIVR, Varanasi
12.	Kashi Madhu	IIVR, Varanasi	28.	VRMM-153	IIVR, Varanasi
13.	IC-0599709	CIAH, Bikaner	29.	VRMM-106	IIVR, Varanasi
14.	IC-0624304	CIAH, Bikaner	30.	VRMM-207	IIVR, Varanasi
15.	IC-0624305	CIAH, Bikaner	31.	VRMM-201	IIVR, Varanasi
16.	VRMM-11	IIVR, Varanasi	32.	Jodhpur Local	Raymalwara, Osian-Jodhpur

Table-2 : Mean performance of muskmelon genotypes for growth, fruit characters and yield.

S. No.	Genotype	Main vine length at harvest (cm)	Fruit set (%)	Number of marketable fruits / plant	Days to first fruit harvest	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (kg)	Fruit yield / plant (kg)	Fruit yield (q/ha)
1.	GMM-3	86.2	80.3	3.2	73.7	11.8	10.4	0.647	2.09	213.4
2.	MHY-5	90.9	83.3	3.9	68.5	10.0	11.6	0.683	1.78	238.1
3.	MHY-3	98.6	77.6	3.9	69.6	8.9	11.6	0.681	1.990	236.9
4.	RM-43	95.5	82.4	3.7	70.2	7.8	13.7	0.567	1.56	202.9
5.	RM-50	87.1	77.5	3.3	71.5	10.0	11.0	0.550	1.82	187.5
6.	Durgapura Madhu	91.9	78.2	2.8	70.8	7.9	14.8	0.820	2.07	210.1
7.	Arka Jeet	98.7	78.0	3.6	71.4	10.9	10.1	0.468	1.51	154.2
8.	Pusa Madhuras	95.4	78.4	3.4	69.9	12.4	11.8	0.562	1.92	190.5
9.	Pusa Sharbati	101.9	78.1	3.7	68.9	9.9	10.3	0.569	2.14	207.5
10.	Punjab Sunehri	105.5	83.2	3.8	70.7	11.9	11.3	0.663	2.29	252.8
11.	Hara Madhu	92.7	77.7	3.3	71.7	11.5	11.9	0.717	1.78	242.4
12.	Kashi Madhu	93.6	81.9	3.8	71.0	12.3	9.3	0.731	2.01	283.2
13.	IC-0599709	87.3	72.2	2.7	72.5	10.6	10.8	0.709	1.60	197.5
14.	IC-0624304	85.8	73.5	3.2	73.9	10.0	10.4	0.585	1.55	192.6
15.	IC-0624305	93.0	77.1	3.5	72.7	9.3	9.3	0.560	1.48	207.6
16.	VRMM-11	88.3	72.3	2.6	73.5	10.3	8.7	0.370	0.942	99.5
17.	VRMM-163	79.1	75.1	2.2	74.5	10.7	11.6	0.472	1.02	104.8
18.	VRMM-313	93.9	72.5	3.0	75.9	8.4	12.3	0.325	0.977	99.7
19.	VRMM-205	106.5	84.8	4.1	71.2	14.5	14.2	0.646	2.60	262.1
20.	VRMM-158	83.1	73.1	2.8	76.3	9.7	8.5	0.330	0.888	90.6
21.	VRMM-194	84.2	70.9	3.1	77.4	9.4	10.5	0.383	1.20	99.9
22.	VRMM-196	95.5	75.5	3.1	77.6	12.5	13.9	0.494	1.48	150.6
23.	VRMM-307	103.3	75.7	2.2	76.6	9.5	14.1	0.445	1.10	97.3
24.	VRMM-315	81.1	74.2	2.4	72.2	9.8	13.0	0.357	1.04	98.5
25.	VRMM-127	96.6	76.0	2.1	76.1	7.8	12.2	0.275	0.601	64.3
26.	VRMM-423	91.7	72.4	2.6	80.6	10.2	8.3	0.285	0.733	74.8
27.	VRMM-402	87.7	82.0	2.8	76.4	9.0	8.7	0.332	0.969	100.1
28.	VRMM-153	96.9	76.8	3.8	72.8	9.2	10.1	0.324	1.11	124.8
29.	VRMM-106	95.1	78.0	2.4	73.3	9.9	8.4	0.313	1.16	78.9
30.	VRMM-207	84.9	74.6	1.7	74.0	11.0	13.5	0.462	1.14	105.8
31.	VRMM-201	79.3	73.9	3.2	77.5	13.4	12.8	0.295	0.962	97.2
32.	Jodhpur Local	73.2	65.8	1.7	78.3	6.2	9.7	0.208	0.348	38.8
	SEm ($\pm$)	5.64	3.12	0.35	2.27	0.48	0.85	0.0400	0.16	19.61
	CD (P=0.05)	16.0	8.8	1.0	6.4	1.4	2.4	0.110	0.44	55.4
	CV (%)	10.7	7.1	19.9	5.3	8.1	13.1	13.8	18.9	21.7

Table-3 : Mean performance of muskmelon genotypes for fruit and quality parameters.

S. No.	Genotype	Rind thickness (cm)	Flesh thickness (cm)	Width of cavity (cm)	Length of cavity (cm)	TSS (%)	Shelf life (Days)
1.	GMM-3	0.92	2.07	7.6	7.5	8.1	2.7
2.	MHY-5	0.80	2.56	6.0	9.0	8.5	2.9
3.	MHY-3	0.74	2.16	6.4	9.6	10.5	3.3
4.	RM-43	0.65	2.12	5.9	12.8	11.0	2.9
5.	RM-50	0.96	2.51	6.8	8.3	9.2	3.4
6.	Durgapura Madhu	0.72	2.11	5.9	12.0	11.2	3.8
7.	Arka Jeet	0.90	2.16	6.1	7.5	8.7	4.3
8.	Pusa Madhuras	0.86	2.20	7.3	8.9	10.1	2.9
9.	Pusa Sharbati	1.12	2.04	7.9	7.6	9.7	3.4
10.	Punjab Sunehari	0.66	2.06	5.8	7.9	10.2	5.5
11.	Hara Madhu	0.91	1.81	6.7	9.3	8.4	4.0
12.	Kashi Madhu	0.89	2.14	5.7	7.9	12.2	2.4
13.	IC-0599709	0.99	1.91	5.4	8.2	10.5	2.4
14.	IC-0624304	1.06	2.07	6.3	7.8	8.1	2.7
15.	IC-0624305	0.95	1.63	5.2	7.7	10.9	2.6
16.	VRMM-11	1.19	1.62	5.3	6.7	11.1	3.8
17.	VRMM-163	0.74	2.14	5.3	8.2	7.2	3.4
18.	VRMM-313	0.97	1.75	6.1	9.3	8.5	3.5
19.	VRMM-205	0.83	2.24	5.8	10.3	10.3	5.1
20.	VRMM-158	1.01	1.65	3.9	6.8	9.1	4.3
21.	VRMM-194	0.73	1.78	4.2	7.6	10.9	4.7
22.	VRMM-196	0.82	1.71	6.3	10.0	7.9	4.7
23.	VRMM-307	1.05	2.14	5.3	10.2	8.7	2.7
24.	VRMM-315	0.65	1.95	4.4	10.1	8.0	2.5
25.	VRMM-127	1.11	1.83	4.0	9.0	7.6	3.4
26.	VRMM-423	0.82	1.99	4.4	5.4	8.8	3.5
27.	VRMM-402	0.98	2.05	3.7	5.3	7.9	3.0
28.	VRMM-153	1.09	1.93	4.8	6.3	7.7	3.8
29.	VRMM-106	0.82	1.90	7.1	8.8	9.0	3.2
30.	VRMM-207	0.95	1.88	6.4	10.5	7.4	4.4
31.	VRMM-201	0.67	1.97	6.3	9.5	10.2	4.3
32.	Jodhpur Local	1.07	1.40	4.0	8.0	7.1	2.1
	SEm ($\pm$)	0.090	0.14	0.34	0.55	0.02	0.76
	CD (P=0.05)	0.24	0.40	0.9	1.6	0.6	0.2
	CV (%)	16.6	12.5	10.2	12.0	3.9	3.8

thickness; width, and length of the cavity were recorded from the three randomly selected fruits of each genotype from different plants. The total soluble solids (TSS) were determined by Abbe's hand refractometer, and shelf-life was determined based on the 15% weight loss of fruits at room temperature. Statistical analysis was done on the mean basis across the genotypes. The analysis of variance was calculated individually according to the standard statistical method for each character (Panse and Sukhatme, 1985). The significance was tested by referring to the 'F' table values (Fisher and Yates, 1963). The Phenotypic variances were calculated according to Comstock and Robinson (1952). Genotypic variances, heritability in the broad sense, and expected genetic advance for each character was calculated according to the formulae suggested by Johnson *et al.* (1955).

Results and Discussion

The existence of genetic variability in germplasm is an essential effective selection in a crop improvement programme. Therefore, the extent of variability among 32 genotypes of muskmelon was measured in terms of mean performance (Table-2 and 3), range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in the broad sense (h^2) and genetic advance as percent of the mean (GAM) (Table 4). The mean performance of genotypes revealed a wide range of variability for all the characters (Table 2). Mean performance of genotypes indicated that among 32 genotypes, maximum main vine length was recorded in VRMM-205 followed by Punjab Sunehari. Pusa Sharbati and Durgapura Madhu had a maximum number of primary

Table-4 : Mean, range, GCV, PCV, heritability in broad sense (h^2) and genetic advance as percent of mean (GAM) for various characters in muskmelon.

Character	Mean	Range		GCV (%)	PCV (%)	h^2 (%)	GAM
		Min.	Max.				
Main vine length at harvest (cm)	91.4	73.2	106.5	6.07	12.30	24.36	3.10
Number of primary branches vine ⁻¹	5.0	3.6	6.5	7.97	14.61	29.76	4.33
Inter-nodal length (cm)	5.6	4.7	6.8	10.09	13.95	52.31	5.99
Days to first female flower opening	33.6	31.2	38.4	4.83	6.62	53.11	2.86
Number of node at which first female flower appeared	5.2	3.8	6.2	7.99	14.68	29.61	4.34
Fruit set (%)	76.7	65.8	84.8	3.60	7.92	20.65	1.73
Number of marketable fruit Plant ⁻¹	3.0	1.7	4.1	18.21	26.97	45.61	10.79
Days to first fruit harvest	73.5	68.5	80.6	2.76	6.01	21.00	1.33
Fruit diameter (cm)	10.2	6.2	14.5	16.44	18.33	80.52	7.75
Fruit length (cm)	11.0	8.3	14.8	14.90	19.85	56.35	8.79
Fruit weight (kg)	0.490	0.208	0.820	32.37	35.20	84.58	13.90
Fruit yield (kg plant ⁻¹)	1.43	0.348	2.60	36.19	40.84	78.56	17.67
Fruit yield (q ha ⁻¹)	156.4	38.8	283.2	41.81	47.12	78.75	20.34
Rind thickness (cm)	0.90	0.65	1.19	14.01	21.71	41.68	8.22
Flesh thickness (cm)	1.98	1.40	2.56	10.10	16.04	39.69	5.88
Width of cavity (cm)	6.0	3.7	7.9	18.29	21.44	76.9	9.3
Length of cavity (cm)	9.0	5.3	12.8	14.85	15.34	72.7	9.7
TSS (%)	9.2	7.1	12.2	14.85	15.35	93.68	4.30
Shelf life (Days)	3.5	2.1	5.5	24.32	24.61	97.65	4.38

branches vine-1 while, maximum fruit set was observed in VRMM-205 followed by MHY-3. Genotype VRMM-205 and MHY-5 showed the highest marketable fruits per plant and early fruit harvesting, respectively. Durgapura Madhu and VRMM-205 had maximum fruit diameter, while VRMM-205 and VRMM-201 showed maximum fruit length. The highest fruit weight was reported in Durgapura Madhu while, fruit yield per plant (kg) and fruit yield (q/ha) were observed highest in VRMM-205, followed by Punjab Sunehri. Genotypes VRMM-315 and RM-43 were observed for minimum rind thickness, while maximum flesh thickness was observed in MHY-5, followed by RM-50. Pusa Sharbati and GMM-3 had a maximum width of the cavity, whereas RM-43 and Durgapura Madhu were observed for the maximum length of the cavity. Maximum TSS was recorded in Kashi Madhu followed by Durgapura Madhu, while Punjab Sunehri and VRMM-205 had a maximum shelf life. These findings of Raja *et al.* (2007) in bitter gourd and Celine *et al.* (2010) in snake gourd supported the variation in the number of fruits per plant, fruit yield per plant, and average fruit weight. Nirmal *et al.* (2008) observed similar results for flesh thickness, fruit cavity size, and TSS content in muskmelon, while Torkadi *et al.* (2007) and Tomar *et al.* (2008) supported the trends for days to first fruit harvest in different genotypes. The findings of Reddy *et al.* (2013) supported the variation in rind thickness while the shelf life was similar to the findings of Rakhi and Rajamony (2005).

In muskmelon genotypes high range of variability was observed for most of the characters, viz., main vine length at harvest, fruit weight, fruit set, fruit diameter, fruit length, fruit yield per plant, and fruit yield q/ha. Similar

results were also reported by Torkadi *et al.* (2007) in muskmelon. Whereas, narrow range of variability was observed for the characters viz., number of primary branches per plant, inter-nodal length, days to first female flower opening, number of node at which first female flower appeared, rind thickness, flesh thickness, the width of the cavity, length of the cavity, TSS and shelf life. These results agree with the finding of Tomar *et al.* (2008); and Janghel *et al.* (2018) in muskmelon.

Comparison of the coefficients of variation indicated that the phenotypic coefficient of variation was higher than the genotypic coefficients of variation for all the characters, which indicated the effect of the environment on the character expression. Among all the characters, high GCV and PCV (>20%) were observed for fruit weight as similar to earlier findings of Rakhi and Rajamony (2005) in culinary melon and Mahla and Choudhary (2013) in watermelon. Similar results for fruit yield plant⁻¹, fruit yield (q ha⁻¹) were found in previous studies of Mahla and Choudhary (2013) in watermelon. The results of shelf life obtained in this study are similar to reports of Janghel *et al.* (2018) in muskmelon. The higher GCV and PCV indicated the presence of a high amount of genetic variability for these traits; therefore, selection would be effective for these characters. Moderate GCV and PCV (10-20%) were observed for inter-nodal length, fruit diameter, fruit length, length of the cavity, flesh thickness, and TSS. Similar results were also reported by Tomar *et al.* (2008) in muskmelon and Khan *et al.* (2009) in the pointed gourd. Low GCV and PCV (<10%) for days to first female flower opening was similar to Samadia (2007) in round melon and Reddy and Shanthi (2013) in

muskmelon. The results of the fruit set and days to first fruit harvest were supported by Janghel *et al.* (2018) and Potekar *et al.* (2014) in muskmelon. Low PCV and GCV depicted lesser variability for these characters, and selection for these traits will be less effective.

The heritability estimate was high (>60%) for fruit weight, fruit yield (q/ha), fruit yield per plant, fruit diameter, length of the cavity, the width of cavity, TSS, and shelf life. These results are in close conformity with earlier findings of Janghel *et al.* (2018) for fruit weight, fruit yield (q/ha), fruit yield per plant and fruit diameter, Reddy and Shanthi (2013) for the length of cavity and width of cavity, and Rakhi and Rajamony (2005) for TSS and shelf life in muskmelon. Heritability estimate was moderate (30-60%) for days to first female flower opening, the number of marketable fruits per plant, inter-nodal length, fruit length, rind thickness, and flesh thickness which were similar to the results of Tomar *et al.* (2008) and Reddy and Shanthi (2013) in muskmelon. Low estimates heritability (<30%) was recorded for main vine length at harvest, number of primary branches per plant, number of node at which first female flower appeared, fruit set, days to first fruit harvest, which were similar to results of Khan *et al.* (2009) in pointed guard. The heritability estimates and genetic advances were more helpful than heritability estimates alone in predicting the response to selection (Johanson *et al.*, 1955). In the present investigation, a relative comparison of heritability and GAM over the characters indicated that characters *viz.* fruit yield per plant, fruit yield (q/ha), fruit weight, and a number of marketable fruits per plant had high heritability along with high GAM. These results indicated a preponderance of additive gene action involved in the inheritance of particular traits, and selection may be helpful for these traits. These results were similar to the earlier finding of Rakhi and Rajamony (2005) in culinary melon, Tomar *et al.* (2008); and Janghel *et al.* (2018) in muskmelon.

It is concluded that the higher estimates of the genotypic and phenotypic coefficient of variation for most of the characters under study indicated adequate variability in the existing germplasm for developing potential futuristic pre-breeding lines of muskmelon for its genetic improvement. Furthermore, high or moderate estimates of heritability and genetic advance for the characters like fruit yield (q/ha), fruit weight, and fruit yield per plant indicated additive gene action and effectivity for selection.

References

1. Celine V.A., Seeja G. and Gokulapalan C. (2010). Evaluation of snake gourd genotypes for different seasons in the humid tropics. *Indian J. Hortic*, 67: 185-188.
2. Comstock R.E. and Robinson H.F. (1952). Genetic parameters, their estimation and significance. In: *Proceeding of 6th International Grassland Congress*, 1: 284-291.
3. Fisher R.A. and Yates F. (1963). *Statistical Tables for Biological, Agricultural and Medical Research*. Oliver and Boyd, Edinburgh.
4. Janghel A.K., Trivedi J., Sharma D., Lodhi Y.K. and Kumar L. (2018). Genetic variability in muskmelon (*Cucumis melo* L.) under protected condition. *Int. J. Curr. Microbiol. Appl. Sci.*, 6: 211-217.
5. Johanson H.W., Robinson H.F. and Comstock R.E. (1955). Estimates of genetic and environmental variability of soybean. *Agron. J.*, 47: 314-318.
6. Johnson H.W., Robinson H.F. and Comstock E. (1955). Estimates of genetic and environment variability in Soy-bean. *Agron. J.*, 47: 314-318.
7. Khan S.M.M.R., Kabir M.Y. and Alam M.M. (2009). Variability, correlation path analysis of yield and yield components of the pointed gourd. *J. Agric. Rural Dev.*, 7(1/2): 93-98.
8. Kuma, R., Solankey S.S. and Singh M. (2012). Breeding for drought tolerance in vegetables. *Vegetable Sci.*, 39 (1): 1-15.
9. Mahla H.R. and Choudhary B.R. (2013). Genetic diversity in seed purpose watermelon (*Citrullus lanatus*) genotypes under rainfed situations of Thar Desert. *Indian J. Agric. Sci.*, 83: 300-303.
10. Nirmal D.E., Ram D. and Pandey S. (2008). Physiological traits as determinant of yield in muskmelon under field conditions. *Indian J. Hortic*, 65(1): 40-43.
11. Panse V.G. and Sukhatme P.V. (1985). Statistical methods for agricultural workers 2nd Ed. Indian Council of Agricultural Research, New Delhi, pp. 245-250.
12. Potekar S.V., Nagre P.K. and Sawant S.N. (2014). Genetic variability study in muskmelon. *J. Trop. Agric.*, 32: 3-4.
13. Raja S., Bagle B.G. and Dhandar D.G. (2007). Genetic variability studies in bitter gourd for zero irrigated condition of semi-arid eco system. *Indian J. Hortic*, 64(4): 425-429.
14. Rakhi R. and Rajamony L. (2005). Variability, heritability and genetic advance in landraces of culinary melon (*Cucumis melo* L.). *J. Trop. Agric.*, 43: 79-82.
15. Reddy S.A.K. and Shanthi A. (2013). Variability and genetic diversity studies of muskmelon accession in the recoastal region of Karaikal. *Green Farming*, 4(6): 764- 766.
16. Reddy B.P.K., Begum H., Sunil N. and Reddy M.T. (2013). Variance component analysis of quantitative traits in musk-melon (*Cucumis melo* L.). *Trakia J. Sci.*, 2: 118-124.
17. Samadia D.K. (2007). Studies on genetic variability and scope of improvement in round melon under hot arid conditions. *Indian J. Hortic*, 64: 58-62.
18. Tomar R.S., Kulkarni G.U. and Kakade D.K. (2008). Genetic analysis in muskmelon (*Cucumis melo* L.). *Int. J. Hortic. Sci.*, 3: 112-118.
19. Torkadi, S.S., Musmade, A.M. and Mangave, K.K. 2007. Genetic variability studies in muskmelon (*Cucumis melo* L.). *J. Soils and Crops*, 17:308-311.



Crop Weed Competition in Late Sown Wheat (*Triticum aestivum* L.) Central Punjab

Hidam Roji Devi and Uddham Singh Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

A field experiment was carried out during *rabi* season of 2020 to study the crop-weed competition of late sown wheat (*Triticum aestivum* L.). The experiment was laid out in randomized complete block design (RCBD) with ten treatments in three replications. The weed control treatments comprised of weedy check throughout, weed free throughout, weed free for 20, 40, 60 and 80 days and weedy check for 20, 40, 60 and 80 days. The highest weed density (64.0 plants/m²) and weed dry weight (60.0 g/m²) were recorded in weedy check throughout, whereas, weedy check at 20 days recorded minimum (18.0 plants/m² and 15.0 g/m² respectively). Weedy check treatments recorded higher weed density and weed dry weight and weed free treatments recorded lower weed density and weed dry weight. 100% weed control efficiency and 0% weed index were recorded in weed free throughout. Weed free for 20, 40, 60 and 80 days and weedy check for 20 days recorded significantly higher weed control efficiency and lower weed index however weedy check for 40, 60 and 80 days recorded lower weed control efficiency and higher weed index. All weed free treatments recorded significantly higher grain yield over weedy check treatments. The highest grain yield (45.0 q/ha) was recorded in weed free throughout which was significantly higher than weed free for 80 days and weed free 60 days (41.0 q/ha and 40.8 q/ha respectively) but was at par with rest of the treatments. Lowest grain yield (24.1 q/ha) was recorded in weedy check throughout. Similar trend was also observed in growth parameters and yield attributes. The highest growth parameter viz. plant height at harvest (89.0 cm) and yield attributes, viz. ear length (12.5 cm), grains per ear (61), weight of grains per ear (2.22g) and 1000 grain weight (43.3g) were recorded in weed free throughout whereas lowest plant height (78.0), ear length (9.5 cm), grains per ear (46.5), grain weight per ear (1.60 g) and 1000 grain weight (38.7 g) were recorded in weedy check throughout. Among the weedy check treatments, weedy check for 20 days recorded the highest growth parameters, yield and yield attributes.

Key words : Wheat, crop-weed competition, growth, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is the most extensively grown cereal crop in the world, covering about 237 million hectares annually accounting for a total of 420 million tonnes and for at least one-fifth of man's calorie intake. It is used in production of bread, biscuits, feeds confectionary, amongst many utilization (Oyewole, 2016). Globally, wheat occupies around 217 million hectares holding the position of the highest acreage among all the crops with the annual production covering around 751 million tonnes. Maximum area under wheat is in India (14%), followed by Russia (12.43%), China (11.4%) and the USA (6.90%) which altogether accounts for about 45% of global area (Ramdas *et al.* 2019). Presently, India is the second largest wheat producing country in the world with an area of 29.14 m ha and produced 102.19 mt of wheat with a productivity of 3507 kg/ha (Anonymous, 2019). In Punjab, wheat was grown on an area of 35.20 lakh hectares during 2018-19 with production of 182.62 lakh tonnes and average yield of 51.88 quintals per hectare (21.0 quintals per acre) (Anonymous, 2020). Among the biotic factors, weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allelopathy and by providing habitat for pathogens as well as serving as alternate host for various insects, fungi and

increase harvest cost. Weed competition is most serious when the crop is young and active at growth stage (Ayana, 2020). The dependence on single method of weed control cannot give the desired results in all situations. The best approach is integrated weed management in which all the suitable methods of weed control are used in a compatible manner to reduce weed population and maintain them at levels below the threshold causing economic injury (Chhokar *et al.* 2012). To obtain maximum wheat yield, weeds should be controlled at proper time in right manner (Chaudhary *et al.* 2008). Keeping in view, the present investigation has been planned to view weed control measures in wheat.

Materials and Methods

The field experiment was conducted during *rabi* season of 2020 at the Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab). Mandi Gobindgarh is situated in Punjab, at 30.6642°N latitude and 76.2914°E longitude at an altitude of 268 meters above mean sea level. The maximum temperature often exceeds 40 °C during summer. Minimum temperature falls below 6°C with some frosty spells of 8-10 days during the winter months of December and January. The average annual rainfall of Mandi Gobindgarh is 730.2mm, about three-fourth of which

Table-1 : Effect of crop-weed competition on the weed parameters, growth parameters, yield attributes and yield of wheat.

Treatments	Weed density (plants/m ²)	Weed dry weight (g/m ²)	Weed control efficiency (%)	Weed index (%)	Plant height (cm)	1000 grain weight (g)	Ear length (cm)	Grains /ear	Grain weight /ear (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Weedy check throughout	8.03 (64.0)	7.78 (60.0)	0	46.4	78.0	38.7	9.5	46.5	1.60	24.1	40.3	37.3
Weed free throughout	0.7 (0.0)	0.7 (0.0)	100	0	89.0	43.3	12.5	61.0	2.22	45.0	58.8	43.3
Weed free for 20 days	5.98 (35.3)	5.61 (31.0)	48.3	17.6	84.5	40.8	11.5	57.0	2.11	37.1	52.4	41.4
Weed free for 40 days	5.81 (33.3)	5.24 (27.0)	55.0	14.2	85.0	41.0	11.8	58.0	2.15	38.6	54	41.7
Weed free for 60 days	5.52 (30.0)	4.95 (24.0)	60.0	9.33	86.5	41.5	12.0	58.5	2.16	40.8	54.4	42.8
Weed free for 80 days	4.95 (24.0)	4.42 (19.0)	68.3	8.89	88.0	42.3	12.3	59.0	2.19	41.0	54.5	42.9
Weedy check for 20 days	4.30 (18.0)	3.94 (15.0)	75.0	18.9	82.0	40.5	11.0	56.0	2.09	36.5	52	41.3
Weedy check for 40 days	6.20 (38.0)	5.96 (35.0)	41.7	24.7	80.0	40.0	10.5	55.0	1.84	33.9	50	40.4
Weedy check for 60 days	6.52 (42.0)	6.23 (38.3)	36.2	35.8	79.0	39.5	10.3	54.0	1.80	28.9	44.3	39.4
Weedy check for 80 days	7.04 (49.0)	6.77 (45.3)	24.5	39.1	78.5	39.0	10.0	52.0	1.76	27.4	42.7	39.2
C.D.	5.10	5.23			3.10	2.33	1.07	1.59	0.20	6.1	6.73	NS

Data of weed parameters (Weed density and weed dry weight) were subjected to square root $\sqrt{x - 0.5}$ transformation and the figures in parentheses are the original values.

is contributed by the south-west monsoon during July to September. The experimental field tested was low in organic carbon (0.48%), low in available nitrogen (144.6 kg N/ha) medium in available phosphorus (17.3 P₂O₅/ha) and medium in potassium (168 kg K₂O/ha). The experiment was laid out in a randomized complete block design (RCBD) comprising ten treatments and three replications. The 112.5 kg seed per hectare was used. The gross plot size was 4.3 m × 3.5 m i.e. 15.05 sqm and net plot size was 4.0 m × 3.0 m i.e. 12 sqm. The seed was sown on 31st December with a seed-cum-fertilizer drill at a depth of 4-6 cm and 15 cm row spacing.

The weed control efficiency (WCE) was calculated by using the following formula :

$$WCE = \frac{\text{Weed dry weight in unweeded plot} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in unweeded plot}} \times 100$$

To determine the weed index, the following formula was used :

$$WI (\%) = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

Results and Discussion

Weed studies : Major weeds found in the experimental field were gulli danda (*Phalaris minor*), jangli palak (*Rumex dentatus*), kandiali palak (*Rumex spinosus*), bathu (*Chenopodium album*) and billi booti (*Anagallis arvensis*).

The data (Table-1) revealed that weed parameters were significantly influenced by different weed management treatments. Highest number of weed density (64.0 plants/m²), dry matter of weed (60.0 g/m²) and weed index (46.4%) were recorded in weedy check throughout resulting in 0% weed control efficiency. 100% weed control efficiency and 0% weed index were recorded in weed free throughout. The weed density and weed dry weight in weed free treatment was taken as zero as the weeds were removed completely and significantly minimum weed density (18.0 plants/m²) and weed dry weight (15.0 g/m²) were recorded in weedy check throughout. Higher weed index was observed in weedy check treatments and lower weed index was observed in weed free treatments. Increased in duration period of weed crop competition increased the fresh and dry matter weight of weeds resulting in decreased of weed control efficiency. Similar observations was recorded by Chaudhary *et al.* (2008).

Growth parameters : The plant height was significantly affected by weed management treatments (Table-1). The weed free throughout recorded the highest plant height (89.0 cm) and the weedy check throughout recorded the lowest plant height (78.0 cm). Higher plant height was observed in weed free treatments and lower plant height was observed in weedy check treatments. This is because, in weedy check treatments, there is heavy competition between the crop and weeds for the nutrients, water and space and hence reduced the plant

height whereas in weed free treatments, higher plant height was observed due to the less competition between the crop and weeds.

Yield Attributes : The yield attributes viz. 1000 grain weight, ear length, grains per ear and grain weight per ear were significantly affected by weed management treatments (Table-1). The highest yield attributes viz. 1000 grain weight (43.3 g), ear length (12.5 cm), number of grains per ear (61.0) and weight of grains per ear (2.22 g) were recorded in weed free throughout and lowest in weedy check throughout viz. 1000 grain weight (38.7 g), ear length (9.5 cm), grains per ear (46.5) and grain weight per ear (1.60 g). Among the weedy check treatments, weedy check throughout recorded the lowest yield attributes followed by weedy check for 80 days in which the yield attributes are 1000 grain weight (39.0 g), ear length (10.0 cm), grains per ear (52), grain weight per ear (1.76 g). The higher yield attributes in weed free treatments is because of the less competition between the crop and weeds and lower yield attributes in weedy check treatments is because of the heavy competition between the crop and weeds that resulted in reduced uptake of nutrients and water.

Grain yield : The weed management treatments affected the grain yield of wheat significantly. The data (Table-1) shows that all the weed-crop competition treatments have significant effect on grain yield. The highest grain yield (45.0 q/ha) was recorded in the weed free treatment and lowest was recorded in the weedy check treatment (24.1 q/ha). Among the weedy check treatments, highest grain yield was recorded in weedy check for 20 days (36.5 q/ha) and lowest grain yield was recorded in weedy check throughout followed by weedy check for 80 days (27.4 q/ha). It is observed that weed free treatments have higher grain yield than weedy check treatments. This is because weeds reduce productivity by competing with the crops for nutrients, water and space, by serving as alternate host for various insects, fungi and increase harvest cost. Similar

trend was observed in straw yield. However, the weed management treatments failed to influence the harvest index of late sown wheat. Though the weed management treatments does not significantly affect the harvest index (H.I.), slightly higher H.I. were observed in weed free treatments and lower H.I. in weedy check treatments. Similar observations were recorded by Chaudhary *et al.* (2008).

Conclusion

It may be concluded that weed free treatments were better and produce higher yield than weedy check treatments. The treatment in which weeds were removed throughout produced highest yield whereas the treatment in which weeds were allow to grow throughout produced the lowest yield. Maximum wheat yields can be obtained by controlling the weeds at proper time and in right manner.

References

1. Anonymous (2019). Agricultural Statistics at a Glance. Government of India, Pp: 50-51.
2. Anonymous (2020). Package of practices for crops of Punjab, Rabi 2018-19. Punjab Agricultural University, Ludhiana, India, Pp: 1-18
3. Ayana B. (2020). Wheat production as affected by weed diversity and other crop management practices in Ethiopia. *International Journal of Research Studies in Agricultural Sciences (IJRSAS)* 6 (9): 14-21.
4. Chaudhary S.U., Hussian M., Ali, M.A., and Iqbal, J. (2008). Effect of weed competition period on yield and yield components of wheat. *J Agric. Res.* 46(1): 47-53.
5. Chhokar R.S., Sharma R.K. and Sharma I. (2012). Integrated weed management in wheat- A review. *J. Wheat Res.* 4 (2): 1-21.
6. Oyewole C. (2016). The wheat crop. *Researchgate* 10.13140: 13776-92164.
7. Ramdas S., Kumar T.M.K. and Singh G.P. (2019). Wheat production in India: Trends and prospects. *Intech. Open* 10.57772:86341.



An Economics Analysis of Tomato Crop in Bilaspur District of Chhattisgarh State, India

Yogeshwari Marko¹, B.C. Jain¹ and V.K. Choudhary²

¹Department of Agricultural Economics, IGKV, Raipur (C.G.)

²College of Agriculture and Research Station, Kurud, Dhamtari

Abstract

The Present Study deals with of the cost and return of tomato production in Bilaspur district of Chhattisgarh. In Chhattisgarh, total production of tomato is 868.60 („000) MT from an area of about 52.89 (000”) Ha. (Director of horticulture, 2018-19). The major tomato producing districts are Raipur, Durg, Bastar, Jashpur and Bilaspur. The total cost of cultivation of tomato of sample farms at overall was Rs. 141507.17/ha. The overall total cost of cultivation of tomato was Rs. 141507.17/ha, it was vary from Rs. 130563.72/ha to Rs. 157471.26/ha for marginal to large farms size. The cost of production was found to be Rs 324.45/qlt, Rs. 322.22/qlt, Rs. 317.21/qlt and Rs 313.88/qlt for marginal, small, medium, and large farms size, respectively. While overall input-output ratio were found to be 1:1.49, On an overall basis Gross returns (total income) was observed to the Rs. 352475.47/ha, while net returns was found to be Rs 210968.30/ha and overall production of tomato was 440.59 quintal /ha.

Key words : Variable cost, Input-output ratio, Benefit cost ratio.

Introduction

The tomato is the edible berry of the plant *Solanum lycopersicum*, commonly known as a tomato plant. The species originated in western South America and Central America. The Nahuatl word *tomatl* gave rise to the Spanish word *tomate*, from which the English word *tomato* derived. Its domestication and use as a cultivated food may have originated with the indigenous peoples of Mexico. Tomato (*Lycopersicon esculentum*) belongs to the genus *Lycopersicon* under *Solanaceae* family. Tomato is rich source of vitamins A, C, potassium, minerals and fibers. Tomato is one of the most important protective food crops of India. India ranks second in the area as well as production of tomato next to China. Chhattisgarh produces about 0.63 m. MT of tomatoes from an area to around 0.04 m. ha, accounting for 4% of total tomato production in the country. Crop productivity is 14.6 t/ha. Raipur, Durg, and Bastar are the state's major tomato- producing belts. The major tomato producing districts are Raipur, Durg, Bastar, Balod and Jaspur.

Materials and Methods

Collection of data : The study is based on both primary and secondary data. The primary data was collected from the selected respondents with the help of pre-tested interview schedule by the personal interview method and secondary data was collected from Chhattisgarh agriculture statistics, land record office, annual districts statistics and other published and unpublished reports.

Methodology : 60 farmers were selected randomly from three different farming area of Chhattisgarh. A

multistage simple random sampling technique (SRS) was adopted to select the block, villages and the respondents, market and different farmer involved in tomato production and marketing in Bilaspur district area. The details of the sampling techniques at various stages are given as under:

Profitability concept

Gross income = (Quantity of main product X price of main product) + (Quantity of by product X price of by product.)

Net income = Gross income - Cost C_2

Family labour income = Gross income - Cost B_2

Family business income = Gross income - Cost A_1

Benefit cost ratio = Gross income/Cost C_2

Cost of Production = $\frac{\text{Total Cost}}{\text{Main Produced (q / ha)}}$

Results and Discussion

Cost concept : All most every day in farm organization and operation cost consideration enters. It is an important tool for measuring farm business activities. The farm management specialists have specified cost of cultivation into cost A_1 , A_2 , B_1 , B_2 cost C_1 , C_2 and C_3 . These cost concepts have already been taken up in the methodology chapter. In this section efforts have been made to discuss according to (various costs concepts) tomato cultivation in Bilaspur district of Chhattisgarh state.

Cost on different heads of tomato in the Bilaspur district : Costs and return of tomato cultivation is essential to understand that how much cost incurred for different inputs and whether farmers are receiving the profit or not. It is therefore, the cost and return of tomato

Table-1 : Cost of cultivation of tomato in Bilaspur district (Rs/ha).

Particular	Marginal		Small		Medium		Large		Overall	
	Rs/ha	%	Rs/ha	%	Rs/ha	%	Rs/ha	%	Rs/ha	%
A. Variable costs										
1. Human labour										
(a) Family labour	34065.25	26.09	24605.55	16.93	12200	7.92	1156.33	0.73	24243.14	17.13
(b) Hired labour	24125.65	18.48	36125.45	24.85	48253.25	31.32	59455.63	37.76	35281.99	24.93
Total human labour	58190.9	44.57	60731	41.78	60453.25	39.24	60611.96	38.49	59525.13	42.07
2. Machine power	5510.5	4.22	5125.65	3.53	5825.5	3.78	5915.25	3.76	5506.10	3.89
3. Seed	6125.32	33.55	7210.25	35.53	7965.45	37.85	8005.25	37.58	6939.98	4.90
4. Manure and fertilizer	9225.65	50.53	9875.5	48.66	10126.33	48.12	10131.25	47.56	9654.63	6.82
5. Plant protection	16585.45	90.84	24450.5	120.49	28652.55	136.16	30195.5	141.74	22256.10	15.73
6. Irrigation	1765.5	9.67	2250.5	11.09	2495.65	11.86	2565.12	12.04	2108.66	1.49
7. Staking	15650.5	11.99	16580.25	11.41	19022.65	12.35	20165.55	12.81	16968.17	11.99
8. Interest on working capital	5377.17	4.12	6054.90	4.17	6435.79	4.18	6583.73	4.18	5872.63	4.15
Total Variable costs	112305.67	86.02	125068.30	86.04	133011.72	86.34	136168.36	86.47	121891.42	86.14
B. Fixed cost										
1. Land revenue	12	0.01	12	0.01	12	0.01	12	0.01	12.00	0.01
2. Rental value of land	18000	13.79	20000	13.76	20500	13.31	20650	13.11	19256.67	13.61
3. Depreciation	123.5	0.09	145.5	0.10	165.55	0.11	235.25	0.15	148.25	0.10
4. Interest on fixed capital	122.55	0.09	135.33	0.09	365.66	0.24	405.65	0.26	198.84	0.14
Total fixed cost	18258.05	13.98	20292.83	13.96	21043.21	13.66	21302.90	13.53	19615.76	13.86
Total cost (A+B)	130563.72	100	145361.13	100	154054.93	100	157471.26	100	141507.17	100

Table-2 : Measures of farm profit in tomato cultivation in Bilaspur district (Rs/ha).

Particular	Marginal	Small	Medium	Large	Overall
Cost of cultivation (Rs/ha)	130563.72	145361.13	154054.93	157471.26	141507.17
Cost of production (Rs/qlt)	324.45	322.22	317.21	313.88	321.17
Yield main product (qlt)	402.42	451.12	485.66	501.69	440.59
Gross Income (Rs/ha)	321936	360896	388528	401352	352475.47
Net income (Rs/ha)	191372.28	215534.87	234473.07	243880.74	210968.30
Input output ratio	2.47	2.48	2.52	2.55	2.49
B:C ratio	1.47	1.48	1.52	1.55	1.49

cultivation in Bilaspur district was estimated in Rs/ha, which is given in table-1.

The total cost of cultivation of tomato of sample farms at overall was Rs 141507.17/ha. total variable cost was 86.14 per cent and the share of human labour (hired and family labour) cost was maximum and found to be 42.07 per cent followed by materials imputed cost manure and fertilizer (6.82 per cent), plant protection (15.73 per cent), machine power cost (3.89 per cent), seed (4.90 per cent), interest on working capital (4.15 per cent), irrigation (11.99 per cent). Total fixed cost was 13.86 per cent, rental value of owned land was 13.61 per cent and interest on fixed capital was 0.14 per cent. Among all the input cost human labour was noticed to be the major cost. In which, imputed value of hired labour cost was shared comparatively more than that of family labour cost i.e. 24.93.

The total cost of cultivation of tomato was increasing with respect to farm size of holdings and found to be

maximum under large farms Rs 136168.36 /ha and minimum at marginal farms Rs 112305.67/ha.

Measures of farm profit in tomato cultivation in Bilaspur district : The economics of tomato cultivation presented in table 2. It has been observed from empirical findings that overall total cost of cultivation of tomato was Rs 141507.17/ha, it was vary from Rs 130563.72/ha to Rs 157471.26/ha for marginal to large farms size. The cost of production was found to be Rs 324.45/qlt, Rs 322.22/qlt, Rs 317.21/qlt and Rs 313.88/qlt for marginal, small, medium, and large farms size, respectively. While overall input-output ratio were found to be 1:1.49, On an overall basis Gross returns (total income) was observed to the Rs 352475.47/ha, while net returns was found to be Rs 210968.30/ha and overall production of tomato was 440.59 quintal/ha.

Cost obtain on the basis of different cost concept of tomato in Bilaspur district : Cost of cultivation of

Table-3 : Break-up of total cost obtained over different cost of tomato in Bilaspur district (Rs/ha).

Cost/Category	Marginal	Small	Medium	Large	Overall
Cost A ₁	78375.92	100620.25	120989.27	135259.28	97808.52
Cost A ₂	78375.92	100620.25	120989.27	135259.28	97808.52
Cost B ₁	78498.47	100755.58	121354.93	135664.93	98007.36
Cost B ₂	96498.47	120755.58	141854.93	156314.93	117264.03
Cost C ₁	112563.72	125361.13	133554.93	136821.26	122250.50
Cost C ₂	130563.72	145361.13	154054.93	157471.26	141507.17
Cost C ₃	143620.09	159897.24	169460.43	173218.39	155657.89

Table-4 : Return obtained over different cost of tomato in Bilaspur district (Rs/ha).

Particulars	Marginal	Small	Medium	Large	Overall
Return over cost A ₁	243560.08	260275.75	267538.73	266092.72	254666.94
Return over cost A ₂	243560.08	260275.75	267538.73	266092.72	254666.94
Return over cost B ₁	243437.53	260140.42	267173.07	265687.07	254468.10
Return over cost B ₂	225437.53	240140.42	246673.07	245037.07	235211.44
Return over cost C ₁	209372.28	235534.87	254973.07	264530.74	230224.96
Return over cost C ₂	191372.28	215534.87	234473.07	243880.74	210968.30
Return over cost C ₃	178315.91	200998.76	219067.57	228133.61	196817.58

**Fig.-1 : Total Costs of tomato cultivation of sampled household in Bilaspur district.****Fig. 2 : Measures of farm profit in tomato in Bilaspur district (Rs/ha).**

tomato of sample farms in the Bilaspur district has been worked out and presented in table 3. It is envisaged that Cost A₁ as designated the variable cost and it was found to be Rs 975808.52/ha an overall basis, which was added of rent paid for lease in land and dignified with Cost A₂, found to be Rs. 97808.52/ha, indicates the interest on fixed capital imputed with Cost B₁ Rs 98007.36/ha rental value

of own land Rs 19256.67/ha prevailed in the study area. Normally, farmers are cultivating the crop in their own land but it has imputed rental value of land of Rs 19256.67/ha notified Cost B₂ was Rs. 117264.03/ha. The Cost C₁ found to be Rs. 122250.50/ha, includes the value of Cost B₁ and imputed value of family labour was found to be Rs 24243.14/ha, The Cost C₂, found to be Rs 141507.17/ha,

includes the value of Cost B₂ and imputed value of family labour and The Cost C₃, found to be Rs. 155657.89/ha, imputed value of managerial allowances at 10 per cent of Cost C₂.

Return obtained over different cost of tomato in Bilaspur district : Table-4 shows the returns over Cost A₁, Cost A₂, Cost B₁, Cost B₂, Cost C₁, Cost C₂, and Cost C₃ was obtained to be Rs. 254666.94/ha, Rs. 254666.94/ha, Rs. 254468.10/ha, Rs. 235211.44/ha, Rs. 230224.96/ha, Rs. 210967.58/ha and Rs. 196817.58/ha, respectively.

References

1. Anonymous (2018-19). Directorate of NHM, Department of National Horticulture Mission, Raipur.
2. Jain, B.C. and Tegar, A. (2003). Economic of production and marketing of tomato in Jaspur district of Chhattisgarh. *Agricultural Marketing*. 46(3): 5-10.
3. Koshta, A.K. and Chandrakar, M.R. (1999). Economics of production and Marketing of vegetable crops in Durg district of Chhattisgarh region. *Agricultural Marketing*. 42(2): 28-30.
4. Kumar A. 2015. To study different marketing channel, marketing efficiency and problem in vegetable marketing in Varanasi district of Uttar Pradesh. *International Journal of Sales and Marketing Management Research and Development*, 5:35-44
5. Ramya, S.I. (2009). Production and Marketing of major vegetable in Bilaspur District. Thesis submitted to department of Agricultural and Natural Resource Economics IGKVV Raipur, Chhattisgarh.
6. Shende, N.V. and Meshram, R.R. 2015. Cost benefit analysis and marketing of tomato vegetable in Bhandara district. *American International Journal of Research in Formal, Applied and Natural Sciences*, 11(1): 46-54.
7. Sonawani, M. and Jain, B.C. 2015. Economics of production and marketing of Tomato in Mahasamund district of Chattisgarh. *Research Journal of Agril. Sciences*, 6: 1580-1583.
8. Ramya, S.I. (2009). Production and Marketing of major vegetable in Bilaspur District. Thesis submitted to department of Agricultural and Natural Resource Economics IGKVV, Raipur, Chhattisgarh.
9. Verma Anjali, Jain B.C., Sharma S. and Sai Y.K.. 2020. Cost of Cultivation of Tomato Crop in Durg District of Chhattisgarh, India. *Int. J. Curr. Microbiol. App. Sci.* 9(06): 3406-3410.



Response of Late Sown Wheat (*Triticum aestivum* L.) to Nitrogen Levels under Different Sowing Methods

Amandeep Kaur and Udham Singh Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

A field experiment was conducted during the *rabi* season of 2020 at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the response of late sown wheat (*Triticum aestivum* L.) to nitrogen levels under different sowing methods. The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments comprised of three sowing methods viz. conventional sowing, bi-directional sowing and bed planting; and three nitrogen levels viz. 75, 100 and 125% of recommended dose of nitrogen (RDN). All the growth and yield attributing characters significantly increased in bed planting and bi-directional sowing over conventional except ear length. The grain yield was significantly higher in bi-directional (44.9 q ha⁻¹) and bed planting (47.7 q ha⁻¹) over conventional method (35.4 q ha⁻¹). The magnitude of increase in grain yield in bed planting and bi-directional sowing over conventional sowing was 23 and 31 per cent, respectively. But the differences in grain yield between bed planting and bi-directional was non-significant. Straw yield also followed the same trend but harvest index was not influenced significantly by sowing methods. The application of 125 and 100% RDN recorded significantly higher growth and yield attributes over 75% RDN except ear length. The 125% RDN recorded significant higher grain yield (47.4 q ha⁻¹) over 75% RDN (36.8 q ha⁻¹) but was at par with 100% RDN (42.0 q ha⁻¹). The differences in grain yield between 75 and 100% RDN was also non-significant. The application of 125% RDN recorded 29.1 and 12.8 percent higher grain yield of late sown wheat over 75 and 100% RDN, respectively. Straw yield also followed the same trend but harvest index was not influenced significantly by nitrogen levels. Interaction between sowing methods and nitrogen levels was found non-significant in all the parameters.

Key words : Nitrogen level, Sowing methods, growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) has the highest importance among all the crops grown for the grain purpose worldwide. In India wheat alone covers about 25% of the total area covered by cereal crops. Wheat flour mostly used for making chapati and bread (Singh *et al.* 2007). Wheat is major cereal crop in Punjab. Presently, in Punjab wheat crop occupy 35.20 lakh hectares during 2020-21 with the production of 176.2 lakh tonnes and average yield of 50.04 quintal per hectares (Anonymous, 2021). There were various factors involved in low production of wheat including application of nitrogen fertilizer in improper amount, edaphic properties, method of sowing, quality of irrigation water, prevailing climate condition and mismanagement of field operation by the farmer due to lack of knowledge and awareness. Nitrogen is main component and major constitute of plants for formation of living tissues. It is necessary to apply nitrogen fertilizer in the soil for bumper yield of wheat (Ullah *et al.* 2018). Wheat is planted with different sowing methods depending upon the available soil water, time of planting amount residue in the field (Tanveer *et al.* 2003). So, it is essential to evaluate the location specific nutrient management to restore the nutrient balance in soil and to sustain the crop productivity. Keeping these in view the

present study entitled “Response of late sown wheat to nitrogen levels under different sowing methods” was undertaken.

Materials and Methods

The experiment was carried out during the *rabi* season 2020-21 at the Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of three methods of sowing viz. Conventional sowing, bi-directional sowing and bed planting and three nitrogen levels viz. 75, 100 and 125% RDN. The seed at the rate of 112.5 kg was used irrespective of the sowing methods. The nitrogen in the form of urea (46% N) was applied as per the treatments. The gross plot size was 4.3 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on December 31, 2020 and harvested on May 10, 2021. All the other practices were applied uniformly to the treatments.

Table-1 : Effect of nitrogen levels under different sowing methods on the growth parameters, yield attributes and yield of late sown wheat.

Treatments	Plant height (cm)	Ear length (cm)	Grains/ear	Grain wt./ear	Test wt. (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index (%)
Sowing methods								
Conventional	72.6	9.1	44.6	1.55	36.5	35.4	50.1	39.3
Bi-directional	88.7	10.8	52.5	1.96	42.8	44.9	61.1	41.6
Bed planting	89.1	13.2	54.6	2.15	47.7	47.7	63.8	42.4
CD at 5%	8.7	2.97	6.91	0.40	5.6	7.48	5.07	NS
Nitrogen levels								
75% RDN	73.5	8.9	41.5	1.33	37.1	36.8	51.4	39.5
100% RDN	87.7	11.0	48.7	1.86	43.5	42.0	57.6	41.3
125% RDN	90.1	13.0	52.8	2.20	48.5	47.4	66.5	42.4
CD at 5%	8.7	2.97	6.91	0.40	5.6	7.48	5.07	NS
CD interaction at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV %	4.1	8.2	7.6	9.8	7.06	7.5	6.9	5.8

% of recommended dose of nitrogen = 75% 100% and 125%.

Results and Discussion

Growth Parameters : The plant height of late sown wheat was influenced significantly by sowing methods and nitrogen levels (Table-1). Among different sowing methods, the significantly higher plant height was observed in bed planting (89.1 cm) and bi-directional sowing (88.7 cm) over conventional method (72.6 cm). The magnitude of increase in plant height was 27.1 and 22.7 percent, respectively. However, the differences between bed planting and bi-directional sowing were non-significant. Jani *et al.* (2008) observed the higher plant height in bed planting over conventional sowing which was might be due to higher dry matter production, translocation and the conversion of photosynthesis to growing shoot. Dhingra *et al.*, (1986) Reported that the higher plant height in bi-directional over conventional sowing due to uniform distribution of the plants per unit area and better establishment of seedling. The nitrogen level 125% (90.1 cm) and 100% RDN (87.7 cm) recorded significantly higher plant height over 75% RDN (73.5 cm) by a margin of 22.5 and 19.3 per cent, respectively. But the differences between 100 and 125% RDN was non-significant. The interaction effect between sowing methods and nitrogen levels was found to be non-significant. Wysocki *et al.* (2007) also reported higher plant height at higher nitrogen levels (203 kg ha⁻¹). The application of nitrogen increased cells protein content and size of plant cell, as a result of which leaf area and photosynthetic rate increased resulting in higher plant height.

Yield Attributes : The ear length of late sown wheat was influenced significantly by sowing methods and nitrogen levels (Table-1). The bed planting method recorded significantly higher ear length (13.2 cm) over conventional sowing (9.1 cm) but at par bi-directional sowing (10.8 cm). The bi-directional sowing was at par with conventional

sowing. The application of 125% RDN (13.0 cm) was significantly higher over 75% (8.9 cm) but was at par with 100% RDN (11.0 cm). The interaction between sowing methods and nitrogen levels was found non-significant. Patel and Upadhyay (1993) observed that the application of 120 kg N ha⁻¹ increased ear length significantly over 90 kg N ha⁻¹ and further increase of nitrogen level 150 kg N ha⁻¹ did not influence the ear length significantly.

The grains ear⁻¹ of late sown wheat were influenced significantly by sowing methods and nitrogen levels (Table-1). Among different sowing methods, grains ear⁻¹ increased significantly in bed planting (54.6) and bidirectional sowing (52.5) over the conventional sowing (44.5) by a margin 22.4 and 17.7 percent higher, respectively. However, the differences between bi-directional sowing and bed planting were non-significant. Tripathi (1999) also reported that conventional planting gave 2.4 percent less grain ear⁻¹ in conventional sowing as compared to bed planting. The application of 125 (52.8) and 100% RDN (48.7) recorded significantly higher grains ear⁻¹ over 75% RDN (42.5). But the differences between 100 and 125% RDN was non-significant. The non-significant interaction between effect was observed in sowing methods and nitrogen levels. Gundapur and Bhatti (1993) observed that nitrogen promote the initiation of ear that resulted in a greater number of grains ear⁻¹.

Grain weight ear⁻¹ of late sown wheat was influenced significantly by sowing methods and nitrogen levels (Table-1). The grain weight ear⁻¹ in bed planting (2.15 g) and bi-directional sowing (1.96 g) was significantly higher over conventional sowing (1.55 g) but the differences between bi-directional sowing and bed planting were non-significant. The application of 125 (2.2 g) and 100% RDN (1.86 g) was recorded significantly higher grain weight over 75% RDN (1.33 g). But the

difference between 100 and 125% RDN was non-significant. nitrogen level 100% was at par with 125% RDN. Non-significant interaction between effect between nitrogen levels and sowing methods was recorded.

Test weight of late sown wheat was influenced significantly by sowing methods and nitrogen levels (Table-1). Among different sowing methods, the significantly higher test weight was observed in bed planting (47.7 g) and bi-directional sowing (42.8 g) over conventional sowing (36.5 g). But the differences between bed planting and bi-directional was non-significant. Hussan and Akbar (2005) observed that the higher test weight obtained from planting wheat on beds than conventional method because the beds are made by taking soil from furrow. In this way, beds receive a higher concentration of nutrient fertilizer. The application of 125 (48.5 g) and 100% RDN (43.5 g) recorded significantly higher test weight over 75% RDN (37.1 g). But the nitrogen level 125% RDN was at par with 100% RDN. Non-significant interaction effect was noticed between sowing methods and nitrogen levels was. Parihar and Tripathi (1990) also revealed that test weight increased significantly with increasing nitrogen rates up to 100 kg N/ha and further increase in nitrogen to 150 kg/ ha did not show considerable increase in grain weight.

Yield Parameters : Grain yield of late sown wheat was influenced significantly by sowing methods and nitrogen level (Table-1). The bi-directional sowing (44.9 q ha⁻¹) and bed planting (47.7 q ha⁻¹) recorded significantly higher grain yield over conventional method (35.5 q ha⁻¹). The magnitude of increase in grain yield was 23 and 31 per cent, respectively. But the differences between bi-directional sowing and bed planting was non-significant. Hassan and Akbar (2005) reported higher grain yield over conventional sowing due to deposition of fertile top soil in bed planting. Walia and Cheema (1986) also reported that higher grain yield in bidirectional over conventional sowing was due to increased crop growth rate because of less weeds in bi-directional sowing and higher light interception by crop. The application of 125% RDN recorded significantly higher grain yield (47.4 q ha⁻¹) over 75% RDN (36.8 q ha⁻¹) but was at par with 100% RDN (42.0 q ha⁻¹). The differences in grain yield between 75 and 100% RDN is also non-significant. The application of 125% RDN recorded 29.1 and 12.8 percent higher grain yield of late sown wheat over 75 and 100% RDN, respectively. Interaction between sowing methods and nitrogen levels was found non-significant. Beheraa and Rautaray (2010) reported the higher grain yield obtained with increased nitrogen levels up to (165 kg N ha⁻¹) which was might be due to its favorable effect on yield attributing characters.

Straw yield of late sown wheat was influenced by sowing methods and nitrogen levels (Table 1). The bed planting sowing (63.8 q ha⁻¹) and bi-directional sowing (61.6 q ha⁻¹) recorded significantly higher straw yield over conventional sowing (50.1 q ha⁻¹) by a margin of 22.9 and 27.1 per cent higher, respectively. But the differences between bi-directional sowing and bed planting was non-significant. The highest straw yield was observed with 125% RDN (66.5 q ha⁻¹) which was significantly higher over 75 (51.4 q ha⁻¹) and 100% RDN (57.6 q ha⁻¹). The magnitude increase was 29.8 and 15.6 percent, respectively. Moreover, the application of 100% RDN (57.6 q ha⁻¹) also recorded significantly higher straw yield over 75% RDN (51.4 q ha⁻¹) by margin 12.6 percent. Non-significant interaction between sowing methods and nitrogen levels was recorded. Ghobadi *et al.* (2010) also observed the taller plants, greater number of tillers per unit and total dry matter which collectively resulted in higher straw yield. However, nitrogen levels and sowing methods failed to affect the harvest index of late sown wheat.

Conclusion

It may be concluded that significantly higher grain yield of late sown wheat (47.7 and 44.9 q ha⁻¹) may be obtained with the bed planting method and bi-directional sowing over conventional sowing (35.4 q ha⁻¹). The nitrogen levels of 125% RDN (47.4 kg N ha⁻¹) recorded significantly higher grain yield over 75% RDN (36.8 q ha⁻¹) but was at par with 100% (42.0 q ha⁻¹).

References

1. Anonymous (2021). Packages of Practices for Crops of Punjab, Rabi, *Punjab Agriculture University*, Ludhiana, 38 (2): 1-7.
2. Beheraa, U.K. and Rautaray, S.K. (2010). Effect of biofertilizers and chemical fertilizers on productivity and quality parameters of durum wheat (*Triticum turgidum*) on vertisol of Central India. *Arch. Agron. Soil Sci.* 56(1): 65-72.
3. Dhingra, K.K. Dhillon, M.S. Grewal, D.S. and Sharma, K. (1986). Effect of row orientation on growth, yield and yield attributes of wheat sown on the three dates. *J. Agric. Sci. Comb.* 107-343.
4. Ghobadi, M. Ghobadi, M. E. and Sayah, S. S. (2010). Nitrogen application management in triticale under post-anthesis drought stress. *Word Acad. Sci. Eng. Technol.* 70: 252-254.
5. Gundapur, M. and Bhatti, A. (1993). Effect of nitrogen and phosphorus levels on the wheat cultivar. *Pakistan J. Agri. Res.*, 4: 41-43.
6. Hassan, Z.H. Akbar, G. (2005). Effect of permanent raised beds on water productivity for irrigated maize -wheat cropping system. *Aust. Centre for Int. Agric.* 3: 118-124.

7. Jani, P.P. Tanwar, S.P.S. and Singh, S.M. (2008). Performance of durum wheat (*Triticum durum*) varieties under varying sowing methods and input levels. *Indian, J. of Ferti.* 4(7): 71-73.
8. Patel, R.M. and Upadhyay, P.N. (1993). Response of wheat to irrigation under varying levels of nitrogen and phosphorus. *Indian J. Agron.* 36 (1): 113-115.
9. Parihar, S.S and Tripathi, R.S. 1990. Yield, water use and nutrients uptake of wheat as influenced by sowing time, irrigation and nitrogen levels. *Madras Agric. J.* 77 (7-8): 309-16.
10. Singh, H. Singh, A.K. Kushwaha, H.L. and Singh, A. (2007) Energy consumption pattern of wheat production in India. *Energy*, 32, 1848-1854.
11. Tanveer, S.K. Hussain, I. Kissana, N.S. and Abbas, S.G. (2003). Effect of different planting methods on yield and yield components of wheat. *Asian J. of Plant Sci*, 2. 811-13.
12. Ullah, I. Ali, N., Durrani, S. Shabaz, A.M. Hafeez, A. Ameer, H. Isfaq, M. Fayyaz, N.S. Rehman, A. and Waheed, A. (2018) Effect of different nitrogen levels on growth, yield contributing attributes of wheat. *Inter. J. of Sci. and engin. Res*,9, 2229-5518.
13. Tripathi, S.C. (1999). Studies on agronomic inputs-lodging resistance relationship for relationship for identification of high yield potential genotypes of wheat (*Triticum aestivum* L.) with proven high nitrogen use efficiency. *Ph.D. dissertation, Punjab Agricultural University, Ludhiana, India.*
14. Walia, A.S. and Cheema, S.S. (1986). Microclimate, water use and yield of wheat as affected by directions of sowing. *Indian J. Ecot.*13: 266-271.
15. Wysocki, D.J. M. Corp, D.A.H. and L.K. Lutchter. (2007). Nutrient management guide: Irrigated and dryland canola. *Oregon State University.* 8943.



Integrated Nutrient Management in Late Sown Wheat (*Triticum aestivum* L.) in Central Punjab

Athokpam Sushma Luwang and Udham Singh Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

The field experiment was carried out during *Rabi* season of 2020 to study the integrated nutrient management in late sown wheat (*Triticum aestivum* L.). The experiment was laid out in a randomized complete block design (RCBD) with nine treatments in three replications. The treatment comprised of nine treatments *i.e.* T₁ - control, T₂ - RDF (125kg N + 62.5kg P₂O₅ + 32kg K₂O), T₃ - FYM (20t ha⁻¹), T₄ - FYM (20t ha⁻¹) + 50% RDF, T₅ - FYM (20t ha⁻¹) + 75% RDF, T₆ - FYM (15t ha⁻¹) + 50% RDF, T₇ - FYM (15t ha⁻¹) + 75% RDF, T₈ - FYM (10t ha⁻¹) + 50% RDF, T₉ - FYM (10t ha⁻¹) + 75% RDF. The recommended dose of fertilizer (RDF) *i.e.* (125 kg N + 62.5 kg P₂O₅ + 32kg K₂O) T₂ recorded significantly higher grain yield (43.53 q/ha) than T₁ (26.16 q/ha), T₃ (32.06 q/ha), T₄ (36.06 q/ha), T₆ (35.7 q/ha) and T₈ (31 q/ha) but was at par with T₅ (43.1 q/ha), T₇ (40 q/ha) and T₉ (38 q/ha), respectively. The higher grain yield was might be due to significantly higher number of growth parameters *viz.* plant harvest (90.8cm) and the yield attributes, *viz.* ear length (13.6 cm), no. of grains per ear (55.2), weight of grains per ear (2.15 g) and 1000 grain weight (49.1 g).

Key words : Wheat, INM, FYM, growth, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world and occupies second position after rice in the total area and production. It is known as “King of Cereals” and it contains about 13% of protein which is relatively high adaptability of different climatic regions (Dey *et al.* 2020). The high temperature during grain filling stage leads to premature ripening and reduction in grain weight. It is used in the production of bread, biscuits, feeds, confectionary (Oyewole. 2016). Globally, it occupies around 217 million hectares holding the position of highest acreage among all the crops with an annual production covering around 731 million tones. Maximum area under wheat in India (14%), followed by Russia (12.43%), China (11.14%) and the USA (6.90%) which altogether accounts for about 45% of global area (Ramadas *et al.* 2019). In India, wheat productivity with an area of 29.14 m ha and produced 102.19 million tones with a productivity of 3507 kg/ha (Anonymous, 2019). In Punjab, wheat crop occupied an area of 35.20 lakh hectares and production of 182.62 lakh tones during 2018-19. The average yield of wheat was 51.88 quintals per hectares (21.0 quintals per acre) (Anonymous, 2020). The integrated nutrient management helps to restore and sustain soil fertility. Further, it brings economy and efficiency in fertilizers. The use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity. An enormous amount of organic fertilizer would be required to maintain soil fertility levels. And a combination of both organic and inorganic fertilizers is the answer for

sustainability (Zeleeke 2004). So, integration nutrient supplying sources is a flexible approach to minimize the use of chemical sources of nutrient along with maximization of their efficiency and farmer's economics (Meena *et al.* 2020). Keeping in view the above, the present study was undertaken to study the integrated nutrient management in late sown wheat.

Materials and Methods

The present experiment was carried out during *Rabi* season of 2020 at the Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab). Mandi Gobindgarh is situated at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The maximum temperature often exceeds 40° C during summer. Minimum temperature falls below 6° C with some frosty spells of 8-10 days during winter months of December and January. The average rainfall of Mandi Gobindgarh is 730.2 mm. The experiment field tested was in organic carbon (0.48%) and in available nitrogen (144.6 kg N/ha), medium in available phosphorus 17.3 P₂O₅/ha and medium in available potassium (168 kg K₂O/ha). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of *i.e.* T₁ - control, T₂ - RDF (125 kg N + 62.5 kg P₂O₅ + 32 kg K₂O), T₃ - FYM (20 t/ha), T₄ - FYM (20 t/ha) + 50% RDF, T₅ - FYM (20 t/ha) + 75% RDF, T₆ - FYM (15 t/ha) + 50% RDF, T₇ - FYM (15 t/ha) + 75% RDF, T₈ - FYM (10 t/ha) + 50% RDF and T₉ - FYM (10 t/ha) + 75% RDF. The seed at the rate of 112.5 kg per hectare was used for sowing the experiment. The gross plot size was 4.3 m ×

Table-1 : Effect of integrated nutrient management on growth parameters, yield attributes and yield of wheat.

Treatments	Plant height (cm)	Ear length (cm)	Grains/ear	Grain weight/ear	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T ₁ -Control	72.7	9.80	36.1	1.05	36.8	26.1	41.7	38.9
T ₂ -RDF 125kg N + 62.5kg P ₂ O ₅ + 32kg K ₂ O	90.8	13.50	55.1	2.15	49.06	43.5	53.07	45.06
T ₃ -FYM (20 t/ha)	77.6	10.40	43.6	1.40	38.0	32.06	48	40.06
T ₄ -FYM (20 t/ha) + 50% RDF	86.5	11.7	47.8	1.80	40.0	36.06	50	42.4
T ₅ -FYM (20 t/ha) + 75% RDF	89.5	13.06	53.3	2.08	47.03	43.06	52.8	44.9
T ₆ -FYM (15 t/ha) + 50% RDF	78.2	11.8	45.2	1.70	38.60	35.7	49	42.1
T ₇ -FYM (15 t/ha) + 75% RDF	88.2	12.8	52.3	2.05	45.16	40	52.5	43.2
T ₈ -FYM (10 t/ha) + 50% RDF	75.6	10.1	38.03	1.33	37.60	31	47	39.7
T ₉ -FYM (10 t/ha) + 75% RDF	87.5	12.6	49.4	1.95	43.8	38	52	42.6
C.D at 5%	3.52	1.08	4.98	0.281	4.21	5.47	6.57	3.10
C.V. %	2.43	5.26	6.09	9.34	5.77	8.62	7.60	4.22

3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on 31st December, 2020 at spacing of 15 cm and harvested on May 10th, 2020. All the other cultural practices were uniformly followed.

Results and Discussion

Growth parameters : The plant height was influenced significantly with different integrated nutrient management treatments (Table-1). The recommended dose of fertilizer (RDF) and all the integrated nutrient management treatments recorded significantly higher plant height of late sown over control except T₈. The higher plant height was observed with T₂ which was at par with T₅ (89.5 cm), T₇ (88.2 cm) and T₉ (87.5 cm) but was significantly higher than T₁ (72.7 cm), T₃ (77.63 cm), T₄ (86.4 cm), T₆ (78.2 cm) and T₈ (75.6 cm). Among the integrated nutrient management treatments, T₅ recorded the higher plant height (89.5 cm) which was significantly higher over T₁ (72.6 cm), T₃ (77.6 cm), T₆ (78.2 cm) and T₈ (75.6 cm) but was at par with T₄ (86.4 cm), T₇ (88.2 cm) and T₉ (87.5 cm). The higher plant height obtained in RDF and integrated nutrient management treatment might be due to the availability of more nutrients from organic and inorganic fertilizers as compared to the control. Similar results have also been reported by Singh *et al.* (2018) and Channabasaganowda *et al.* (2008).

Yield Attributes

Ear length : The ear length was significantly influenced by different integrated nutrient management treatments (Table-1). The recommended dose of fertilizer (RDF) and all the integrated nutrient management treatments recorded significantly higher ear length of late sown wheat over control except T₈. The higher ear length was observed with T₂ (13.5 cm) which was at par with T₅ (13.06 cm), T₇ (12.8 cm) and T₉ (12.6 cm) but significantly higher than T₁ (9.80 cm), T₃ (10.40 cm), T₄ (11.7 cm), T₆ (11.8 cm) and T₈

(10.1 cm). Among the integrated nutrient management treatments, T₅ (13.06 cm) recorded the higher ear length which was significantly higher over T₁ (9.80 cm), T₃ (10.40 cm), T₄ (11.7 cm), T₆ (11.8 cm), and T₈ (10.1 cm), but was at par with T₇ (12.8 cm) and T₉ (12.6 cm). The greater ear length obtained in RDF and integrated nutrient management treatments might be due to the improvement in the fertility level of the soil and growth development. Patel *et al.* (2018) also observed higher yield attributes with the application of RDF than FYM.

Grains/ear : The integrated nutrient management treatments significantly influenced the grains/ear of late sown wheat (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management recorded significantly higher grains/ear over control except T₈. The higher grains/ear were observed with T₂ which was at par with T₇ (52.3) and T₉ (49.4) but was significantly higher over T₁ (36.1), T₃ (43.6), T₄ (47.8), T₆ (45.2), T₈ (38.1) and T₉ (49.4). Among the integrated nutrient management treatments, T₅ recorded the higher grains/ear (53.3) which were significantly higher than T₁ (36.1), T₃ (43.6), T₄ (47.8), T₆ (45.2) and T₈ (38.03) but was at par with T₇ (52.3) and T₉ (49.4). More grains/ear obtained in RDF and integrated nutrient management were might be due to uptake of essential nutrients *i.e.* N, P and K by crop plants. Similar results have also been reported by Kumar (2000) and Singh and Agrawal (2001).

Grain weight/ear : The integrated nutrient management treatments significantly influenced the weight of grains per ear of late sown wheat (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management recorded significantly higher weight of grains per ear over control except T₈. The higher grain weight/ear was observed with T₂ which was at par with T₇ (2.05 g) and T₅ (2.15 g) but was

significantly than T₁ (2.15 g), T₃ (1.40 g), T₄ (1.80 g), T₆ (1.70 g), T₈ (1.33 g) and T₉ (1.95 g). Among the integrated nutrient management treatments, T₅ recorded the higher weight of grains per ear (2.15 g) which was significantly higher over T₁ (1.05 g), T₃ (1.40 g), T₄ (1.80 g), T₆ (1.70 g) and T₈ (1.33 g) but was at par with T₇ (2.05 g) and T₉ (1.95 g). The significantly higher grain weight/ear obtained in RDF and integrated nutrient management was might be due to higher production of photosynthates and nutrient availability, increased higher yield and production. Similar results were reported by Kumar and Yadav (2018).

1000 grain weight : The 1000 grain weight was influenced significantly with different integrated nutrient management treatments (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management were recorded significantly higher over control except T₈. The higher 1000 grain weight was observed in T₂ (49.1 g) which was par at with T₅ (47.03 g), T₇ (45.16 g) and T₉ (43.8 g) but was significantly higher than T₁ (36.8 g), T₃ (38.0 g), T₄ (40.0 g), T₆ (38.6 g) and T₈ (37.6 g). Among all the integrated nutrient management treatments, T₅ recorded significantly higher 1000 grains weight (47.03 g) which was significantly higher over T₁ (36.8 g), T₃ (38.0 g), T₄ (40.0 g), T₆ (38.60 g) and T₈ (37.60 g) but was at par with T₇ (45.16 g) and T₉ (43.8 g). The higher 1000 grain weight in RDF and integrated nutrient management was might be due to adequate amount of nutrient supply which increased the photosynthetic and translocated more photosynthates reproductive stages of the crop. Similar results were reported by Mubarak and Singh, (2011) and Patel *et al.* (2011).

Grain yield : The integrated nutrient management treatments significantly influenced the grain yield of late sown wheat (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management were recorded significantly higher over control except T₈. The higher grain yield was observed with T₂ (43.5 q/ha) which was par at with T₇ (40 q/ha) and T₅ (43.06 q/ha) which was significantly higher than T₁ (26.1 q/ha), T₃ (32.06 q/ha), T₄ (36.06 q/ha), T₆ (35.7 q/ha), T₈ (31 q/ha) and T₉ (38 q/ha). Among all the integrated nutrient management treatments, the higher grain yield was observed with T₅ (43.06 q/ha) which were significantly higher than T₁ (26.1 q/ha), T₃ (32.06 q/ha), T₄ (36.06 q/ha), T₆ (35.7 q/ha) and T₈ (31 q/ha) but was at par with T₅ (43.06 q/ha), T₇ (40 q/ha) and T₉ (38 q/ha). However, the lowest grain yield was recorded with the application of T₁-control. The higher grain yield in RDF and the integrated nutrient management was due to adequate quantities and balanced proportions of nutrients supplied to the crop that enhanced growth attribute and yield of wheat. Devi *et al.* (2011) also observed higher grain yield with the application of RDF than FYM.

Straw yield : The integrated nutrient management treatments significantly influenced the straw yield of late sown wheat (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management recorded significantly higher straw yield over control. The lowest straw yield was recorded in T₁ (41.7 q/ha) and the rest of the treatments T₂ (53.07 q/ha), T₃ (48 q/ha), T₄ (50 q/ha), T₅ (52.8 q/ha), T₆ (49 q/ha), T₇ (q/ha), T₈ (47 q/ha) and T₉ (52 q/ha) were at par. The highest straw yield was recorded in T₂ (53.07 q/ha). The higher straw yield in RDF and integrated nutrient management was might be due to improvement of physical and chemical properties of the soil through the application of RDF than FYM. Similar results have also been reported by Kakraliya *et al.* (2017).

Harvest index : The higher harvest index was influenced significantly with different integrated nutrient managements (Table-1). The recommended dose of fertilizer (RDF) and all the treatments of integrated nutrient management recorded non-significantly higher harvest index of late sown over control except T₈. The highest harvest index was observed in T₂ (45.06 %) which was significantly than T₁ (38.9 %), T₃ (40.06 %) and T₈ (39.7 %) but was at par with T₄ (42.4 %), T₅ (44.9 %), T₆ (42.1 %), T₇ (43.2 %) and T₉ (42.6 %). Among all the integrated nutrient management treatments, T₅ recorded the higher harvest index (44.9 %) which was significantly higher over T₁ (38.9 %), T₃ (40.06 %), and T₈ (39.7 %) but was at par with T₄ (42.4 %), T₅ (44.9 %), T₆ (42.1 %), T₇ (43.2 %) and T₉ (42.6 %). The higher harvest index in RDF and integrated nutrient management was might be due to maintainance supply of photosynthates to reproductive parts. Similar results also have been reported by Shukla *et al.* (2016).

Conclusion

It may be concluded from the present study that significantly higher grain yield (43.5 q/ha) of late sown wheat was observed with the application of RDF and the combination of FYM (20 t/ha) + 75% RDF, FYM (15 t/ha) + 75% RDF and FYM (10 t/ha) + 75% RDF.

References

1. Anonymous (2019). Agricultural Statistics at a Glance. Government of India, Pp: 50-51.
2. Anonymous (2020). Package of Practices for crops of Punjab, Rabi. Punjab Agricultural University, Ludhiana, India. Pp: 1-19.
3. Channabasanagowda N., K.P. Biradar B.N. Pail, J.S. Awaknavar, B.T. Ningnur and R. Hunje (2008). Effect of organic manures on growth, seed yield and quality of wheat. *Karnataka J. Agric. Sci.*, 21: 366-368.
4. Dey Anwesha, Dinesh and Rashmi (2020). Rice and wheat production in India: an overtime study on growth and

- instability. *Journal of Pharmacognosy and Phytochemistry*, 9(2): 158-161.
5. Devi K.N., Singh M.S., Singh N.G. and Athokpam S.H. (2011). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.) *Journal of Crop and weed*. 7(2): 23-7.
 6. Kakraliya S.K., Jat R.D., Kumar S., Choudhary K.K., Prakash Jai. and Singh L.K. (2017). Integrated nutrient management for improving, fertilizer use efficiency, soil biodiversity and productivity of wheat in irrigated rice wheat cropping system in Indo-Gangetic plains of India. *Int. J. Curr. Microbiol. App. Sci.*, 6(3): 152-163.
 7. Kumar R. (2000). Effect of organic and inorganic fertilizer levels in normal and saline soil on wheat. *M.Sc. thesis submitted to Choudhary Charan Singh Haryana Agricultural University*, Hisar.
 8. Kumar J. and Yadav M.P. (2008). Effect of integrated nutrient management on growth, yield attributes, yield and economics of hybrid rice (*Oryza sativa* L.). *Crop Res.*, 39: 20-23.
 9. Meena M. and Meena M. (2020) Effect of different fertility levels and organic nutrient Sources on growth and yield of wheat (*Triticum aestivum* L. Emend. Fiori & Paol). *International Journal of Current Microbiology and Applied Sci.*, 9(2): 1624-30.
 10. Mubarak T. and Singh K.N. (2011). Nutrient management and productivity of wheat (*Triticum aestivum* L.) based-cropping system in temperate zone. *Indian Journal of Agronomy*, 56(3): 176-181.
 11. Oyewole C. (2016). The wheat Crop. *Research Gate*, 10.13140: 13776-92164.
 12. Patel B.N., Solanki M.P., Patel S.R. and Desai J.R. (2011). Effect of bio-fertilizers growth, physiological parameters, yield and quality of binjal cv. Surti Ravaiya. *Indian Journal of Horticulture*, 6(3): 370- 374.
 13. Patel G.G., Sadhu A.C., Patel H.K., Shan S.N. and Lakum Y.C. (2018). Effect of organic and inorganic fertilizers in comparison with humic acid on growth and yield of wheat (*Triticum aestivum* L.). *International Journal of Agricultural Sciences*, 10: 6524-6527.
 14. Ramadas S., Kumar K.T.M. and Singh P.G. (2019). Wheat production in India: trends and prospects. *IntechOpen*, 10.57772: 86341.
 15. Singh R. and Agarwal S.K. (2001). Analysis of growth and productivity of wheat (*Triticum aestivum* L.) in relation to levels of FYM and nitrogen. *Ind. J. Plant Physiol.*, 6(3): 279-283.
 16. Singh G., Kumar S., Sidhu G.S. and Kaur R. (2018) Effect of integrated nutrient Management on yield of wheat (*Triticum aestivum* L.) under irrigated conditions. *International Journal of Chemical Studies*, 6(2): 904- 907.
 17. Sukla S., Meena R.N., Meena R., Verma V.K., Ghilotia Y.K. and Gaurav (2016). Effects of different organic sources of nutrition on nutrient uptake, yield attributes and economics of *Oryza sativa* L. *Bangladesh Journal of Botany*, 45(2): 445-449.
 18. Zeleke T.B., Grevers M.C.J., Si B.C., Mermut A.R. and Beyne S. (2004). Effect of residue incorporation on physical properties of the surface soil in the south central rift valley of Ethiopia, *Soil and Tillage Research*, 77(1): 35-46.



Influence of Boron and NAA on Fruiting, Yield and Quality Attributes of Litchi (*Litchi chinensis* Sonn.) cv. Rose Scented

Prakash Pandey, R.K.S Gautam, Shubham Gupta and Jitendra Singh Yadav

Department of Fruit Science, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

Email : rajkaraningh9320@gmail.com

Abstract

An experiment was carried out at Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology Kanpur (U.P.) during 2020-21. The experimentation was laid out in Factorial Completely Randomized Design with 3 replications and ten treatments, involving NAA, Boron and control. From the results obtained reported that individual application of NAA and Boron brought about significant changes in plant metabolism. NAA 30 ppm reduced fruit cracking, improved fruit retention, length of fruit, width of fruit, fresh weight of fruit, pulp weight, marketable yield, total sugars and TSS content. Boron @ 0.5% was found more effective on enhancing fruit retention, reducing fruit cracking, increasing length of fruit, weight of fresh fruit, pulp weight, marketable yield, total sugars and TSS content, and also seed weight. NAA 30 ppm in association with 0.5% Boron was more effective on length, diameter of fruit, marketable yield, sugar content and TSS content in central U.P. conditions.

Key words : Litchi, boron, NAA, fruit cracking, fruit retention, physico-chemical parameters.

Introduction

Litchi (*Litchi chinensis* Sonn.) is a subtropical evergreen fruit tree of family Sapindaceae, having chromosome number of $2n=30$. It is one of the most relished fruit by virtue of its colour and distinct taste. It is native to South China particularly the provinces of Kwangtung and Fukien and South-Eastern Asia. Fruit cracking is universal problem of a number of fruits such as litchi, citrus, grapes, date palm, pomegranate, cherry and losses due to this malady are some times as high as 75%. Alternate spells of humid conditions and dry heat in summer months are mainly responsible for cracking and dropping of the fruits in litchi. Sun-burning and skin cracking of developing fruits is a universal problem in litchi cultivation. Plant bio-regulators and micronutrients play significant role in many physiological phenomenon. They are used in increasing fruit set, prevention of fruit drop, regulation of flowering, fruit size, thinning of flowers and fruits and improving yield and quality.

Application of NAA increased the leaf index, length of flower panicles, fruit set, reduction of malformation and even the bio-chemical status likes carbohydrate, nitrogen and enhanced RNA and DNA level. Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, and pollination and seed set. Boron influences fruit setting and yield of different plant.

Materials and Methods

The present experiment was conducted at Garden,

Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during the years of 2020-2021. The experiment was planned with 10 treatments viz., NAA 30 ppm and four concentrations each of Boron (0.3, 0.4, 0.5 and 0.6%) and their combination including a control, replicated thrice in a Factorial Completely Randomized Design. Uniform and healthy 41 years old plants of litchi cv. Rose scented were selected for the purpose of the experimentation and on each plant similar three branches were identified and each branch was used as a plot unit, thus, different levels of NAA as well as boron sprays were done twice: first prior to flower initiation (10 Feb.) and second at pea stage (06 April). Manurial requirement, cultural practices and plant protection measured were adopted according to norms. plants were selected randomly in each treatment for recording observation on fruit retention, percentage of cracked fruit, The fruits harvested in each treatment were weighted and yield expressed in terms of Kg/per plant. The length and width of fruits were recorded with the help of Vernier Calliper at the maximum point of longitudinal and horizontal expansion, respectively. After removing the pulp, the seeds were weighed on an electronic balance and expressed in terms of g. The TSS of fruit was determined with the help of Erma Hand Refractometer, whereas the total sugar content was analysed as the method suggested by A.O.A.C. (1980).

Results and Discussion

Fruit retention : The data presented in Table-1, clearly revealed that fruit retention was significantly increased under the 30 ppm NAA concentration (39.28%) over NAA

Table-1 : Influence of Boron and NAA on fruit retention in litchi (%).

Treatments		Boron					
		B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	Mean
N ₀ NAA		31.38	35.53	36.88	37.61	37.38	35.75
N ₁ NAA (30 ppm)		36.96	38.99	39.67	40.60	40.18	39.28
Mean		34.17	37.26	38.27	39.10	38.78	
	S.E.	C.D.					
N	0.28	0.59					
B	0.34	0.72					
NXB	0.63	1.31					

Table-2 : Influence of Boron and NAA on Cracked fruit (%).

Treatments		Boron					
		B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	Mean
N ₀ NAA		19.08	14.03	13.98	12.53	13.06	14.53
N ₁ NAA (30 ppm)		15.01	14.56	12.74	11.92	13.76	13.59
Mean		18.54	14.29	13.36	12.22	13.41	
	S.E	C.D					
N	0.37	0.73					
B	0.43	0.86					
NxB	0.82	1.38					

Table-3 : Influence of Boron and NAA on length of fruit (cm).

Treatments		Boron					
		B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	Mean
N ₀	NAA	2.40	2.57	2.68	2.73	2.70	2.62
N ₁	NAA (30 ppm)	2.69	2.81	2.85	2.90	2.81	2.81
Mean		2.54	2.69	2.76	2.81	2.75	
	S.E.	C.D.					
N	0.016	0.034					
B	0.020	0.042					
NXB	0.037	0.076					

(N₀) (35.75%). Significantly minimum (34.17%) fruit retention was noted under the Boron control (B₀). Boron concentration significantly maximized (39.10%) fruit retention in Litchi fruits it's at 0.5% concentration, followed by (38.78%) improvement on fruit retention due to Boron 0.6% and (38.27%) in concentration of Boron (0.4%). Foliar application of Boron at moderate concentration may be helpful in maintaining nutritional status of plant which ultimately improved fruit retention in Litchi fruits. These findings of present experimentation get support with the observation of Singh *et al.*, (2007) in aonla and Sharma *et al.*, (2005) in litchi.

Cracking of fruits : The fruit cracking was influenced with the application of NAA at 30 ppm concentration significantly minimized fruit cracking in litchi fruits (13.59%) NAA 0 ppm (N₀) exhibiting (14.53%) fruit cracking. Similarly, auxin has been reported to cause cell wall plasticization due to growth of new cell wall and contents of cell such as cellulose, hemicelluloses and pectin, which cause cell enlargement by lowering the wall pH so that wall loosening and growth occur, thus such physiological effect of auxin possibly result in preventing the cracking of fruit. These findings of present experimentation get support with

the observation of Saraswat *et al.*, (2006), Sahay *et al.*, (2018) and Chauhan *et al.*, (2019) in litchi. Application of micronutrient Boron also reduced fruit cracking and significantly minimum fruit cracking was recorded under B₃ (0.5%) concentrations of Boron showing 12.22% fruit cracking was obtained against *i.e.*, control B₀ (18.54%). It was proved earlier that deficiency of Boron caused interveinal chlorosis of older leaves resulted distortion in shape and appearance of fruits as well as in leaves which promoted cracking of fruits in Litchi. The finding are in accordance with the reports of Saraswat *et al.*, (2006), Chauhan *et al.*, (2019), and Sinha *et al.*, (1999) in litchi.

Length and width of fruit (cm) : Foliar application of NAA improved fruit length and width consistently and positively. Its 30ppm concentration (N₁) proved most responsive treatment to increase the average fruit length and width revealing 2.81 cm and 2.74cm value during investigation. The smaller fruits *i.e.*, length and width revealing 2.62 cm and 2.44cm respectively under control (N₀). The superiority caused by NAA treatment might be due to its involvement in cell division, cell elongation and increased volume of intra cellular spaces in the mesocarpic cells which could have boosted plant health

Table-4 : Influence of Boron and NAA on width of fruit (cm).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	2.25	2.36	2.50	2.55	2.52	2.44
N ₁ NAA (30 ppm)	2.55	2.67	2.78	2.88	2.80	2.74
Mean	2.40	2.51	2.64	2.71	2.66	
S.E	C.D					
N	0.020	0.042				
B	0.024	0.051				
NxB	0.045	0.093				

Table-5 : Influence of Boron and NAA on fresh weight of fruit (g).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	16.12	17.13	17.77	18.10	18.05	17.43
N ₁ NAA (30 ppm)	18.57	19.45	19.59	19.67	19.60	19.37
Mean	17.34	18.29	18.68	18.88	18.82	
S.E.	C.D.					
N	0.084	0.175				
B	0.103	0.215				
NXB	0.188	0.392				

Table-6 : Influence of Boron and NAA on weight of fruit (g).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	10.12	11.45	11.90	12.18	12.05	11.54
N ₁ NAA (30 ppm)	11.93	12.57	12.80	13.10	12.95	12.67
Mean	11.02	12.01	12.35	12.64	12.50	
S.E	C.D					
N	0.091	0.190				
B	0.111	0.232				
NxB	0.203	0.424				

thereby producing healthy and larger fruits. Naphthalene acetic acid (NAA) increase the growth rate of fruit which result in bigger fruit. The findings are in agreement with the reports of Chaudhary *et al.*, (2018) in aonla and Shahay *et al.*, (2018) in litchi. Badal and Tripathi (2021b) in guava found increased fruit size with NAA spray.

Micronutrient Boron proved beneficial and improved length and width of Litchi fruit in experimentation. Its 0.5% concentration (B₃) enhanced length significantly showing 2.81cm. Micronutrient Boron plays significant role in enhancing the fruit size may be attributed to its role in elongation. Expansion of cells which caused desirable improvement in the size of Litchi fruits. These findings are in line with the reports of Sharma *et al.*, (2005) in litchi, Singh *et al.*, (2007) and Tiwari *et al.*, (2017) in aonla. Shukla *et al.*, (2011), who also found increased fruit size in aonla with boron treatment.

Fresh weight of fruits, pulp weight and fresh seed weight (g) : Significantly heaviest fruits of 19.37g were harvested from the plants treated with NAA 30ppm concentrations against significantly lightest in 17.43g were noted under control (N₀). The increment in fruit

weight due to their application of NAA might be due to the fact that NAA may have induced the auxin concentrations in the fruits which finally helped in the development of fruits as there is a perceptible correlation between the content and fruit growth. These findings are in accordance with the reports of Saraswat *et al.*, (2006), Tripathi *et al.*, (2019) in mango and Shahay *et al.*, (2018) in litchi. Badal and Tripathi (2021b), also found increased fruit size with NAA 75 ppm spray in guava. Maurya *et al.*, (2020) in mango also found increased fruit weight by NAA @ 60 ppm. Application of Boron also influenced fruit weight of litchi. The maximum of 18.88g weight was recorded under 0.5% Boron (B₃) treated plants and 17.34g fruits having poorest weight obtained from control (B₀). Fruit weight ranged from 17.34 to 18.88g. Application of Boron in moderate concentration increased fruit weight considerably due to enhancement in accumulation of sugar and extended high juice percentage in Boron treated fruits. These findings are in agreement with reports of Sharma *et al.*, (2005), Saraswat *et al.*, (2006), Tiwari *et al.*, (2017) in aonla, Verma *et al.*, (2021) in strawberry and Katiyar *et al.*, (2008) in litchi.

Table-7 : Influence of Boron and NAA on weight of seed (g).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	3.71	4.20	4.36	4.47	4.42	34.2
N ₁ NAA (30 ppm)	4.37	4.61	4.69	4.80	4.75	44.6
Mean	4.04	4.40	4.52	4.63	4.58	
S.E.	C.D.					
N	0.034	0.072				
B	0.042	0.088				
NxB	0.077	0.161				

Table-8 : Influence of Boron and NAA on marketable yield (kg).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	43.97	49.78	51.68	52.98	52.38	50.15
N ₁ NAA (30 ppm)	51.79	54.64	55.68	56.89	56.30	55.04
Mean	47.88	52.21	53.63	53.93	53.34	
S.E	C.D					
N	0.386	0.804				
B	0.472	0.985				
NxB	0.862	1.798				

Table-9 : Influence of Boron and NAA on total sugars (%).

Treatments	Boron					Mean
	B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	
N ₀ NAA	11.34	11.68	12.51	12.65	12.59	12.15
N ₁ NAA (30 ppm)	11.73	12.65	13.26	13.70	13.40	12.94
Mean	11.53	12.16	12.88	13.17	12.99	
S.E	C.D					
N	0.058	0.120				
B	0.071	0.147				
NxB	0.129	0.269				

The pulp weight was derived subtracting the weight of stone and rind from the fruit weight. In this regard NAA 30ppm concentration treated plants induced maximum *i.e.*, 12.67g (N₁) pulp weight the minimum of it was 11.54g observed with untreated plant *i.e.*, control (N₀). There is some evidence that is auxin cell wall. Thus, increasing its flexibility and plasticity. This would allow stretching of the cell wall along with greater water uptake increasing cell size which ultimately promoted pulp weight in the litchi fruits. These findings are in line with the reports of Singh *et al.*, (2007) in aonla. Boron nutrition also influence pulp content of fruit positively and its 0.5% concentration induced maximum *i.e.*, 12.64g against Boron control *i.e.*, B₀ revealed 11.02g pulp weight being minimum as compare to rest of treatments. Boron sprays acts as acceleration of pulp weight and this appreciable increase might be due to enhancing absorption of water and solutes and this activity enhance mobilization of sugar in cell increasing thereby pulp. These findings are in accordance with the reports of Singh *et al.*, (2015) in mango, Banyal *et al.*, (2013) in litchi.

Heaviest seed weighing (4.23g) were recorded

under control NAA (N₀). The lighter seed weight on the other hand weighing 4.64g noted under 30ppm (N₁). NAA caused enhancing of the flexibility and plasticity of cell which promoted stretching of cell wall along with greater water uptake which are possible causes to increase the pulp weight and vice versa seed weight was ultimately reduced. These findings are in line with the reports of Singh *et al.*, (2007) in aonla and Saraswat *et al.*, (2006). Boron treatments also influence seed weight of litchi fruit and significantly heaviest (4.63g) seed weight was recorded under control (B₀). The lightest seed weight (4.04g) was revealed under the treatment of 0.5% concentration (B₃). The range of seed weight was reduced in the tune of 4.04 to 4.63g. Micronutrient Boron promoted pulp content of litchi fruit there by possibly caused to decrease seed weight in the litchi fruits. These findings are in agreement with the reports of Singh *et al.*, (2007) in aonla, Singh *et al.*, (2015) in mango and Saraswat *et al.*, (2006) in litchi. Interactive effect of NAA x Boron caused significant variation or seed weight of litchi fruits. The maximum of 4.80 seed weight was observed under the control (N₀B₀) against the minimum of 3.71g

Table-10 : Influence of Boron and NAA on TSS (%).

Treatments		Boron					
		B ₀	B ₁ (0.3%)	B ₂ (0.4%)	B ₃ (0.5%)	B ₄ (0.6%)	Mean
N ₀ NAA		16.96	17.92	18.01	18.67	18.23	17.95
N ₁ NAA (30 ppm)		17.98	18.30	17.98	19.05	18.10	18.28
Mean		17.47	18.11	18.00	18.16		
	S.E.	C.D.					
N	0.12	0.18					
B	0.14	0.23					
NXB	0.21	0.46					

weight was expressed under the treatment of N₁B₃. Singh *et al.*, (2007) in alola and Saraswat *et al.*, (2006) in litchi.

Yield per plant (kg/plant) : Significantly higher yield 55.04 kg per plant was indicated under the treatment of NAA 30 ppm treatment. The minimum of 50.15 kg marketable fruits per plant were harvested when the plants did not receive any NAA treatment (N₀). The improvement brought about by NAA may be attributed to its physiological activities in the plants which could have checked fruit drop reduced cracking and minimized number of blemished fruits considerably thereby increasing yield as well as marketable yield. The above findings are in line with the reports of Saraswat (2006) and Chauhan *et al.*, (2019) in litchi. Badal and Tripathi (2021a), also found higher yield with NAA 75 ppm spray in guava. Plants deprived of Boron gave lowest yield of 47.88 kg marketable fruit per plant under Boron control and significant maximum yield 54.93 kg per plant was registered under the treatment of 0.5% boron during the experimentation. Boron helps in translocation of metabolites from source to sink which enhance to retention of more number of fruits on tree which ultimately promoted the yield of fruits in plants. These findings are in accordance with the reports of Singh *et al.*, (2015) in mango, Katiyar (2008), Saraswat *et al.*, (2006) and Chauhan *et al.*, (2019) in litchi. Interactive effect of NAA association with Boron on the yield of marketable fruits caused significant variation and the maximum of 56.89kg per plant marketable yield was noted under the interactive treatment of N₁B₃. N₀B₀ recorded 43.97 kg per plant marketable yield. These findings are in line with the reports of Pandey *et al.*, (2012) in ber, Saraswat *et al.*, (2006), Chauhan *et al.*, (2019) in litchi.

Total sugar and Total soluble solid content : Foliar sprays of NAA influenced the total sugar content in Litchi fruits its 30ppm (N₁) increased (12.94%) total sugar content against 12.15% observed under N₁. The increase in total sugar may be attributed further to conversion of reserve starch and other polysaccharide into soluble form of sugar. These findings are in accordance of Kumar and Tripathi (2009) in strawberry, Kumar *et al.*, (2017) in aonla, Saraswat *et al.*, (2006) in litchi. Tripathi *et al.*, (2019) also reported increased TSS

and total sugars content in mango with the application of GA₃ 50 ppm + NAA 40 ppm. Maurya *et al.*, (2020) also reported the increased of TSS and total sugar in mango at spray of GA₃ 75 ppm + NAA 40 ppm. The minimum of 11.53% total sugar was obtained under untreated plant *i.e.*, control (B₀). A range of 11.53 to 13.17% was noted in this regard. The possible reason for increase in total sugar in fruit pulp by foliar sprays of Boron might be due to the conversion of starch and acid into sugars in addition to the continuous mobilization of sugars from leaves to fruits. the present findings and in line with the reports of Rawat *et al.*, (2010) in Guava and Saraswat *et al.*, (2006) in litchi. NAA × Boron interaction improved significantly the total sugar content in Litchi fruits and treatment of N₁B₃ revealing 13.70% total sugar followed by N₁B₄ (13.40%). The minimum sugar content was observed under the control (N₀B₀) with 11.34% total sugar content. These findings are in agreement with the reports of Pandey *et al.*, (2012) in ber and Saraswat *et al.*, (2006) in Litchi.

Application of 30ppm NAA expressed higher (19.05 °Brix) TSS during experimentation than the plants devoides of NAA (N₀) treatment with 16.96 °Brix. The improvement in TSS with the use of growth regulator NAA might have been due to the diversion of more solid metabolites towards developing fruits increasing amylase activity and thus, there was conversion of starch into simple sugar thereby enhancing total soluble content in fruits. The findings are in accordance with the reports of Kumar and Tripathi (2009) in strawberry, Kumar *et al.*, (2017) in aonla and Saraswat *et al.*, (2006) in litchi. Badal and Tripathi (2021b), also found increased TSS and total sugars with NAA 75 ppm spray in guava. Micronutrient Boron at 0.5% concentration recorded highest (B₃) of 18.86°Brix TSS and its control (B₀) revealed the lowest of 17.47 °Brix TSS content during investigation. TSS content ranged from 17.47 to 18.86 °Brix. This might be attributed to the fact that Boron is credited with certain contribution in the hydrolysis of complex polysaccharides into simple sugar, synthesis of metabolites and fast translocation of photosynthetic Produces and minerals from one part to other parts of the plant to the developing fruits. The present results are in line with the reports of Saraswat *et al.*, (2006) and Katiyar *et al.*, (2008) in Litchi.

References

1. A.O.A.C. (1980). Official method of analysis. *Association of Official Analytical Chemists* (12th edn.), Washington. D.C.
2. Badal, D.S. and Tripathi, V.K. (2021a). Influence of foliar feeding of naa and boron on growth, flowering, fruiting, and yield of winter season guava (*Psidium guajava* L.) cv. L-49. *Biological Forum-An International Journal*, 13(3): 387-391.
3. Badal, D.S. and Tripathi, V.K. (2021b). Effect of foliar application of NAA and Boron on physico-chemical parameters of winter season guava (*Psidium guajava* L.) cv. Lucknow-49. *The Pharma Innovation Journal*, 10 (9): 928-932.
4. Banyal, A.K., Sharma, U. and Thakur, J. (2013). Effect of different chemicals and mulch materials on fruit quality and productivity of litchi cv. Dehradun. *Progressive Research*, 8(2): 254-256.
5. Chaudhary, M., Singh, D.P., Singh, J.P. and Mishra, K.K. (2018). Effect of foliar application of PGRs and mineral nutrients on fruiting behaviour, growth and yield of Aonla cv. NA-7. *Journal of Pharmacognosy and Phytochemistry*, 7(4): 2714-2718
6. Chauhan, A.S., Kumar, K., Saini, P.K., Singh V. and Singh, J.P. (2019). Effect of NAA and Zinc Sulphate on Fruiting, Yield of Litchi (*Litchi chinensis*, Sonn.) cv. Calcuttia. *International Journal of Current Microbiological Applied Science*, 8(3): 836-843.
7. Katiyar, P.N., Prakash, O., Singh, J.P. and Singh, P.C. (2008). Effect of zinc sulphate, borax and calcium nitrate on flowering, fruiting, yield and quality of Litchi cv. Dehradun. *Journal of Rural Agricultural Research*, 8(2): 49-51.
8. Kumar, A., Tripathi, V.K., Dubey, V., Katiyar, N.K., Tiwari, P. (2017). Influence of foliar application of calcium, zine and boron on fruit drop, yield and quality attributes of aonla (*Emblca officinalis*) cv. NA-7. *Res. on Crops*, 18(1):91-97.
9. Kumar, R. and Tripathi, V.K. (2009). Influence of NAA, GA₃ and boric acid on growth, yield and quality of strawberry cv. Chandler. *Progressive Horticulture*, 41(1): 113-115,
10. Maurya, P.K., Tripathi, V.K. and Gupta, S. (2020). Effect of pre-harvest application of GA₃, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali. *Journal of Pharmacognosy and Phytochemistry*, 9(6): 2123-2127.
11. Pandey, A., Tripathi, V.K., Pandey, M., Mishra, A.N. and Kumar, D. (2011). Influence of NAA, GA₃ and Zinc Sulphate on fruit drop, growth, yield and quality of ber cv. Banarsi Karaka. *Proceeding of ISMF & MP, held at BCKV, W.B. from Dec. 19-22, 2011*, pp-184-187.
12. Rawat, V., Tomar, Y.K., Rawat, J.M.S. (2010). Influence of foliar application of micronutrient on the fruit quality of guava cv. Lucknow-49. *Journal of Hill Agriculture*, 1(1): 63–66
13. Sahay, S., Kumari, P., Mishra, P.K., Rashmi, K., Shrivastava, P., Ahmad, Md. F. and Kumar, R. (2018). Pre-harvest foliar spray of micronutrients and growth regulators on yield attributes of litchi (*Litchi chinensis* Sonn.) 'Purbi'. *Acta Horticultureae*, 1211.
14. Saraswat, N.K., Pandey, U.N. and Tripathi, V.K. (2006) influence of NAA and Zinc sulphate on fruit drop, cracking, fruit size, yield and quality of litchi cv. Calcuttia. *Journal of Asian, Horticulture*, 2(4): 255-259.
15. Sharma, P.; Singh, A.K. and Sharma, R.M. (2005). Effect of plant bio-regulators (PBRs) micro-nutrients on fruit set, quality of litchi cv. Dehradun. *Indian Journal of Horticulture*, 62(1): 24-26.
16. Shukla, H.S., Kumar, V. and Tripathi, V.K. (2011). Effect of gibberellic acid and boron on development and quality of aonla fruits cv. Banarasi. *Acta Horticulture*, 890: 375-380.
17. Singh, A., Yadav, A.L., Singh, J.P. and Vishwakarma, G. (2015). Effect of foliar spray of nutrients on yield attributing characters of mango (*Mangifera indica* L.). *Res. Environ. Life Sci.*, 8(3): 469-470.
18. Singh, J.K., Prasad, J. and Singh, H.K. (2007) Effect of micro- nutrients and plant growth regulators on yield and physiochemical characteristics of aonla fruits in cv. Narendra Aonla-10. *Indian Journal of Horticulture*, 64(2): 216-218.
19. Sinha, A.K.; Singh, L. and Jain, B.P. (1999). Effect of micro nutrients and growth regulators on yield and quality of litchi (*Litchi chinensis* Sonn.). *Journal of Research Birsa Agriculture University*, Nattingham, 15(1): 66 – 68
20. Tiwari, P., Tripathi, V.K. and Singh, A. (2017). Effect of foliar application of plant bio-regulators and micronutrients on fruit retention, yield and quality attributes of aonla. *Progressive Research-An International Journal*, 12 (Special-IV): 2565-2568.
21. Tripathi, V.K., Singh, A., Bhadauria, A.S. and Gupta, S. (2019). Influence of GA₃ and naphthalene acetic acid alone and in combination on fruit drop, yield and quality of mango cv. Amrapali. *Progressive Research-An International Journal*, 14(1): 10-13.
22. Verma S., Dwivedi, A.K. and Tripathi, V.K. (2021). Effect of gibberellic acid and boron on growth, yield and yield attributory traits in strawberry (*Fragaria x ananassa* Duch.) under North Gangetic Plains. *Biological Forum-An International Journal*, 13(3): 262-267.



Knowledge Level of Chickpea Growers Regarding Pradhan Mantri Fasal Bima Yojna with Reference to Chickpea Growers in Raipur District of Chhattisgarh

Vijay Singh Thakur and K.K. Shrivastava

Department of Agricultural Extension, College of Agriculture, IGKV, Raipur-492012 (C.G.) India

Email : vijubhai.t@gmail.com

Abstract

In this, study the majority of the respondents (86.25%) acquired the credit from co-operative society, slightly more than 50 per cent respondents (51.25%) were expressed that agriculture department official were the main sources of information, the overall used of sources of information about PMFBY by the respondents were medium category farmers was maximum used of sources of information was 0.45.000 per cent. The majority of the respondents (60.00 %) were medium level economic motivation category regarding risk bearing ability three-fourth respondents were medium level, The results on overall Knowledge level regarding PMFBY related crop revealed that the half of sample respondents comes under medium category of knowledge. In case of Practice wise knowledge level of chickpea growers showed, that the majority of respondents had good knowledge about time of irrigation practices, whereas respondents had least knowledge regarding seed treatment with rhizobium culture. The results on knowledge about chickpea growers regarding PMFBY showed that the higher percentage of the majority of the respondents knows about crop cutting experiment. The analysis on attitude of chick pea growers revealed that more than three-fourth of respondents was expressed moderately favorable attitude towards P.M.F.B.Y. The maximum number of respondents 51.25 per cent were expressed medium level of satisfaction level.

Key word : Pradhan mantri fasal bima yojna, knowledge, satisfaction level, attitude.

Introduction

Pradhan Mantri Fasal Bima Yojna was launched on February 18, 2016 by Prime Minister Shri Narendra Modi. 21 states implemented the plan in Kharif 2016, while 23 states and 2 UT implemented the plan in Rabi 2016-17. According to the data available on March 31, 2017, about 3.7 million farmers in Kharif provided insurance for 370 million hectares of land in 2016 at a premium of Rs 16,212 crore and a total insurance coverage of Rs 128,568.94 crore.

PMFBY provides comprehensive insurance against crop failures, thereby helping to stabilize farmers' income. The plan covers all grain and oil crops as well as annual commercial/horticultural crops, which can provide past yield data, and the necessary crop reduction experiments (CCE) have been conducted based on the conventional crop estimation survey (GCES). The plan is implemented by experienced general insurance companies. The selection of the relevant implementation government is completed by the relevant state government through bidding.

For borrowing farmers, the program is mandatory, they use crop loans/KCC accounts to get notified crops and voluntarily use them for others. The plan is managed by the Ministry of Agriculture. The premium rate of PMFBY is uniformly determined as a uniform premium crop or actuarial rate of 2% of the insurance amount paid

by farmers for all kharif crops, 1.5% of the insurance amount of all Rabi crops, and 5% of the annual commercial and horticultural insurance amount. The lower shall prevail. The remaining premium will be paid by the government to provide farmers with full insurance coverage for crop losses caused by natural disasters. Subsidies are divided equally between the state and the central government. There is no upper limit on government subsidies for actual premiums. There is an urgent need to protect the agricultural income of Chhattisgarh farmers. Looking ahead to Chhattisgarh, the coverage of crop insurance continues to expand, and its contribution to stabilizing agricultural income against natural risks and disasters requires research on the performance of the state's crop insurance program.

In Chhattisgarh state of chickpea 2017-18 area, production and productivity 335.03, 331.68, 990 representatively (area 000, ha. production 000, m.t. productivity 000, kg/ha.) the major district of Chhattisgarh based on cultivated area of chickpea are Bemetara, Rajnandgaon, Kabirdham, Dhamtari, Balod, Mungeli, Durg, and Raipur. In Raipur district the area and production of chickpea cultivated area is 4.19 thousand ha. With production 4.98 thousand metric tons and productivity 1189 kg/ha. Hence recognizing the importance of Pradhan Mantri Fasal Bima Yojana the present study was taken with the objective as: To study the knowledge level of Chickpea growers regarding PMFBY.

Research Methodology

The study was conducted in 2019-20, and the Abhanpur block was selected from the Raipur district. The total of 80 respondents were selected. From 8 villages of Abhanpur Block and then 10 respondents were selected from each village. The data were collected through personal interview schedule, and analyze the data with the help of statistical methods, such as average, percentage, S.D., etc.

Knowledge Level of chickpea growers Regarding PMFBY : Knowledge stage, the individual is exposed to the PMFBY scheme but lack of complete information about it. This process occurs by chance or by the purpose of efforts person himself. A teacher made scale, was used for the study where total ten statements (seven positive and three are negative statements) and knowledge score of an individual has been computed by putting together the dichotomous response, i.e. 'Yes' and 'No' by assigning score 1 or 0, respectively.

Considering the total score, respondents were categorized on the basis of Mean $\pm$ standard deviation below :

Sl. No.	Categories	Score
1.	Low	1
2.	Medium	2
3.	High	3

Results and Discussion

Knowledge level of chickpea growers regarding PMFBY : The Knowledge level regarding PMFBY were presented on the table-1 indicates that majority of respondents were comes under medium level of category 48.75 per cent followed by low- and high-level category with 32.50 per cent and 18.75 percent respectively.

Table-1 : Overall Knowledge level of respondents regarding PMFBY. (n = 80)

Sl.No.	Category	Frequency	Percentage
1.	Low (Less than 7.17)	26	32.50
2.	Medium (7.17 to 10.65)	39	48.75
3.	High (More than 10.65)	15	18.75
	Total	80	100

$$\bar{x} = 8.91$$

$$S.D. = 1.74$$

Knowledge level about PMFBY : Table-2 shows that Majority of the farmer i.e. 67.50 percent knows about crop cutting, followed by 63.75 percent of the farmers have knowledge about the PMFBY and their benefits, 60.00 percent farmers have notified crops under the PMFBY, about 43.75 percent knows about rate of premium in PMFBY, knowledge about amount of claim in PMFBY and insurance company have same percent i.e. 31.25 percent and only 25 percent have claim settlement process in PMFBY.

Table-2 : Distribution of respondents according to their knowledge level regarding various component of Pradhan Mantri Fasal Bima Yojna. (n = 80)

Sl. No.	Knowledge about various component of PMFBY	Frequency	Percentage
1.	Knowledge about the PMFBY and their benefits	51	63.75
2.	Rate of premium in PMFBY	35	43.75
3.	Amount of Claim in PMFBY	25	31.25
4.	Notified crops under the PMFBY	48	60.00
5.	Claim settlement process in PMFBY	20	25.00
6.	Insurance company	25	31.25
7.	Crop Cutting Experiment	54	67.50

* Based on multiple response.

Practice wise knowledge of chickpea growers :

Table-3 expressed that majority of the respondents i.e. 87.50 percent were knows about time of irrigation followed by sowing time and sowing method which is (85.00%), (81.25%) about seed rate, (77.50%) knows about plant protection measure, (75.00%) have knowledge about land preparation, 65 percent have idea about improved variety, 58.75 per cent say that the have the knowledge about recommended fertilizer dose, and just 45 percent have knowledge about seed treatment with Rhizobium culture.

Table-3 : Practice wise knowledge level of chickpea growers. (n=80)

Sl. No.	Practice wise knowledge level about chickpea production Technology	Frequency	Percentage
1.	Land preparation	60	75.00
2.	Improved variety	52	65.00
3.	Seed Rate	65	81.25
4.	Seed treatment with Rhizobium culture	45	45.00
5.	Sowing Time and Sowing Method	68	85.00
6.	Recommended fertilizer doses	47	58.75
7.	Time of Irrigation	70	87.50
8.	Plant Protection measure	62	77.50

*based on multiple responses

Conclusions

From the above results, it can be concluded that in Pradhan Mantri Fasal Bima Yojna, the overall knowledge i.e. 48.75 percent respondent were medium level their fore extension effort should be done to aware the chickpea growers about Pradhan Mantri Fasal Bima Yojana its benefit etc. organized the training programs, meetings etc. So that they can easily under stand the benefit of the P.M.F. B.Y. program. The Government and NGO efforts should also be increasing their knowledge level of farmer regarding P.M.F.B.Y.

References

1. Angadi S.C. (1999). A study on knowledge, adoption and marketing pattern of pomegranate growers in Bagalkot district in Karnataka. *M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.*
2. Chaturvedi Deepak (1997). A study of knowledge and adoption of improved practices of cauliflower among farmers of Udaipur district, Rajasthan. *M.Sc. Thesis to Rajasthan Agricultural University, Bikaner, Rajasthan.*
3. Karpagam C. (2000). A study on the knowledge and adoption behaviour of turmeric growers in Erode district of Tamil Nadu. *M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.*
4. Lavania R., Patel H.L. and Sharma H.O. (1998). Knowledge level of trained and untrained farmers in improved practices of wheat crop. *Rural India*, 61:165-166.
5. Nagaraj K.H. (1996). Knowledge and adoption pattern of improved cultivation practices of groundnut among farmers of Pavagada taluk in Tumkur district. *M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bangalore.*
6. Raghunandan H.C. (2004). A study on knowledge and adoption level of soil and water conservation practices by the farmers in northern Karnataka. *M.Sc.(Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.*
7. Reddy Gurava K. (1998). Knowledge of agricultural officers on sustainable agricultural practices. *M.Sc.(Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad, Andhra Pradesh. Research Review*, 98: 23-25.
8. Reddy V. Venkata Shiva. (2006). Knowledge and adoption of integrated pest management practices among vegetable growers of Gadag district in north Karnataka, *M.Sc (Agri) Thesis.*
9. Shakhya, M.S., Patel, M.M. and Singh, V.B. (2008). Knowledge Level of Chickpea Growers about Chickpea Production Technology. *Indian Research Journal of Extension Education* 8(2&3): 65-68.
10. Singh P., Lakhera J.P. and Chandra S. (2012). Knowledge and Adoption of Mothbean Production Technology in Western Zone of Rajasthan. *Rajasthan Journal of Extension Education*, 20: 35-38.



Study on Growing Degree Days, Heat Use Efficiency and Weather Indices of Timely Sown Wheat (*Triticum aestivum* L.) Varieties

Prashun Sachan^{1*}, V.K. Verma¹, C.B. Singh¹, A.K. Sachan², Ram Pyare¹ and Dhananjai Singh¹

Department of Agronomy, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

Directorate Seed and Farm, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

*Corresponding Author Email : prashun.sachan@gmail.com

Abstract

The field experiment was conducted during *Rabi* season of 2017-18 at Students' Instructional Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, UP (India) to assess the performance of timely sown wheat varieties in relation to climate change situation and to assess impact of maximum temperature, minimum temperature and growing degree days on wheat cultivars. The treatments consisted 10 wheat varieties viz., K307, K 402, K 607, K 1006, HD-2733, DBW-17, HD-2967, PBW-343, PBW-502 and PBW-550, laid out in Randomized Block Design replicated three times. The varieties were sown on 17th November, 2017 and harvested at physiological maturity ranged 130 days to 142 days after sowing. The inputs were given time to time at recommended rates. The meteorological data viz. minimum temperature maximum temperature at standard meteorological weeks (SMW) were collected from meteorological observatory and growing degree days were calculated. The results exhibited that temperature (maximum and minimum) and growing degree days established positive correlation with growth characters, yield attributes and grain yield wheat varieties. Comparatively more duration (140 days) varieties viz., HD 2967 and PBW 343, recorded maximum growing degree days (1909.9), yielded maximum grain yield (5590.0 kg and 5277.00 Kg/ha), better harvest index (42.23% and 39.90%), respectively. The minimum grain yield (4601.00 kg/ha) and harvest index (35.67%) was recorded under PBW 502. The heat use efficiency of K402, HD 2967 and PBW-343 was found higher (3.05, 2.93 and 2.76 kg °C/day, respectively) while, K307 recorded minimum (2.62 Kg°C/day) HUE.

Key words : Growing degree days, heat use efficiency, minimum and maximum temperature, wheat varieties.

Introduction

Wheat is one of the most important food crop of whole world. Globally it is grown in 122 countries and occupies an area of 218.5 m.ha, producing nearly 771.7 mtonnes, with a productively of 3.53 t/ha. It is the third most produced cereal after maize (1134.7 million tonnes) and rice (769.66 million tonnes). (FAO, statistical data, 2017).

In India, wheat is grown mainly in northern states, with Uttar Pradesh being the highest contributor at 34% of the total production followed by Punjab, Haryana and Madhya Pradesh. The average productively of wheat in Uttar Pradesh (28.76 q/ha) is lower than Punjab (42.67 q/ha) Haryana (39.67 q/ha) and even the national average (32 q/ha).

Currently agriculture is facing multi-dimensional challenges including climate change. Projected increase in temperature and frequency of weather extremes could significantly constrain wheat production in future climate. Average global temperature have increased over the last decades and are predicted to continue rising, along with a greater frequency of extremely hot days. Surprisingly, observed variation of $\pm 2^{\circ}\text{C}$ in average growing season in the main wheat growing regions can cause reduction in grain production of up to 50%. Most of this can be

attributed to increased leaf senescence as a result of temperature $> 34^{\circ}\text{C}$. (Assang *et al* 2011). Wheat varieties vary for their duration as well as tolerance to temperature stress. A shorter duration cultivars is likely to yield less, while the longer duration variety may be exposed to more climatic stress. Hence farmer's always are in dilemma regarding the choice a variety. The majority of previous studies showed that increase in temperature shortened crop growing period, leading to reduced crop productivity (Wang *et al* 2012). This study was aimed to quantify the response of long duration and medium duration varieties to high temperature and is expected to provide scientific basis for the choice of a variety in changing climate Conditions.

Materials and Methods

The field experiment was conducted during *rabi* season of 2017-18 at Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur Uttar Pradesh, India, situated at 125.9 meter altitude, 26.4148 North latitude, and 80.2321 East longitude. Treatments involved 10 wheat varieties viz. K-307, K-402, K-607, K-1006, HD2733, DBW-17, HD-2967, PBW-343, PBW-502 and PBW-550 matures in 135 to 145 days after sowing. The treatments were laid out in Randomized Block Design replicated three times. The

Table-1 : Correlation coefficient of growth characters of wheat varieties.

Treatments	Correlation coefficients of different growth characters											
	Plant Height (cm)			Fresh Weight (g)			Dry Weight (g)			Tillers/m		
	T _{max}	T _{min}	GDD	T _{max}	T _{min}	GDD	T _{max}	T _{min}	GDD	T _{max}	T _{min}	GDD
K307	0.384	0.404*	0.763*	-0.682*	-0.705*	-0.266	0.599*	0.594*	0.835*	0.107	0.143	0.569*
K402	0.379	0.400*	0.800*	-0.688*	-0.716*	-0.240	0.600*	0.596*	0.877*	0.098	0.134	0.605*
K607	0.382	0.401*	0.791*	-0.683*	-0.711*	-0.244	0.600*	0.596*	0.866*	0.104	0.137	0.598*
K1006	0.387	0.406*	0.764*	-0.680*	-0.703*	-0.264	0.600*	0.595*	0.836*	0.108	0.144	0.570*
HD2733	0.389	0.410*	0.746*	-0.680*	-0.699*	-0.280	0.600*	0.593*	0.816*	0.091	0.133	0.539*
DBW17	0.387	0.406*	0.764*	-0.682*	-0.705*	-0.266	0.601*	0.595*	0.836*	0.128	0.164	0.585*
HD2967	0.388	0.409*	0.754*	-0.681*	-0.701*	-0.274	0.600*	0.594*	0.825*	0.117	0.156	0.567*
PBW343	0.388	0.409*	0.754*	-0.681*	-0.701*	-0.273	0.600*	0.594*	0.825*	0.110	0.149	0.561*
PBW502	0.388	0.407*	0.759*	-0.681*	-0.704*	-0.270	0.592*	0.586*	0.822*	0.110	0.146	0.567*
PBW550	0.384	0.403*	0.809*	-0.680*	-0.704*	-0.224	0.600*	0.596*	0.888*	0.107	0.143	0.614*

T_{max}OC = Maximum temperature degree centigradeT_{min}OC = Minimum temperature degree centigrade

GDD = Growing Degree Days

Table-2 : Correlation coefficient of yield attributes of wheat with maximum temperature, minimum temperature and Growing Degree Days.

Treatments	No. of Ear's/m	Length of Ear (cm)	No. of grain/Ear	Grain Weight/plant(g)	Test Weight (g)	Biological Yield (kg/ ha)	Grain Yield (kg/ ha)	Straw Yield (kg ha)	Harvest Index (%)
K307	392.87	8.40	49.42	8.25	37.65	12341.00	4875.00	7466.00	39.50
K402	419.42	8.84	51.98	8.67	39.60	13235.00	5128.00	8107.00	38.75
K607	390.32	8.33	49.01	8.18	37.33	13231.00	4834.00	8397.00	36.54
K1006	418.83	8.98	52.83	8.82	40.25	13239.00	5211.00	8028.00	39.36
HD2733	405.70	8.67	50.99	8.52	38.84	13237.00	5030.00	8207.00	38.00
DBW17	414.28	8.84	52.01	8.68	39.62	13228.00	5130.00	8098.00	38.78
HD2967	450.66	9.64	56.67	9.46	43.17	13238.00	5590.00	7648.00	42.23
PBW343	425.53	9.10	53.49	8.93	40.75	13226.00	5277.00	7950.00	39.90
PBW502	386.62	7.90	47.65	7.96	36.30	12900.00	4601.00	8299.00	35.67
PBW550	400.18	8.59	50.51	8.43	38.48	13228.00	4983.00	8245.00	37.67
Correlation(r)	0.160	0.172	0.210	0.218	0.210	-0.125	0.177	-0.289	0.253
T _{max} (°C)									
Correlation(r)	0.326	0.321	0.358*	0.366*	0.358*	-0.018	0.326	-0.321	0.370*
T _{min} (°C)									
Correlation(r)	0.269	0.221	0.267	0.275	0.267	-0.161	0.228	-0.373*	0.327
GDD									

soil of experimental field was sandy loam with 55% sand, 25.50% silt and 19.50% clay with pH of 7.95. It was moderately fertile being low in organic carbon (0.42%) available N (179.0 kg/ha), and Potash (156.0 kg/ha).

The meteorological observations recorded during the study period revealed that at the time of germination (November 2017) the temperature ranges 7.6 °C to 26.7 °C. The temperature during growth period i.e. December 2017, January 2018, February 2018 was ranged 5.3 °C to 14.6 °C (minimum temperature) and 17.1 °C to 30.3 °C (maximum temperature). During maturity in the month of March and April 2018, the minimum temperature varies 13.9 °C to 22.3 °C and maximum temperature varies 30.7 °C to 36.1 °C. The relative humidity ranged between 45.9% to 83.8% and cumulative rainfall limited to only 15.8 mm, which reveals that almost dry *Rabi* season was notified in 2017-18.

Yield Attributes : The data pertaining to yield attributes (Table-2) exhibited that among different varieties tested HD-2967 and PBW-343 recorded maximum ears (m-2), ear length (cm), grains/ear, grain weight/plant and test weight (g). All the above expressed yield attributing characters showed positive correlation with maximum temperature and growing degree days, while minimum temperature observed significantly positive correlation with grains/ear, grain weight/plant and test weight of different varieties, Sandhu *et al* 2016, expressed that wheat varieties are sensitive to high temperature, particularly when it occurs during reproductive and grain tilling phases.

Yield : The data expressed in Table-2, exhibited that among different varieties tested HD2967 recorded maximum grain yield (5590.00 kg/ha) and harvest index (42.23%) with 140 days maturity time, followed by PBW

Table-3 : Growing Degree Days and Heat Use Efficiency of different varieties on the basis of biological yield and grain yield.

Treatments	Days to Maturity	GDD	HUE (kg °C day ⁻¹) of Biological Yield	HUE (kg °C day ⁻¹) of Grain Yield
K307	138	1857.4	6.64	2.62
K402	130	1678.0	7.88	3.05
K607	132	1723.9	7.68	2.80
K1006	138	1857.4	7.13	2.80
HD2733	142	1954.5	6.77	2.57
DBW17	138	1857.4	7.12	2.76
HD2967	140	1907.9	6.94	2.93
PBW343	140	1907.9	6.93	2.76
PBW502	139	1882.6	6.85	2.44
PBW550	137	1832.2	7.22	2.71

GDD – Growing Degree Days, HUE – Heat use efficiency.

342 which recorded grain yield (5277.00 kg/ha) and harvest index (39.90%) during similar maturity time. In terms of maximum straw yield (8397 kg/ha), variety K607 grasped better rank among different varieties. The biological yield and straw yield of different varieties observed negative correlation with maximum temperature, minimum temperature and growing degree days. While, grain yield and harvest index established positive correlation with maximum temperature, minimum temperature and growing degree days. The temperature (maximum and minimum) and cumulative heat unit plays important role in dry matter production and translocation of food material from source to sink which ultimately increase grain yield of wheat varieties and higher harvest index.

Results and Discussion

Growth Variables : The data summarized in Table-1 revealed that plant height of different varieties showed positive but non-significant correlation with maximum temperature, while minimum temperature established significantly positive correlation with plant height. Similarly growing degree days express significantly positive correlation with plant height of different varieties. Fresh weight of different varieties exhibited significantly negative correlation with maximum and minimum temperature and growing degree days. Dry weight of plant in different varieties exhibited significantly positive correlation with minimum temperature, maximum temperature and growing degree days. Tillers per meter square established positive but non-significant correlation with minimum and maximum temperature, while growing degree days exhibited significantly positive correlation with tiller's per meter square. It may be concluded that maximum temperature, minimum temperature and growing degree days observed positive correlation with growth variables of different varieties of wheat at different stages. The

above findings are corroborated with the findings of Chapman *et al.* 2012 and He *et al.* 2015.

Growing degree days and heat use efficiency : The data presented in Table-2 revealed that increase in growing degree days or cumulative heat unit of different varieties is directly correlated with increase in maturity time. The growing degree days found maximum (1954.5) under HD 2733 followed by HD-2967 (1907.9) and PBW 343 (1907.9) and minimum GDD was recorded under K402 (1678.0) with minimum maturity time. The heat use efficiency of biological yield was recorded maximum (7.88 kg °C/day) under variety K402 and minimum (6.64 kg °C/day) under K307. While heat use efficiency of grain yield was recorded maximum (3.05 kg °C/day) under K402 and minimum (2.62 kg °C/day) under K307. The varieties HD-2967 and PBW-343 recorded comparatively better GDD (1907.9) and heat use efficiency of biological yield (6.94 and 6.93 kg °C/day) and grain yield (2.93 and 2.76 kg °C/day), respectively. It might be due to these varieties possess better genome characteristics to access more solar radiation for the production of dry matter. The above findings are corroborated with the findings of Dangi and Shrestha (2018), Karambir *et al.* (2003), Sharma *et al.* (2003) and Kaur *et al.* (2004).

Conclusion

Based on the findings of results it may be concluded that comparatively more duration varieties viz. HD2967 and PBW 343, when sown timely (17th November) recorded more growing degree days (1907.9) was least affected by temperature fluctuations, positively correlated with minimum temperature at growth stages, yielded comparatively better grain yield (5590.0 and 5277.00 kg ha⁻¹), harvest index (42.23% and 39.90%), heat use efficiency of grain yield (2.93 and 2.76 kg °C/day), respectively.

References

1. Anonymous (2017). The food and Agriculture Organisation Corporate statistical Database.
2. Assang S., Foster L. and Turner N.C. (2011). The impact of temperature variability on wheat yield. *Glob. Change Biol.*, 7: 997-1012.
3. Chapman S.C., Chakraborty S., Dreccer M.F. and Howden S.M. (2012). Plant adaptation to climate change opportunities and priorities in breeding. *Crop Pasture Sci.*, 63: 251-268.
4. He L., Asseng S., Zhao G., Wu D., Yang X. and Zhuang W. (2015). Impacts of recent climate warming cultivar changes and crop management on winter wheat phenology across the loess plateau of China. *Agri. Forest Meteorol.*, 200: 135-143.
5. Karambir S., Niwas R. and Singh M. (2003). Heat use efficiency of wheat cultivars under different sowing dates. *Journal of Research*, 33(2): 103-106.
6. Kaur P., Dhaliwal L.K. and Handal S.S. (2004). Agrometeorological analysis for predicting growth and yield of wheat (*Triticum aestivum* L.) under Punjab conditions. *Journal of Agrometeorology*, 6: 16-20.
7. Sandhu S.S., Prabhjyot Kaur, Tripathi P., Patel S.R., Solanki N.S. and Kumar R. (2016). Effect of intra seasonal temperature on wheat at different locations of India: A study using CERES wheat model. *J. Agrometeorol*, 18(2): 222-233.
8. Sharma K., Niwas R. and Singh M. (2003). Photothermal indices in relation to phenology of wheat. *Agriculture Science digest*, 23(4): 279-281.
9. Wang J., Wang E., Yang X., Zhang F. and Yin H. (2012). Increased yield potential of wheat-maize cropping system in the north China Plain by climate change adaptation. *Climate Change*, 113: 825-840.
10. Dangi, Shrestha (2018). Evaluation of growing degree days, accumulation and agroclimatic indices in different genotype of wheat in Far-Western Hills Nepal. *EC Agriculture*, 4(1): 39-44.



Screening of Timely Sown Wheat (*Triticum aestivum* L.) Varieties in Relation to Climate Change in Central Plain Zone of Uttar Pradesh

Prashun Sachan^{1*}, V.K. Verma¹, A.K. Sachan² and Ram Pyare¹

Department of Agronomy, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

Directorate Seed and Farm, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) India

*Corresponding Author Email : prashun.sachan@gmail.com

Abstract

The field experiment was conducted during *rabi* season of 2017-18 at Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP) India to screen out timely sown varieties of wheat on the basis of their growth characters, yield attributes and yield under agro climatic situation of Central Plain Zone of Uttar Pradesh. The treatments consisted ten wheat varieties viz., K307, K402, K607, K1006, HD-2733, DBW-17, HD2967, PBW-343, PBW-502 and PBW-550, laid out in Randomized Block Design replicated three times. The varieties were sown on 17th November 2017 and harvested of Physiological maturity ranged 130 days to 142 days after sowing. The inputs were given timely at recommended rates. The results exhibited that the performance of HD2967 and PBW-343 was found significantly superior over other varieties in terms of growth, yield attributes and yield. The variety HD-2967 recorded maximum grain yield (5590.0 kg/ha), Harvest index (42.23%), net income (Rs. 80490/ha) and B:C ratio (2.89) followed by PBW 343 recorded grain yield (5277.0 kg/ha), harvest index (35.67%), net income (Rs. 65358/ha) and B: ratio (2.53) was recorded under PBW 502.

Key words : Wheat, varieties, growth characters, yield attributes, yield.

Introduction

World trade in wheat is greater than for all other crops combined with rice, wheat is the world's most favoured staple food. It is a major diet component because of the wheat plants, agronomic adaptability with the ability to grow from near arctic regions to equator, from sea level to plains of tibet, approximately 4000 m. (13000 fit) above sea level. In addition to agronomic adaptability, wheat offers ease of grain storage and ease of converting grain into flour for making edible, palatable, interesting and satisfying foods.

In 100 grams, wheat provides 327 Kilocaloreis and is a rich source of multiple essential nutrients such as protein, dietary fibre, manganese, phosphorus and niacin. Several B vitamins and other dietary mineral are in significant content. Wheat is 13% water, 71% carbohydrates, and 1.5% fat. Its 13% protein content is mostly gluten (75-80% of the protein in wheat). Wheat proteins are deficient in the essential amino acid, lysine, white flours are more deficient in lysine compared with whole grains.

Currently agriculture is facing multi-dimensional challenges including climate change. Projected increase in temperature and frequency of weather extremes could significantly constrain wheat production in future climate. Average global temperature have increased over the last decades and are predicted to continue rising, along with a greater frequency of extremely hot days. Surprisingly,

observed variation of ± 2 oC in average growing season in the main wheat growing regions can cause reduction in grain production of up to 50%. Most of this can be attributed to increased leaf senescence as a result of temperature > 34 oC. (Assang *et al.* 2011) [1]. Wheat varieties vary for their duration as well as tolerance to temperature stress. A shorter duration cultivars is likely to yield less, while the longer duration variety may be exposed to more climatic stress. Hence farmer's always are in dilemma regarding the choice a variety. The majority of previous studies showed that increase in temperature shortened crop growing period, leading to reduced crop productivity (Wang *et al.* 2012) [2]. This study was aimed to quantify the response of long duration and medium duration varieties to high temperature and is expected to provide scientific basis for the choice of a variety in changing climate conditions.

Materials and Methods

The field experiment was conducted during *rabi* season of 2017-18 at Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur Uttar Pradesh, India, situated at 125.9 meter altitude, 26.4148 North latitude, and 80.2321 East longitude. Treatments involved 10 wheat varieties viz. K307, K402, K607, K1006, HD2733, BDW-17, HD2967, PBW343, PBW502 and PBW 550 matures in 135 to 145 days after sowing. The treatments were laidout in Randomized Block Design replicated three times. The soil of experimental field was sandy loam with 55% sand,

Table-1 : Growth characters of different wheat varieties.

Treatments	Plant Height (cm)	No. of Tillers m ⁻²	Absolute Growth Rate (g day ⁻¹)						
	Maturity	95 DAS	0-35 DAS	35-45 DAS	45-55 DAS	55-75 DAS	75-95 DAS	95-105 DAS	Maturity
K307	78.32	416.65	0.055	0.400	0.238	0.274	0.165	0.155	0.034
K402	83.55	444.28	0.059	0.420	0.251	0.289	0.173	0.168	0.046
K607	77.75	413.37	0.056	0.396	0.236	0.272	0.163	0.159	0.040
K1006	83.43	444.59	0.060	0.427	0.255	0.293	0.176	0.172	0.035
HD2733	80.82	427.46	0.058	0.412	0.246	0.283	0.170	0.165	0.030
DBW17	82.06	438.51	0.059	0.420	0.251	0.288	0.174	0.169	0.034
HD2967	89.95	477.29	0.064	0.458	0.274	0.314	0.189	0.184	0.036
PBW343	84.77	451.73	0.061	0.432	0.258	0.297	0.179	0.173	0.034
PBW502	77.02	410.21	0.055	0.392	0.234	0.269	0.162	0.124	0.041
PBW550	79.72	424.64	0.058	0.408	0.243	0.281	0.168	0.164	0.035
SE(d)±	2.6872	5.927	0.0054	0.0040	0.0028	0.0016	0.0018	0.0025	0.0019
CD(P=0.05)	5.6458	12.548	N.S.	0.0084	0.0059	0.0033	0.0039	0.0052	0.0040

Table-2 : Yield attributes of different wheat varieties.

Treatments	No. of Ear's m ⁻²	Length of Ear (cm)	No. of grain ear ⁻¹	Test Weight (g)
K307	392.87	8.40	49.42	37.65
K402	419.42	8.84	51.98	39.60
K607	390.32	8.33	49.01	37.33
K1005	418.83	8.98	52.83	40.25
HD2733	405.70	8.67	50.99	38.84
DBW17	414.28	8.84	52.01	39.62
HD2967	450.66	9.64	56.67	43.17
PBW343	425.53	9.10	53.49	40.75
PBW502	386.62	7.90	47.65	36.30
PBW550	400.18	8.59	50.51	38.48
SE(d)±	16.266	0.1732	1.6873	0.7365
CD (P=0.05)	34.438	0.3632	3.5461	1.5480

25.50% silt and 19.50% clay with pH of 7.95. It was moderately fertile being low in organic carbon (0.42%) available N (179.0 kg/ha), and Potash K (156.0 kg/ha).

The meteorological observations recorded during the study period revealed that at the time of germination (November 2017) the temperature ranges 7.6 °C to 26.7 °C. The temperature during growth period i.e. December 2017, January 2018, February 2018 was ranged 5.3 °C to 14.6 °C (Minimum temperature) and 17.1 °C to 30.3 °C (maximum temperature). During maturity in the month of March and April 2018, the minimum temperature varies 13.9 °C to 22.3 °C and maximum temperature varies 30.7 °C to 36.1 °C. The relative humidity ranged between 45.9% to 83.8% and cumulative rainfall limited to only 15.8 mm, which reveals that almost dry *Rabi* season was notified in 2017-18.

Results and Discussion

Growth variables : The data presented in Table-1 exhibited that significantly maximum plant height (89.95

cm) and tiller per meter square (477.29) was recorded under HD 2967 followed by PBW 343 and minimum plant height (77.02 cm) and tiller m-2 (410.21) observed under variety PBW 502. The production of dry matter in terms of absolute growth rate (g/day) recorded maximum at 35-45 days after sowing stage in all the varieties and later on a decreasing trend was observed till maturity. The wheat variety HD2967 recorded maximum absolute growth rate at different stages till 95-105 DAS stage. At maturity stage K402 recorded maximum growth rate compared to other varieties. The overall performance in terms of absolute growth rate HD 2967 and PBW-343 found better among all other varieties tested. The difference in growth characters in varieties might be due to their genetic diversity (Aslam *et al.* 2003).

Yield attributes : The data summarised in table-2 revealed that all the varieties exhibited significant difference in terms of yield attributes. The variety HD 2967 recorded significantly maximum ears (450.66 m⁻²), ear length (9.64 cm), grains ear-1 (56.67) and test weight

Table-3 : Yield and economics of different wheat cultivars.

Treatments	Grain Yield (kg ha ⁻¹)	Straw Yield (kg ha ⁻¹)	Harvest Index (%)	Gross Income (Rs ha ⁻¹)	Net Income (Rs ha ⁻¹)	B:C Ratio
K307	4875.00	7466.00	39.50	110224=00	67519=00	2.58
K402	5128.00	8107.00	38.75	116832=00	74127=00	2.74
K607	4834.00	8397.00	36.54	112776=00	70071=00	2.64
K1006	5211.00	8028.00	39.36	117987=00	75282=00	2.76
HD2733	5030.00	8207.00	38.00	115534=00	72829=00	2.70
DBW17	5130.00	8098.00	38.78	116835=00	74130=00	2.73
HD2967	5590.00	7648.00	42.23	123195=00	80490=00	2.89
PBW343	5277.00	7950.00	39.90	118853=00	76148=00	2.78
PBW502	4601.00	8299.00	35.67	108063=00	65358=00	2.53
PBW550	4983.00	8245.00	37.67	114817=00	72112=00	2.69
SE(d)±	181.32	229.27	0.3296	1158.0067	883.2486	0.0774
CD (P=0.05)	381.08	481.85	0.6930	2433.7065	1856.2654	0.1647

(43.17 g) followed by PBW 343 which recorded 425.53 ears m⁻², 9.10 cm ear length, 53.49 grains ear⁻¹ and 40.75 g test weight found significantly at par and minimum ear's m⁻² (386.62), ear length (7.90 cm) grains ear⁻¹ (47.65) and test weight (36.30 g) recorded under PBW 502 variety. The better yield attributes in varieties might be due to better growth of particular variety. The highest grain yield was correlated with longer spike, growth duration, partitioning higher crop growth rate and grain spike weight ratio at anthesis phase (Gill, 2009).

Yield and economics : The data presented in Table-3 revealed that maximum grain yield (5590.0 kg ha⁻¹) was recorded in variety HD 2967 and the growth yield of the varieties PBW 343 and K1006 found significantly at par. The minimum grain yield (4601.00 kg ha⁻¹) was recorded under variety PBW 502. The grain yield increased to the tune of 21.49%, 14.69% and 13.25% under HD 2967, PBW 343 and K1006, respectively, compared to the variety PBW 502. The straw yield was recorded maximum (8397.00 kg ha⁻¹) in the variety K607 followed by PBW -502, PBW 550, HD 2733 found significantly at par. The harvest index was recorded maximum (42.23%) in HD 2967 followed by PBW-343 (39.90%), K307 (39.50%) and K1006 (39.36%) found significantly at par. The yield data are closely related to absolute growth rate and dry matter production of different varieties. The above findings are closely related to the findings of Gill (2009), Naresh *et al.* (2014).

The economics of different varieties in terms of gross income, net income and B:C ratio revealed that among ten varieties tested three varieties viz HD-2967,

PBW-343, and K 1006 evaluated maximum profit. The maximum gross income (Rs. 123195.00 ha⁻¹), net income (Rs. 40490.00 ha⁻¹) and B:C ratio (2.89) was obtained with the variety HD 2967, followed by PBW 343 and K1006. The minimum gross income (Rs. 108063.00/ha), net income (Rs. 65358.00/ha) and B:C ratio (2.53) was recorded under PBW 502.

Conclusion

Based on the findings of results it might be concluded that the variety HD2967, PBW-343 and K-1006 showed better performance in terms of grain yield, net income under timely shown situation of Central Plain Zone of Uttar Pradesh.

References

- Assan S., Foster L. and Turner N.C. (2011). The impact of temperature variability on wheat yield. *Glob. Change Biol.* 17: 997-1012.
- Wang J., Wang E., Yang X., Zhang F. and Yin H. (2012). Increased yield potential of wheat-maize cropping system in the north China Plain by climate change adaptation. *Climate change*, 113: 825-840.
- Aslam M., Husain M., Akhtar M., Cheema M.S. and Ali L. (2003). Response of wheat varieties to sowing dates. *Pakistan Journal of Agronomy*, 2(4): 190-194.
- Gill D.S. (2009). Agrophysiological traits for screening heat tolerant lines of wheat (*Triticum aestivum* L.) under late sown conditions. *Indian J. Agric. Res.*, 43(3): 211-214.
- Naresh Kumar S., Agrawal P.K., Rani D.N.S., Saxena R., Chauhan A. and Jain S. (2014). Vulnerability of production to climate change in India. *Climate Research*, 59: 173-187.



Productivity of Rice (*Oryza sativa* L.) in Relation to Nitrogen Levels and Time of Application

P.D. Singh and U.S. Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab)

Abstract

The field experiment was carried out at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during the *kharif* season of 2019 to study the productivity of rice (*Oryza sativa* L.) in relation to nitrogen levels and time of application. The treatments consisted of three N levels viz. 75, 100 and 125 kg N/ha and three time of nitrogen application viz. 7, 14 and 21 days after transplanting (DAT) and 7, 21 and 28 DAT and 7, 28 and 42 DAT. The experiment was laid out in randomized complete block design (RCBD) with three replications. The growth parameters and yield attributes were significantly influenced with nitrogen levels and time of nitrogen application. The maximum grain yield was recorded with the application of 125 kg N/ha (73.8 q/ha) which was at par with 100 kg N/ha (70.1 q/ha) but was significantly higher than 75 kg N/ha (67.2 q/ha). The increase in grain yield of rice was 5.2 and 9.8 per cent higher with application of 125 kg N/ha than 100 and 75 kg N/ha, respectively. The maximum grain yield was recorded with the time of nitrogen application at 7, 28 and 42 DAT (74.0 q/ha) which was at par with at 7, 21 and 28 DAT (69.8 q/ha) but was significantly higher than time of nitrogen application at 7, 14 and 21 DAT (67.4 q/ha). The grain yield of rice increased with time of nitrogen application at 7, 28 and 42 DAT than at 7, 14 and 21 DAT and 7, 21 and 28 DAT by a margin 9.7 and 6.0 per cent, respectively. The interaction between different nitrogen levels and time of nitrogen application was non-significant in all morphological, yield attributes and yield.

Key words : Plant population, nitrogen, basmati rice, growth, yield attributes and yield.

Introduction

Rice is the most important food crop and major food grain for more than one third of the world's population (Zhao *et al.* 2011). Rice crop grows both under irrigated and rainfed conditions worldwide contributing 75 per cent and 25 per cent of the paddy production each, respectively. Rice prefers a tropical or warm climate, with a lot of rainfall. But if irrigation water is not available, rice can also be grown in drier areas or during dry season. Depending on the variety and soil, rice plants are between 1 to 1.8 meter tall and usually grown on heavier soils that have a good water holding capacity. Nitrogen (N) is the main nutrient associated with yield as N affects the growth and yield of rice. N availability promotes crop growth and tillering and determines the number of panicles during the early panicle formation stage. This nutrient also provides a sink during the late panicle formation stage. N fertilizer is a major essential plant nutrient and a key input for increasing crop yield. (Hirzel *et al.* 2011). Nitrogen fertilization and proper time of its application is the major agronomic practice that affects the yield and quality of rice crop. It requires N as much as possible at an early and mid-tillering stage to maximize panicle numbers and during reproductive stages to produce a greater number of spikelet's per panicle and percentage filled spikelet's (Lampayan *et al.* 2010).

Materials and Methods

The present experiment was carried out during *kharif*

season of 2019 at the Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh Punjab. The Mandi Gobindgarh is situated at 30.6642° N latitude and 76.2914° E longitudes at an altitude of 268 meters above mean sea level. The experiment was laid out in randomized complete block design (RCBD) with three replications. The soil of the experimental field was low in organic carbon (0.37 %) and available soil nitrogen (145.6 kg N/ha), medium in available soil phosphorus (18.3 P₂O₅/ha) and in available soil potassium (166 kg K₂O/ha). The treatments included three N levels viz. 75, 100 and 125 kg N/ha and three time of nitrogen application viz. 7, 14 and 21 days after transplanting DAT and 7, 21 and 28 DAT and 7, 28 and 42 DAT. The twenty kg seed per hectare was used for sowing and crop was transplanted on July 5, 2019 at a spacing of 20 × 15 cm. The gross plot size was 3.4 × 4.5 m and net plot size was 3 × 4 m. The crop was sown on July 5, 2019 and Harvested on October 21, 2019. The all-other cultural practices were followed uniformly applied in all the treatments.

Results and Discussion

Growth parameters : Plant population was not influenced significantly with nitrogen levels and time of application. The plant height was increased significantly with the application of 125 kg N/ha (95.8 cm) (Table-1) over 100 kg N/ha (87.9 cm) and 75 kg N/ha (81.3 cm). However, the nitrogen application with 100 kg N/ha also recorded

Table-1 : The productivity of rice (*Oryza sativa* L.) in relation to nitrogen levels and time of applications.

Treatments	Plant population (m ⁻²)	Plant height (cm)	Tillers/hill	50% flowering	Panicles / hill	1000-grains weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Nitrogen levels (kg N/ha)									
75	30.2	81.3	14.1	54.8	12.3	21.2	67.2	89.0	42.9
100	30.4	87.9	14.3	57.6	12.4	21.8	70.1	92.2	43.2
125	31.5	95.8	15.2	72.7	13.2	22.3	73.8	94.2	44.6
CD at 5%	NS	4.18	0.90	3.41	0.67	NS	4.66	NS	0.89
Time of application									
7,14,21 DAT	30.3	85.6	13.2	58.6	11.6	21.4	67.4	91.4	42.3
7,21,28 DAT	30.5	88.1	14.5	62.5	12.4	21.9	69.8	91.3	43.5
7,28,42 DAT	31.3	91.3	15.9	64.1	13.8	22.0	74.0	92.7	44.9
CD at 5%	NS	4.18	0.90	3.41	0.67	NS	4.66	NS	0.89
CD for interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	5.2	4.6	6.1	5.4	5.3	5.5	6.5	5.1	2.0

significantly higher plant height than 75 kg N/ha. The increase in plant height of rice with application of 125 kg N/ha was 17.8 and 8.9 per cent higher over 75 and 100 kg N/ha, respectively. The increase in plant height of rice with the increased application of nitrogen fertilizer. This could be attributed to the more chlorophyll formation and improved photosynthesis and there by increased the plant height. Chandrika *et al.*, (2017) also reported similar results. The maximum plant height was recorded with the time of nitrogen application at 7, 28 and 42 DAT (91.3 cm) which was at par with time of nitrogen application at 7, 21 and 28 DAT (88.1 cm) but was significantly higher than at 7, 14 and 21 DAT (85.6 cm). However, the time of nitrogen application at 7, 21 and 28 DAT failed to produce significantly higher plant height over than at 7, 14 and 21 DAT. The increase in plant height of rice with time of nitrogen application at 7, 28 and 42 DAT over at 7, 21 and 28 DAT and 7, 14 and 21 DAT was 3.6 and 6.6 per cent, respectively. The increase in plant height with higher nitrogen rates were might be due to reason that N is a major constituent of chlorophyll which rise the photosynthesis and also major component of amino acid. Dahipahle and Singh (2018) also obtained significantly higher plant height (87.1 cm) with 33.3 per cent N at 15-20 DAS + 33.3 per cent at active tillering stage + 33.3 per cent at panicle initiation stage.

The maximum number of tillers/hill (Table-1) was recorded with the application of 125 kg N/ha (15.2) which was significantly higher than 100 kg N/ha (14.3) and 75 kg N/ha (14.1). However, the differences between 75 and 100 kg N/ha were non-significant. The number of tillers/hill of rice increased with application of 125 kg N/ha than 100 kg and 75 kg N/ha with margin of 6.2 and 7.8 per cent respectively. The increase in tillers with significantly higher dose of nitrogen may be attributed to stimulatory effect of nitrogen on tillering through cytokine in synthesis resulting into more number of tillers. Djaman *et al.*, (2018)

also reported the similar results. The application of nitrogen at 7, 28 and 42 DAT (15.9) produced significantly higher number of tillers/hill over time of nitrogen application at 7, 14 and 21 DAT (13.2) and time of nitrogen application at 7, 21 and 28 DAT (14.5). Moreover, the number of tillers/hill was also significantly increased with the time of nitrogen application at 7, 21 and 28 DAT over than 7, 14 and 21 DAT, respectively. The magnitude of increase in number of tillers/hill of rice with time of application 7, 28 and 42 DAT was 9.6 and 20.4 per cent, over at 7, 21 and 28 DAT and 7, 14 and 21 DAT, respectively. The application of nitrogen with increasing levels and timely planting significantly enhanced the production of tillers of the rice at all stages of the crop and tillers will get sufficient water, light and space for a better growth and development. Anil *et al.*, (2018) also obtained significantly increase number of tillers (m⁻²) with the application of 15, 30, 45, and 60 days after emergence (DAE).

The higher 50 % flowering (Table-1) were recorded with the application of 125 kg N/ha (72.7 days) which was significantly higher than 100 kg N/ha (57.6 days) and 75 kg N/ha (54.8 days). However, the difference between nitrogen 100 and 75 kg N/ha nitrogen application was also non-significant. The increase in flowering of rice with application of 125 ka N /ha over 75 and 100 kg N/ha was 32.6 and 26.2 per cent, respectively. Delayed flowering with higher nitrogen levels might be due to more vegetative growth, as reflected by increase plant height of rice. Pal *et al.*, (2107) also reported that increase in flowering of rice (83.4) with application of 125 ka N /ha. The 50 % flowering maximum was recorded with time of nitrogen application at 7, 28 and 42 DAT (64.1) which was at par with 7, 21 and 28 DAT (62.5) but was significantly higher than 7, 14 and 21 DAT (58.6). However, the time of nitrogen application at 7, 21 and 28 DAT also recorded significantly higher 50 % flowering than time of nitrogen

application at 7, 14 and 21 DAT. The increase in number of 50 % flowering in rice with time of application at 7, 28 and 42 DAT over at 7, 21 and 28 DAT and 7, 14 and 21 DAT was 2.5 and 9.3 per cent, respectively. The flower opening or the beginning of reproductive phase of crop is governed by genetic makeup and certain other factor like temperature and photoperiod. N. Maisnam and U.S. Tiwana (2021) also noticed similar results.

Yield attributes : The number of panicles/hill (Table-1) highest recorded with the application of 125 kg N/ha (13.2) which was significantly higher than 100 kg N/ha (12.4) and 75 kg N/ha (12.3). Furthermore, the 100 kg N/ha failed to produce significantly higher numbers panicles/hill over than 75 kg N/ha. The number of panicles of rice increase with the application of 125 kg N/ha over 100 and 75 kg N/ha by a margin of 6.4 and 7.3 per cent, respectively. The panicles development is dependent upon the availability of photosynthetic when there is competition with strong sinks like tiller, leaf and stem. The nitrogen probably favoured the proper cellular activities during panicle formation and development, which led to increased number of effective panicles. Dahipahle *et al.*, (2018) also reported increase in panicles/hill (224.5) m^{-2} with 150 kg N/ha. The number of panicles/hill was increased significantly at 7, 28 and 42 DAT (13.8) over at 7, 14 and 21 DAT (11.6) and 7, 21 and 28 DAT (12.4). Moreover, number of panicles/hill was also significantly higher with the time of nitrogen application at 7, 21 and 28 DAT over 7, 14 and 21 DAT, respectively. The magnitude of increase in number of panicles/hill of rice with time of nitrogen application at 7, 28 and 42 DAT was 11.2 and 18.9 per cent over at 7, 21 and 28 DAT and at 7, 14 and 21 DAT, respectively. The productive panicles may be higher due to the fact that better development of early formed tillers up to reproductive phase of the crop while in case of late planting the production of tillers may take place but due to unavailability of sufficient amount of photosynthesis as source of energy may result in the mortality of tillers and number of productive tillers may reduced. Phong *et al.*, (2014) also reported higher panicles/hill (15.8) at 30, 40 and 50 days after transplanting DAT.

The 1000-grains weight of rice was not affected significantly with the application of nitrogen levels (Table-1). Similarly, time of application also did not influence the 1000-grains weight of transplanted rice significantly. N. Maisnam and U.S. Tiwana (2021) also reported non-significant difference in 1000-grains weight with various time of application and nitrogen levels.

Yield parameters : Grain yield of rice was influenced significantly with nitrogen levels (Table-1). The highest grain yield was recorded with the application of 125 kg N/ha (73.8 q/ha) which was at par with 100 kg N/ha (70.1

q/ha) but was significantly higher than 75 kg N/ha (67.2 q/ha). However, the difference between 100 kg N/ha and 75 kg N/ha was also non-significant. The increase in grain yield of rice was 5.2 and 9.8 per cent higher with application of 125 kg N/ha than 100 and 75 kg N/ha, respectively. The higher grain yield by the application of nitrogen might be due to more availability of nitrogen which increased cell division, cell elongation, promoted auxin synthesis which helped in more growth of rice plant in terms of leaf area and dry matter accumulation, leading to production of more photosynthesis to be translocated from source to sink hence led to enhanced values of yield contributing characters. Islam *et al.*, (2015) also reported that maximum grain yield (6.76 t/ha) at 150 kg N/ha. The higher grain yield was recorded with the time of nitrogen application at 7, 28 and 42 DAT (74.0 q/ha) which was at par with at 7, 21 and 28 DAT (69.8 q/ha) but was significantly higher than time of nitrogen application at 7, 14 and 21 DAT (67.4 q/ha). Moreover, the time of nitrogen application at 7, 21 and 28 DAT failed to produce significantly higher grain yield over than at 7, 14 and 21 DAT, respectively. The grain yield of rice increased with time of nitrogen application at 7, 28 and 42 DAT than at 7, 14 and 21 DAT and 7, 21 and 28 DAT with margin 9.7 and 6.0 per cent, respectively. The higher yield for early planting was mainly due to favourable climatic conditions especially at the time of tillering, flowering, and grain filling stages. Early transplanted crops received more favourable temperature and longer sunshine duration especially at the tillering stage. This led to developments number of panicles and resulted shown in higher grain yield. Tadesse *et al.*, (2017) also reported that maximum grain yield (3.5 t/ha) at 15, 25 and 45 days after transplanting DAT. The similar treatment was also observed in straw yield and harvest index.

Conclusion

It may be concluded that the application of 125 kg N/ha at 7, 28 and 42 days after transplanting DAT produced significantly higher grain yield of rice.

Acknowledgement

The authors are very helpful to RIMT University for providing necessary requirement for the conduct of the study.

References

1. Anil, K., Yakadri, M and Jayasree, G. (2018) Influence of Nitrogen levels and times of application on growth parameters of aerobic rice. *International Journal of Current Microbiology and Applied Sciences*, 7(5): 1525-29.
2. Chandrika., M., Uma Devi., M., Ramulu., V. and Venkata R.M. (2017) Evaluation of different varieties of aerobic rice

- (*Oryza sativa* L.) under different fertigation levels on growth and yield parameters. *International Journal of Current Microbiology and Applied Sciences* 6(5): 2793-01.
3. Dahipahle, A.V. and Singh, U.P. (2018) Effect of crop establishment, nitrogen levels and time of nitrogen application on growth and yield attributing parameters of direct seeded rice (*Oryza sativa* L.). *International Journal of Chemical Studies*, 6(2): 2889-2893.
 4. Djaman, K., Mel, V.C., Ametonou, F.Y., Namaky, R.E., Diallo, M.D. and Koudahe, K. (2018) Effect of nitrogen fertilizer dose and application timing on yield and nitrogen use efficiency of irrigated hybrid rice under semi-arid conditions. *Journal of Agricultural Science Food Research*, 9: 2-10.
 5. Hirzel, J., A. Pedreros and K. Corder (2011) Effect of nitrogen rates and split nitrogen fertilization on grain yield and its components in flooded rice. *Chilean Journal of Agricultural Research*, 71: 437-44.
 6. Islam, S.M.M., Khatun, A., Rahman, F., Hossain, A.T.M.S., Naher, U.A. and Saleque, M.A. (2015) Rice response to nitrogen in tidal flooded non-saline soil. *Bangladesh Rice Journal*, 19(2): 65-70.
 7. Lampayan, R.M., Bouman, B.A.M., Dios, J.L.D., Espirity, A.J., Soriano, J.B., Lactoen, A.T., Faronilo, J.E and Thant, K.M. (2010). Yield of aerobic rice in rainfed lowlands of the Philippines as affected by nitrogen management and row spacing. *Field Crops Research* 116: 165-74.
 8. N. Maisnam and U.S. Tiwana (2021) Response of basmati rice (*Oryza sativa* L.) to nitrogen levels under different times of application. *Progress Research and International Journal* (un-published).
 9. Pal, R., Mahajan., G., Sardana., V. and Chauhan., B.S. (2017). Impact of sowing date on yield day matter and nitrogen accumulation and nitrogen translocation in dry seeded rice in North-West India. *Field crops research* 206: 138-48.
 10. Phong, T.T., Yamakawa, T and Kyi, M.O.E. (2014). Effect of nitrogen application timing on growth, grain yield and eating quality of the KD18 and TH3-3 rice varieties. *Journal of the Faculty Agriculture Kyushu University* 59(1): 55-64.
 11. Tadesse, Z., Tadesse, T and Ayalew, D. (2017) Effects of time of nitrogen fertilizer application on the growth and productivity of rice (*Oryza sativa* L.) in Fogera Plain, North Western Ethiopia. *International Journal of Research Studies in Agricultural Sciences*. 3: 66-70.
 12. Zhao, L., L. Wu, M. W and Y. Li (2011) Nutrient uptake and water use efficiency as effected by modified rice cultivation methods with irrigation. *Paddy Water Environment journal*. 9: 25-32.



Weed Management in Basmati Rice (*Oryza sativa* L.)

Soibam Priya Devi and Udham Singh Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab)

Abstract

Field experiment was carried out during *kharif* season of 2019 to study the effect of weed management in Basmati rice (*Oryza sativa* L.) with eight treatments in three replications. Weed control treatments comprised of butachlor 1.50 kg/ha as pre-emergence alone and followed by one hand weeding and post-emergence application of bispyribac 0.025 kg/ha, bispyribac 0.025 kg/ha as post-emergence, one and two hand weeding, weed free and weedy check. The highest weed density and dry weight were recorded in weedy check, whereas, hand weeding at 15 and 30 DAT recorded minimum. Among herbicidal weed management treatments, application of pre-emergence herbicide butachlor 1.50 kg/ha *fb* post-emergence herbicide bispyribac 0.025 kg/ha resulted lower weed density, dry weight, higher weed control efficiency and lowest weed index. All hand weeding and herbicide treatments recorded significantly higher grain yield over weedy check. The highest grain yield of Basmati rice was recorded in the weed free (47.4 q/ha) which was significantly higher than butachlor 1.50 kg/ha as pre-emergence and hand weeding at 15 DAT (40.7 and 41.5 q/ha, respectively) but was at par with rest of the treatments. Similar trend was also observed in growth parameters and yield attributes. The higher number of growth parameters, viz. plant population (29.7 m⁻²), plant height (111.0 cm) and tillers per hill (15.1 m⁻²) and yield attributes, viz. panicles per hill (14.3 m⁻²), grains per panicle (109.5) and 1000 grain weight (27.5 g) were recorded in weed free treatment over weedy check. Among the herbicide treatments, application of butachlor 1.50 kg/ha as pre-emergence *fb* bispyribac 0.025 kg/ha as post-emergence recorded the highest number of growth parameters, yield and yield attributes.

Key words : *Basmati rice, weed management, growth, yield attributes and yield*

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crop of the world, forming staple diet of 70 per cent of world's population (Sahu *et al.* 2014). India is the second largest rice producing country in the world with an area of 43.79 Mha and produced 112.91 Mt of rice with a productivity of 2578 kg/ha (Anonymous, 2018). In Punjab, rice crop occupied 30.65 lakh hectares with total production of 199.72 lakh tonnes (133.82 lakh tonnes of rice) during 2017-18. The average yield of paddy was 65.16 quintals per hectares (26.37 quintals per acre) (Anonymous, 2019). Basmati rice, a variety of long grain with a fine texture, is the world's best rice for cooking and the leading aromatic fine quality rice in the world trade. Basmati rice has occupied a prime position in national and international markets because of their excellent quality characters (Sharma *et al.* 2016). The low yield of Basmati is associated with various constraints like labour availability, weeds, water, insects, pests and diseases (Singh *et al.* 2013). Among the several production constraints, weeds are the most important as one third (33 %) of the total loss is caused by weeds alone (Mukherjee 2006). Weeds compete with the crop for space, light and nutrients resulting in low yield. Therefore, the management of weeds become imperative to get a higher basmati yield. Keeping in view, the present investigation has been planned to study weed control measures in basmati rice.

Materials and Methods

The field experiment was conducted during *kharif* season of 2019 at the Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab). Mandi Gobindgarh is situated in Punjab, at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The maximum temperature often exceeds 40° C during summer. Minimum temperature falls below 6°C with some frosty spells of 8-10 days during the winter months of December and January. The average annual rainfall of Mandi Gobindgarh is 730.2 mm, about three-fourth of which is contributed by the south-west monsoon during July to September. The experimental field tested was low in organic carbon (0.48%) and low in available nitrogen (144.6 kg N/ha) medium in available phosphorus (17.3 P₂O₅/ha) and medium in potassium (168 kg K₂O/ha). The experiment was laid out in a Randomized Complete Block Design (RCBD) comprising eight treatments and three replications. The 20 kg seed per hectare was used for nursery sowing. The gross plot size was 4 m × 3 m i.e. 12 m² and net plot size was 3.6 m × 2.7 m i.e. 9.7 m². The crop was sown by broadcast on June 12 and transplanted on 13 July 2019 at row to row spacing of 20 cm with plant to plant distance of 15 cm. The recommended dose of fertilizer 41.25 kg N/ha was applied through urea into two equal splits, one after three weeks of transplanting and another at six weeks after transplanting.

Table-1 : Effect of weed management treatments on the weed density, weed dry weight, weed control efficiency and weed index at harvest of Basmati rice.

Treatments	Weed density at harvest (plants/m ²)	Weed dry weight at harvest (g/m ²)	Weed control efficiency at harvest (%)	Weed index (%)
T ₁ Weedy check	8.4 (70.0)	8.0 (63.6)	-	29.7
T ₂ Weed free	0.7 (0.0)	0.7 (0.0)	100.0	-
T ₃ Hand weeding at 15 DAP	6.4 (40.3)	4.7 (22.1)	65.3	12.4
T ₄ Hand weeding at 15 and 30 DAP	4.2 (17.7)	2.9 (8.2)	87.1	4.6
T ₅ Butachlor 1.50 kg/ha as pre-emergence	6.8 (46.0)	5.0 (24.6)	61.3	14.1
T ₆ Butachlor 1.50 kg/ha as pre-em. fb HW at 20 DAP	5.3 (28.3)	3.7 (13.2)	79.2	11.0
T ₇ Bispyribac 0.025 kg/ha as post-emergence	5.8 (33.7)	4.1 (16.1)	74.7	9.5
T ₈ Butachlor 1.50 kg/ha as pre-em. fb bispyribac 0.025 kg/ha as post-em.	4.8 (23.0)	3.3 (10.1)	84.1	6.3
C.D at 5%	2.67 (6.62)	1.86 (2.97)	-	-
S.E(m)	1.63 (2.16)	1.21 (0.96)	-	-
C.V.	3.42 (11.19)	3.01 (8.58)	-	-

Data were subjected to square root ($\sqrt{x + 0.5}$) transformation and the figures in parentheses are the original values.

The weed control efficiency (WCE) was calculated by using the following formula :

$$\text{WCE (\%)} = \frac{\text{Weed dry weight in unweeded control} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in unweeded control}} \times 100$$

To determine the weed index (WI), the following formula was used :

$$\text{WI (\%)} = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

Results and Discussion

Weed studies : Major weed flora observed in the experimental field was *Echinochloa colona*, *Echinochloa crusgalli*, *Cynodon dactylon* and *Eleusine indica* under grass weeds, *Cyperus difformis*, *Cyperus iria*, *Cyperus rotundus* and *Cyperus esculentus* under sedges and *Digeria arvensis* and *Euphorbia hirta* under broadleaf weeds. Weed density was significantly influenced by different weed management treatments (Table-1). Weedy check treatment recorded the highest number of weed density (70.0 plants m⁻²) and dry matter of weed (63.6 g m⁻²) as compared with rest of the treatments. Significantly lowest weed population, dry matter of weed and lowest weed index with highest weed control efficiency were recorded in the weed free treatment followed by hand weeding at 15 and 30 DAT. Among the chemical treatments, pre-emergence application of butachlor 1.50 kg/ha fb post-emergence application of bispyribac 0.025 kg/ha recorded significantly lowest weed density, dry weight, higher weed control efficiency and lowest weed index. Similar observations have been reported by Singh *et al.* (2013).

Growth parameters : The plant population of Basmati rice was not significantly influenced by the weed

management treatments (Table-2). Different weed control treatments significantly influenced the plant height over weedy check (Table-2). Weed free and hand weeding at 15 and 30 DAP recorded significantly higher plant height (111.0 cm and 109.8 cm, respectively) over one hand weeding at 15 DAT and butachlor 1.50 kg/ha as pre-emergence fb hand weeding and was at par with rest of the treatments. Sharma *et al.* (2016) also reported that the plant height was significantly influenced by the weed control treatments.

Weed management also influenced tillers per hill significantly. The highest tillers per hill were found in the weed free treatment (15.1 m⁻²) which was at par with hand weeding at 15 and 30 DAT, application of bispyribac 0.025 kg/ha as post-emergence and butachlor 1.50 kg/ha as pre-emergence fb bispyribac 0.025 kg/ha as post-emergence but was significantly higher over rest of the treatments. Weedy check treatments recorded the lowest tillers per hill (12.0 m⁻²) due to more competition of weeds with the crop. Similar results were also reported by Kumar *et al.* (2014) and Yadav *et al.* (2009).

Yield Attributes : Yield attributes such as panicles per hill, grains per panicle, 1000 grain weight (g), were also influenced significantly by different weed management treatments (Table-2). All the weed management treatments recorded significantly more number of panicles per hill as compare to weedy check. Weed free plot recorded significantly higher panicles per hill (14.3 m⁻²) than one hand weeding at 15 DAP (12.0) and butachlor 1.50 kg/ha as pre-emergence (11.3) but the differences between weed free and rest of the treatments were found to be non-significant. The lowest panicles per hill was obtained in the weedy check (10.7 m⁻²).

Similar results were noticed with grains per panicle (Table-2). The highest grains per panicle were recorded in the weed free treatment (109.5) and the lowest grains per

Table-2 : Effect of weed management treatments on the growth parameters, yield attributes and yield of Basmati rice.

Treatments	Plant population (plants/m ²)	Plant height (cm)	Tillers/hill (m ²)	Panicles/hill (m ²)	Grains/panicle	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T ₁ Weedy check	28.3	105.8	12.0	10.7	104.2	25.3	33.3	68.9	31.6
T ₂ Weed free	29.7	111.0	15.1	14.3	109.5	27.5	47.4	86.7	36.0
T ₃ Hand weeding at 15 DAP	28.7	107.6	13.5	12.0	105.9	25.8	41.5	73.3	34.8
T ₄ Hand weeding at 15 and 30 DAP	29.3	109.8	14.4	13.7	108.9	27.1	45.2	82.2	35.6
T ₅ Butachlor 1.50 kg/ha as pre-emergence	28.7	107.3	13.3	11.3	105.5	25.6	40.7	71.1	34.7
T ₆ Butachlor 1.50 kg/ha as pre-em. fb HW at 20 DAP	29.0	108.1	13.7	12.3	106.2	26.0	42.2	75.5	34.9
T ₇ Bispyribac 0.025 kg/ha as post-emergence	29.0	108.5	14.1	12.7	107.0	26.2	42.9	77.8	35.2
T ₈ Butachlor 1.50 kg/ha as pre-em. fb bispyribac 0.025 kg/ha as post-em.	29.3	109.4	14.2	13.0	108.1	26.5	44.4	80.0	35.3
C.D at 5%	NS	2.22	1.26	1.75	2.99	1.35	5.91	5.33	2.36
S.E(m)	0.43	0.72	0.41	0.57	0.98	0.44	1.93	1.78	0.77
C.V.	2.56	1.15	5.14	7.93	1.59	2.92	7.90	3.98	3.84

panicle were recorded in weedy check (104.2). Two hand weeding at 15 and 30 DAT was at par with the application of butachlor 1.50 kg/ha as pre-emergence fb bispyribac 0.025 kg/ha as post-emergence (108.9 and 108.1) respectively.

The 1000 grain weight of Basmati rice was highest in the weed free condition (27.7 g) which was at par with hand weeding at 15 and 30 DAT (27.1 g) but was significantly over rest of the treatments (Table 2). The results were in conformity with Walia *et al.* (2008) and Yadav *et al.* (2009)

Grain yield : The grain yield of Basmati rice was significantly influenced by the different weed management treatments (Table-2). All hand weeding and herbicide treatments recorded significantly higher grain yield over weedy check. Amongst the weed management treatments, the highest grain yield of Basmati rice was recorded in the weed free (47.4 q/ha) which was significantly higher than Butachlor 1.50 kg/ha as pre-emergence and one hand weeding at 15 DAT (40.7 and 41.5 q/ha, respectively) but was at par with rest of the treatments. Weed free treatment also indicated higher percent increment of grain yield of 70 per cent over weedy check. Among herbicidal treatments, application of butachlor 1.50 kg/ha as pre-emergence fb bispyribac 0.025 kg/ha as post-emergence recorded significantly higher grain yield as compared with single application of pre-emergence herbicides (44.4 q/ha). Similar results of higher grain yield were reported by Pinjari *et al.* (2016). Similar trends were also observed in straw yield. Among the weed control treatments, weed free recorded the highest harvest index (36.0 %) but was at par with rest of the treatments. Sharma *et al.* (2016) also reported similar results.

Conclusion

It may be concluded that all the weed control treatments were better than weedy check. Amongst the weed control treatments, the highest grain yield was recorded with weed free treatment followed by hand weeding at 15 and 30 DAT and the application of butachlor 1.50 kg/ha as pre-emergence fb application of bispyribac 0.025 kg/ha as post-emergence.

References

1. Anonymous (2018). *Agricultural Statistics at a Glance*. Government of India. Pp: 74-75.
2. Anonymous (2019). Package of Practices for crops of Punjab, kharif. *Punjab Agriculture University*, Ludhiana, India. Pp: 1-19.
3. Mukherjee, M. (2006). Weed management strategy in rice-a review. *Agricultural Review* 27(4): 247-257.
4. Pinjari, S.S.; Gangawane, S.B.; Mhaskar, N.V.; Chavan, S.A.; Chavan, V.G. and Jagtap, D.N. (2016). Integrated use of herbicides to enhance yield and economics of direct-seeded rice. *Indian J. of Weed Sci.* 48(3): 279-283.
5. Sahu, R.K., Kauraw, D.L. and Rawat, A.K. (2014). Effect of resources integration on nutrient use efficiency content and quality of rice in vertisol. *The Ecoscan* 8(1&2): 91-95.
6. Sharma, N.; Kumar, A.; Kumar, J.; Mahajan, A. and Stanzen, L. (2016). Sowing time and weed management to enhance productivity of direct-seeded aromatic rice. *Indian J. of Weed Sci.* 48(1): 21-24.
7. Singh, A.; Singh, R.K.; Kumar, P. and Singh, S. (2013). Growth, weed control and yield of direct seeded rice as influence by different herbicides. *Indian J. of Weed Sci.* 45(4): 235-238.
8. Walia, U.S.; Singh, O.; Nayyar, S. and Sindhu, V. (2008). Performance of post-emergence application of bispyribac in dry-seeded rice. *Indian J. of Weed Sci.* 40(3&4): 157-160.
9. Yadav, D.B., Yadav, A. and Punia, S.S. (2009). Evaluation of bispyribac-sodium for weed control in transplanted rice. *Indian J. of Weed Sci.* 41(1&2): 23-27.



Effect of Incorporating Chicken Skin Blend on Quality Attributes of Chicken Patties

Chirag Singh*, Praneeta Singh and P. Prabhakaran

Department of Livestock Products Technology, College of Veterinary and Animal Sciences, GBPUAT, Pantnagar

*Email : singh.chirag0809@gmail.com

Abstract

The present study was conducted to prepare chicken patties with 40% chicken skin blend. Chicken skin blend was prepared by mixing different non-meat ingredients like ragi flour, sorghum flour, chickpea and soy with chicken skin mince. The patties prepared showed percent cooking yield at 65.06 ± 0.36 and percent dimensional shrinkage at 17.41 ± 0.58 . The proximate analysis revealed moisture, protein, fat and ash content at 36.01 ± 1.22 , 49.09 ± 0.45 , 33.13 ± 0.40 and 8.59 ± 0.10 percent (dry basis), respectively. During sensory evaluation of patties acceptable scores were recorded for all the attributes. The collagen content of chicken skin blend containing chicken patties was found to be 6.11 ± 0.05 percent. The chicken patties with enhanced collagen content may serve as a functional ingredient in the geriatric diet.

Introduction

Meat industry is one of the fastest growing enterprises of Indian food industry. To fulfill the needs of growing population the meat industry is under constant pressure to innovate value added meat products which provide health benefits and also earn profit to the industry. Among different sources of meat, chicken is the cheapest; and is a highly acceptable source. It provides ample amount of nutrients and is free from religious and other prejudices. Offals constitute approximately 5 to 6% by weight (20) of chicken. The by-products when inappropriately disposed can cause environmental threats; require additional expenditure for their disposal and can lead to loss of a potentially nutritive food that can contribute to food security (14). To minimize these losses and gain profit, various by-products like fat, skin and giblets are currently being used in value added meat products.

Chicken skin is one of the potential by-products obtained during secondary processing of poultry as part of value added products manufacture. It constitutes about 4% of live weight and 14% of carcass weight (16). Chicken skin contained 47.9% moisture, 45.1% lipids, 6.6% protein and 0.4% ash (22). Chicken skin is a good source of protein and has good digestibility. Therefore, it can potentially be used in the value added meat products. However, the broiler skin when added at higher level can be harmful to meat emulsion because of its poor stability and stabilizing membrane formation (19). Collagen is the predominant protein present in chicken skin, which constitutes 3% of skin weight (7).

High level of fat in the chicken skin leads to detrimental effects on product viz. more cooking loss because fat do not bind water (7). According to (21)

addition of 10-15% skin did not affect cooking loss and binding of poultry meat. To mitigate the high fat content of chicken skin and for reduction of dimensional shrinkage starch sources like ragi and sorghum can be added. These cereal flours are commonly used in minced meat products to retain water, bind meat particles, and replace fat and to impart better texture (15). Soy protein was reported to improve moisture retention and reduce the cooking losses of meat blend (12). Incorporation of soy protein in meat patties reduced the shrinkage (17).

Another non-meat ingredient commonly incorporated in meat products is chickpea (*Cicer arietinum*). It can act as a filler, emulsifier, binder or extenders in meat products to produce cost effective product with increased yield, nutritional quality and improved texture (11).

Few workers (1, 9) have incorporated skin beyond 30% level in meat product formulation. Blend formation incorporating chicken skin with non meat ingredients is less explored. Therefore, the present study was envisaged to incorporate chicken skin in the form of a blend in the meat batter to form chicken patties and study its effects on quality attributes.

Materials and Methods

Preparation of chicken skin and meat mince : Broilers of uniform age group and weight (1.9-2.0 kg) were procured from the Instructional Poultry Farm, GBPUA&T or from local market. Slaughter and dressing was carried out in the Experimental Slaughter Unit of the department in humane manner under hygienic conditions. Mincing of meat and skin was done under hygienic condition in a grinder (Sirman®, Model TC32.IND. BUF.UT.4HP Italy)

using 3.5 mm plate and stored in a freezer at -18°C till further use.

Preparation of Non-Meat Ingredients

Preparation of processed ragi flour and processed sorghum flour : Clean potable water @ 20–25% v/w was sprinkled on the ragi and sorghum flour separately placed in a clean muslin cloth and steamed in a pressure cooker without putting weight on the lid for 20 minutes. These processed ragi and sorghum flours were prepared afresh every time before use.

Preparation of processed chickpea (*Chana dal*) : Equal quantity of *Chana dal* and water was added and cooked in an open vessel for 10 minutes. The excess water was drained off and *chana dal* was minced in a mincer and used in formulation.

Preparation of isolated soy protein (ISP) : Isolated soy protein was weighed and soaked in twice its quantity of water for 3 hr under refrigeration and used in formulation.

Preparation of chicken skin blend : All the ingredients as per the formulation in Table-1 were thoroughly mixed/kneaded till a uniform blend was formed and was used in product formulation.

Table-1 : Formulation of chicken skin blend.

Ingredient	Quantity (%)
Chicken skin mince	78.0
Processed sorghum flour	7.5
Processed ragi flour	7.5
Isolated soy protein	2.0
Processed chick pea	5.0

Preparation of chicken patties : All the ingredients as per the formulation in table-2 were thoroughly mixed/kneaded till a uniform batter was formed to prepare the product.

Table-2 : Formulation of patties containing chicken skin blend incorporated at 40% level.

Ingredient	Quantity
Minced meat	255 g
Chicken skin Blend	170 g
Salt	1.75%
Polyphosphate	0.3%
Onion	3%
Garlic	1%
Ginger	1%
Spice mix	3%
Black pepper	0.5%

Approximately 1.2 kg of partially defrosted frozen deboned meat was minced twice in a meat mincer (Sirman®, Model TC32.IND.BUF.UT.4HP Italy) using 3.5 mm plate. The lean mince was mixed manually along with salt and polyphosphate (dissolved in water) as per

the quantity mentioned in the formulation (Table-2). Then spices and condiments were added as per formulation; and mixing was continued. The batter was molded into patties and cooked by shallow oil frying in fresh refined oil to an end point of not less than 72°C. After cooking, chicken patties were evaluated for physico-chemical and sensory characteristics.

Physico-Chemical Analysis

Cooking Determinants

Cooking yield (percent) : Percentage cooking yield of the patties was estimated by the following formula-

$$\text{Cooking yield} = \frac{\text{Weight of patties after cooking in g}}{\text{Weight of patties before cooking in g}} \times 100$$

Dimensional shrinkage (percent) : Dimensional Shrinkage of patties was calculated as per the method of (13) using following formula :

$$\text{Dimensional shrinkage} = \frac{[(\text{Thickness of raw patties in mm} - \text{Thickness of cooked patties in mm}) + (\text{Diameter of raw patties in mm} - \text{diameter of cooked patties in mm})]}{\text{Thickness of raw patties in mm} + \text{diameter of raw patties in mm}} \times 100$$

Moisture and fat retention (percent) : The moisture and fat retention values represent the amount of moisture and fat retained by the cooked patties per 100 g of raw patties, respectively and calculated by the method of (13).

$$\text{Moisture retention} = \frac{\text{Percent cooking yield} \times \text{Percent moisture in cooked patties}}{100}$$

$$\text{Fat retention} = \frac{\text{Cooked wt. in g} \times \text{Percent fat in cooked patties}}{\text{Raw wt. in g} \times \text{Percent fat in raw patties}} \times 100$$

Proximate composition : Proximate analysis of cooked chicken patties was done by using (2) protocol

Collagen content (percent) : Collagen content was determined as per the method given in (2).

Sensory Evaluation : The sensory evaluation of patties was done by using 8 point hedonic scale according to (18). The semi trained panelists were selected from staff and post graduate students of CVASc, Pantnagar for sensory evaluation.

Results and Discussion

Cooking determinants : The values of cooking determinants viz. cooking yield, dimensional shrinkage and moisture and fat retention for the chicken patties are

presented in Table-3. Cooking yield and dimensional shrinkage for patties were recorded as 65.06 ± 0.36 and 17.41 ± 0.58 , respectively. Higher cooking losses and shrinkage could be attributed to high level of chicken skin incorporated in the product, that occur due to shrinkage of collagen fibers on cooking and expulsion of fat and moisture (4). As per (1) the higher level of chicken skin in meat loaves resulted in the greater shrinkage. Cooking losses were high in the patties containing chicken skin batter at the level of 40% (9). The results of present study were in agreement to (1) and (9). They stated that high level of fat in chicken skin resulted in higher cooking loss in chicken patties.

Moisture and fat retention in patties were observed as 17.17 ± 0.43 and 50.71 ± 0.53 , respectively. Moisture retention by the patties was observed to be quite low, and may be due to high fat content of chicken skin. These results were in agreement with the (9) and (10). (9) reported that high fat containing patties showed lower moisture retention because of inability of fat to retain moisture.

Better fat retention was observed in the patties, this could be attributed to addition of soy in the chicken skin blend, as soy entraps the fat and water and prevent it from leaking out, during cooking. The results were in agreement with (5) who observed that isolated soy protein enhanced the meat batter stability and reduced the expulsion of fat and water during cooking.

Table-3 : Mean $\pm$ S.E. for cooking determinants of chicken patties incorporated with 40% chicken skin blend.

Parameter	Observation
Dimensional Shrinkage#%	17.41 ± 0.58
Cooking Yield# %	65.06 ± 0.36
Moisture Retention* %	17.17 ± 0.43
Fat Retention* %	50.71 ± 0.53

#n=16, *n=3

Proximate composition : Table-4 shows the proximate composition of the chicken skin blend containing chicken patties

Moisture content : Moisture content of the patties was recorded as 36.02 ± 1.22 . High level of moisture content in patties could be attributed to high moisture content of chicken skin and addition of soy and chick pea which facilitate the water binding during cooking. The observation were in accordance with (5), who observed that isolated soy protein enhanced the meat batter stability and reduced the expulsion of fat and water during cooking.

Protein content : Protein content of the patties on dry matter basis was observed as 49.09 ± 0.45 . The results were in agreement with (1) who found that skin incorporation in chicken meat loaves at 10, 20, 30, 40 and

50 percent levels did not affect the protein content of meat loaves.

Fat content : Fat content of the chicken patties was recorded as 33.13 ± 0.40 . High level of chicken skin used in the formulation might have resulted in higher fat content of chicken patties. It can be reduced by processing of chicken skin for partial removal of fat. This finding was in agreement with (9), who reported that fat content of patties increased with increasing levels of chicken skin in the formulation and (6), who observed higher fat content in sausages incorporated with chicken skin and chicken fat. The addition of isolated soy protein in chicken skin blend might have facilitated the fat retention, as it entraps fat in the emulsion and prevent fat expulsion (5).

Ash content : Mean ash content of the chicken patties was recorded as 8.59 ± 0.10 . High ash content of patties could be attributed due to high ash containing non meat ingredients used in the chicken skin blend viz. chickpea, sorghum and ragi flour which usually contain high ash.

Table-4 : Mean $\pm$ S.E. for proximate composition (% dry basis) and collagen (% dry basis) of chicken patties incorporated with 40% chicken skin blend.

Parameter	Observation
Moisture %	36.01 ± 1.22
Protein %	49.09 ± 0.45
Fat %	33.13 ± 0.40
Ash %	8.59 ± 0.10
Collagen %	6.11 ± 0.05

#n= 16, *n=3

Collagen content : Mean collagen content the patties was observed as 6.11 ± 0.05 . The incorporation of high level of chicken skin blend, enriched the collagen content of the patties. (21) reported that the collagen content in meat products increased with increase in chicken skin level incorporation. (1) found that increase in skin level in meat loaves from 10% to 40% led to increase in collagen content of the product. The results of present study were in agreement with (21) and (1).

Sensory Evaluation

Mean $\pm$ S.E. appearance and colour, flavour, texture, juiciness and overall acceptability scores of chicken skin blend containing chicken skin patties are presented in Table-5. The scores for the chicken skin blend containing chicken patties were recorded as 7.06 ± 0.03 , 7.16 ± 0.08 , 7.20 ± 0.05 , 6.80 ± 0.15 , and 7.15 ± 0.12 , respectively.

The patties showed good sensory acceptability for all attributes. Addition of non-meat ingredients and high level of chicken skin incorporation diluted the meat pigment therefore the colour of patties appeared lighter. This finding was in congruency with (17), who observed

that soy protein incorporation in blended beef patties lightened the colour by diluting the meat pigment. Chicken skin blend incorporation improved the flavor of patties due to high fat content. Isolated soy protein added in the chicken skin blend softened the texture of chicken patties. The result was in accordance with (18) who reported that when lean meat was replaced with soy protein the resulting product was softer. Overall the patties were found to be very acceptable.

Table-5 : Mean $\pm$ S.E. sensory scores of chicken patties incorporated with 40% chicken skin blend.

Parameter	Observation
Appearance and colour	7.06 $\pm$ 0.03
Flavour	7.16 $\pm$ 0.08
Texture	7.20 $\pm$ 0.05
Juiciness	6.80 $\pm$ 0.15
Overall acceptability	7.15 $\pm$ 0.12

Conclusions

The chicken patties prepared by incorporation of high level of chicken skin blend showed higher protein content and collagen content, and were found to have very desirable scores for all sensory attributes. Addition of non- meat ingredients in the chicken skin blend facilitated in retaining the quality of patties. Therefore, it can be concluded that addition of chicken skin blend at 40% level resulted in collagen enriched chicken patties, without affecting sensory quality and proved as a better way to utilize the skin obtained as a by-product of poultry industry.

References

1. Acton, J.C. and Dick, R.L. 1978. Effect of skin content on some properties of poultry meat loaves. *Poult. Sci.* 57: 1255-1259.
2. AOAC 1995. *Official Methods of Analysis*. 16th ed. Association of Official Analytical Chemists. Washington D.C.
3. Bader, H.M. 2005. Chemical properties of chicken muscles and skin as affected by gamma irradiation and refrigerated storage. *J Food Technol.*, 3(1): 1-9.
4. Bendall, J.R. 1946. The effect of cooking on the creatine-creatinine, phosphorus, nitrogen and pH values of raw lean beef. *J. Soci. of Chem. Ind.*, 65: 226-230.
5. Bertram, H.C., Meyer, R.L., Wu, Z., Zhou, X. and Andersen, H.J. 2008. Water distribution and microstructure in enhanced pork. *J. of Agri. and Food Chem.*, 56(16): 7201-7207.
6. Biswas, S., Chakraborty, A., Sarkar, S., Barpuzari, R.N. and Barpuzari, T. 2007. Effect of incorporation of chicken fat and skin on the quality of chicken sausages. *J. of Poult. Sci.*, 44(1): 111-115.
7. Bonifer, L.B. and Froning, G.W. 1996. Chicken skin composition as affected by aqueous washing. *J. Food Sci.*, 61: 895-898.
8. Bourne, M.C. 1978. Texture profile analysis. *Food Technol.*, 32: 62-66.
9. Buyck, M.J., Seideman, S.C., Quenzer, N.M. and Donnelly, L.S. 1982. Physical and sensory properties of chicken patties made with various levels of fat and skin. *J Food Protect.*, 45: 214-217.
10. Das, S.K., Prabhakaran, P., Tanwar, V.K. and Biswas, S. 2015. Effect of some plant starches and carrageenan as fat substitutes in chicken patties. *J. of Ani. Sci.*, 93(7): 3704-3712
11. Desmond, E.M., and Troy, D.J., 2003. Sensory and physical characteristics of pork sausages manufactured with dietary fibers. *Irish J. Agri. Food Res.*, 42: 161.
12. Drake, S.R., Hinnergardt, L.C., Kluter, R.A. and Prell, P.A. 1975. Beef patties:
13. El-Magoli, S.B., Laroia, S. and Hansen, P.M.T. 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. *Meat Sci.*, 42: 179-193.
14. Feddern, V., Kupski, L., Cipolatti, E.P., Giacobbo, G., Mendes, G.L., Badiale-Furlong, E. and de Souza-Soares, L.A. 2010. Physico-chemical composition, fractionated glycerides and fatty acid profile of chicken skin fat. *Eur. J.L lipid Sci. Technol.*, 112: 1277-1284.
15. Fiszman, S.M. and Salvador, A. 2003. Recent developments in coating batters. *Trends Food Sci. Technol.*, 14: 399-407.
16. Hayse, P.L. and Marion, W.W. 1973. Eviscerated yield, component parts, and meat, skin and bone ratios in the chicken broiler. *Poult. Sci.*, 52: 718-722.
17. Judge, M.D. 1974. Meat technology to meet the needs of the food service industry: meat patties. In *Proc. Meat conf.*, 27: 396
18. Keeton, J.T., Foegeding, E.A and Patina, A.C. 1984. A comparison of non-meat products, sodium tripolyphosphate and processing temperature effects on physical and sensory properties of frankfurters. *J. Food Sci.*, 49: 1462-1474.
19. Maurer, A.J. and Baker, R.C. 1966. The relationship between collagen content and emulsifying capacity of poultry meat. *Poult. Sci.* 45: 1317-1321.
20. Nollet, L.M. and Toldrá, F. eds. 2011. *Handbook of analysis of edible animal byproducts*. CRC Press.
21. Smolinska, T., Kopec, W. and Trziszka, T. 1988. Effect of skin addition on the technological properties of comminuted chicken meat emulsions. *Int. J. of Food Sci. & Technol.*, 23(5): 441-446.
22. Swatland, H.J. and Barbut, S. 1991. Fluorimetry via a quartz-glass rod for predicting the skin content and processing characteristics of poultry meat slurry. *Int. J. Food Sci Technol.*, 26: 373-380.
23. Vadehra, D.V. and Baker, R.C. 1970. The mechanism of heat initiated binding of poultry meat. *Food Technol.*, 24: 42-55.



EFFECT OF EFS (ENZYMES FEED SUPPLEMENTATION) ON GROWTH AND DEVELOPMENT OF BROILER CHICKS

Ashok Kumar Singh

Department of Animal Husbandry and Dairying, Udai Pratap College Varanasi

ABSTRACT

This study evaluated the effect of EFS (Amylase cellulase protease and lipase) on growth and development of broiler chicks the experiment consist of four treatment, three replicates and 20chiks/ replicate the chickens where reared under the optimum environmental condition the effect of graded level of enzyme 00 gram/kg, 1.5 gram/kg/2.5 gram / kg, 3.5 gram/kg (1gm-Amylase 7500unit, Cellulose 400unit, Protease 200unit, Lipase 300units) G1 ,G2 ,G3 and G4 respectively, incorporated in the usual commercial ration of 240 broiler chicks the results revealed that the weight gain of the chicks was significantly higher ($P < 0.05$) for groups that received usual commercial ration with 3.5 gram / kg enzyme supplementation feed intake where G1 group and feed conversion ratio in the birds of control group was significantly ($P < 0.05$) lower (2.55) in G4 group and higher (3.21) in G1 group the result indicate usual commercial ration with (Amylase ,cellulose, protease, and lipase) incorporated diet slightly improved the digestibility.

Key words : *Digestibility, enzyme feed supplementation (EFS), feed conservative ratio, feed intake.*

INTRODUCTION

India ranks first in having the largest livestock population in the world. Livestock plays an important role in the national economy as well as in the socio economic development by augmenting family income and generating gainful employment in the rural areas, particularly for the land less, small and marginal farmers and woman. With its 1.2 billion populations and 8% GDP growth rate, India is rapidly as one of the biggest market in the world. Livestock sector contributes approximately 4% to GDP and 27 to agriculture GDP. Poultry and dairy sectors are the major sectors contributing to economy. Feeding enzymes in poultry is one of the major nutritional advances in the last fifty years. Additives in poultry diets include not only enhanced bird performance digestibility and utilization of nutrients, but also less environmental and ecological problems. A serious achievement in the field of the feeding enzymes is developing of multi-enzymes preparations, containing combination of different enzymes, considered with the component. Petterson *et al.* (1991) studied the nutritive value of broiler chickens of pelleting and enzyme supplementation of a diet containing barley, wheat and rye. These workers formulated a diet based on barley (40 %), wheat (25 %) and rye (7%) and was given a mash diet or as dry or steam pelleted diets to broiler chickens. Diets were given with or without the addition of fibre degrading enzyme preparation (glucanase GP 500 to contain mixed linked β -glucanase and arabinoxylanase activity). The metabolizable energy, crude protein and crude fibre contents of these diets were 2880 K Cal/Kg, 20 percent and 14 percent, respectively. Results indicated that pelleting increased the water

solubility of starch and crude protein. However, there were no effects on the solubility of dietary fibre components following pelleting or enzyme supplementation. Pelling in, cased NV eiat gain of chicks receiving unsupplemented diet by 30 percent and for those fed on the enzyme supplemented diet 20 percent. Enzyme supplementation improved weight gains and feed conversion efficiency significantly and was more effective in unpelleted diets. Pelleting tended to increase ideal digestibility of unsupplemented diet while enzyme supplementation has similar effect on unpelleted diet. The latter treatment also increased whole tract digestibility. Richter *et al.* (1999) prepared an enzyme mixture zy 38 (containing beta-blucanase, hemicellulase, pectinase and galactosidase or beta-glucanase, xylanase and alpha-amylase) and supplemented to broiler starter and a finishing diets containing 20% peas which enhance.

MATERIALS AND METHODS

This study was carried out at the poultry Research Centre , Udai Pratap College, Varanasi. A total 240 day -old broiler chicks (mixed sex) were obtained from college poultry farm chicks were divided into four treatment of 3 replicates each of 20 chicks. Birds were housed in an open house system bedded by a layer of wood saving with a constant lightning program during the whole experimental freedom (six weeks). Birds were provided continuously with clean drinking water, all birds were kept under standard hygienic conditions and subjected to vaccination program against viral diseases. The birds were fed on a usual commercial ration formulated according to the breed producer requirements. Birds provide diets (starter-grower and finisher).

Table-1 : Proximate Composition of Broiler Ratio Involved under study.

S.N.	Constituents	G1		G2		G3		G4	
		Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
1.	Dry matter	91.00	90.00	92.00	91.00	91.00	92.00	91.00	90.00
2.	Crude protein	18.90	17.60	18.65	17.40	18.80	17.90	19.85	17.80
3.	Ether extract	2.00	2.25	2.15	2.10	2.10	2.00	2.00	2.05
4.	Nitrogen live extract	64.87	65.28	62.92	64.00	61.85	62.95	58.60	58.89
5.	Crude fibre	6.00	6.00	8.00	8.00	8.00	8.00	10.00	10.00
6.	Total carbohydrate	70.75	71.25	70.40	71.55	71.25	72.75	70.00	71.00
7.	Total Ash	12.00	12.25	12.10	12.70	11.50	12.10	11.80	11.50
8.	Calcium	1.45	1.50	2.00	2.15	2.25	2.50	2.25	2A0
9.	Phosphorus	0.75	0.72	0.77	0.75	0.72	0.71	0.73	0.72
10.	Enzyme	—	—	1.50	1.50	2.50	2.50	3.50	3.50

Table-2 : Average Feed intake (g/week/chick).

Weeks	Group	I	II	III	IV	V	VI	Mean	SE+
	G1	138.65	298.35	475.70	732.05	1447.50	1635.00	787.87	618.77
	G2	122.75	388.45	526.05	865.50	1137.00	1519.25	759.83	515.48
	G3	123.55	385.70	562.60	968.20	1105.00	1404.25	758.27	481.98
	G4	127.35	405.55	548.95	878.50	1124.50	1453.50	756.39	489.53
	Mean	128.08	369.51	528.33	861.06	1203.50	I	1503.00	
	SE+	7.33	48.25	38.18	97.38	163.20		99.82	

Preparation of Experimental diets :

GROUP '1': To provide usual commercial ration without any enzym feed supplementation (G1) control group.

GROUP '2': To provide usual commercial Ration with 1.5gm/kg EFS (G2)

GROUP '3': To provide usual commercial Ration with 2.5gm/kg EFS (G3)

GROUP '4': To provide usual commercial Ration with 3.5 gm/kg EFS (G4)

Note : 1gm EFS :

7500 units, Amylase

400 units, Cellulase

200 units, Protease

300 units, Lipase

Calculated and chemical analysis of different diets was performed according to AOAC (1990). Diet composition and chemical analysis are shown in table (1). Birds in different experimental groups were weighted initially then weekly till the end of the six weeks of experimental period. Body weight development, weight gain , feed intake, feed conversion ratio were calculated.

Determination of Proximate Principles : As per AOAC (1990) standard methods, the representative samples of all feed combinations stated above were analysed.

The Experiments were conducted using RBD with

three, replications comprising four levels of enzyme mixture. The mean and SE values have been calculated as per Sendecor and Cochran (1967) at weekly interval in case of different groups. After statistical if significant difference exists it was checked by calculating critical difference CD at 5% or at 1% whichever applicable.

RESULTS AND DISCUSSION

The feed consumption in all experimental group has been recorded during this experimental period presented in Table Number 2 ,the average feed intake per chicks per day in each was higher in G1 group (787.87) without EFS lower in G4 group (756.539 gram) &UCR with 3.5 gm/kg EFS it clearly indicates that the feed consumption was recorded in group G1 manifested 787.87 gram per chicks per week following 759.83 gram in G2, 2758.27 gram in G3 and 756.39 gram in G4 there were no significant difference observed within the the group in respect of feed consumption where as age (in weeks) has significant difference at 1% level of probability this is in fully support with the finding of Kumprch et all 1992 who recorded decrease in feed intake per unit by incorporating cellulose P-10 enzymes at the rate of 4 or 8 unit per gram in broiler diet this is in accordance with the finding of friesen et all 1991 and rended at el. 1994 also recorded 3.67 and 4.5 kg feed intake in case of enzyme treated and control group of broiler respectively. The chicken were weighted at one week of interval from first day to last day of experiment the detail of body weight recorded at one week of interval has been presented in the average live weight of bird have

Table-3 : Body weight gain (g/chick).

Weeks	Group I	II	III	IV	V	VI	Mean	SE
G1	93.35	209.25	442.00	790.50	1196.50	1558.50	619.51	585.64
G2	98.00	238.50	460.25	805.00	1225.00	1590.75	637.07	594.17
G3	93.50	260.50	450.87	858.00	1200.00	1570.25	639.09	586.56
G4	93.60	60.50	1478.25	1910.75	1307.50	1673.00	680.61	632.76
Mean	94.61	242.19	457.84	842.56	1232.25	1598.13		
SE+	2.26	24.28	1457.84	52.98	51.75	51.66		

Table-4 : Net weight gain (g/chick).

Weeks	Group I	II	III	IV	V	VI	Mean	SE
G1	52.85	115.90	232.75	354.50	400.00	362.50	253.08	143.64
G2	57.00	140.50	221.75	344.75	420.00	365.75	258.29	142.06
G3	53.00	167.00	190.37	407.13	342.00	370.25	254.96	139.08
G4	52.90	166.90	217.75	432.50	396.75	365.50	272.05	149.71
Mean	53.94	147.57	215.66	384.72	389.69	366.00		
SE+	2.04	24.52	18.01	142.02	33.41	3.19		

Table-5 : Feed Conversion Ratio FCR.

Weeks	Group I	II	III	IV	V	VI	Mean	SE+
G1	2.65	2.60	2.68	3.00	3.65	4.70	3.213	0.83
G2	2.25	2.75	2.25	2.50	2.75	4.15	2.775	0.71
G3	2.25	2.50	2.75	2.15	3.25	3.85	2.792	0.65
G4	2.25	2.30	2.50	2.25	2.50	3.50	2.550	0.47
Mean	2.35	2.54	2.55	2.47	3.04	4.05		
SE+	0.20	0.19	0.22	0.38	0.51	0.51		

been table number 3 it means the chicks of G4 group show maximum average body weight (1673.00 gram per chicks)followed by 1590.75 gram per chicks in G2 group. 1570.25 Gram. per chicks in G3 group and 1558.50 gram per chicks in G1 group further it is clear that incorporation of enzymes in diet invariably boost the growth rate of broiler chicks the difference observed between the groups was found significant at 1% level of significance G4 was found statistically superior over the others groups where's G2 and G3 proved statistically at per but superior over G1 a significant increase in live weight of broiler chicks was also recorded by Enemakova et 1993, Rended at el 1994 prepared and enzyme mixture containing cellulose, protease, xylanase ,B gluconase and Amylase incorporated the diet and observed that broiler had 4.79 percent improvement in body weight compared with control the initial body body average living weight of chicks ranged between 40.50 gram to 42.00 gram similarly the live weight of broiler chicks at lest of this experiment range between 1518.00 to 1632.30 gram, highest body weight has been recorded in the group G4 at 1632.30 gram UCR with the 3.5 gram per kg EFS it was lower in control group G1 without EFS the data presented in table so that the chicks of G4 gained significantly ($P<0.05$) higher body weight 1632.30 the finding of the present study where well correlated with the observation of other worker (Bedford 1994 ,Richter 1996) to assess

the rate of growth the value of body weight gain weekly were calculated in term of percentage it is clearly evident from the table as well as through the figure that the growth rate of broiler chicks was faster in first and second week and then gradually decrease with the age of broiler chicks the maximum growth rate was observed during second week followed by first week ,3rd week overall highest percent gain in body weight (92.30%) was recorded in G4 and lowest (87.77%) was in case G1 group similar results was also reported by Kadam at all (1994) he reported highest total weight gain (1444.82 gram) and weekly gain 204.40 gram in broiler chicks feed diets containing enzyme additives at the rate of 1 gram per kg the highest FCR was found in 3.21 in UCR without EFS G1 group it was lowest in group G4 in (2.55)UCR with 3.5 gram EFS per kg a view that incorporation of enzyme supplementation in broiler diet reduce the amount of feed required to gain per unit weight and thus improved FCR during the present course of study the maximum improvement about (26%) feed efficiency ratio was recorded in G4 group, however 43% and 22% improvement in feed gain ratio was reported by Frieson at all 1991 and Graham at all 1993 respectively Jercohet at all (1994) recorded that feed conversion efficiency was slightly affected with the incorporation of roxozyme @ 150mg per kg feed in broiler.

CONCLUSION

It may be concluded that incorporation of enzymes with the feed reduced feed and DM consumption but increased gain in body weight. The maximum gain in body weight, lowest feed/gain ratio, maximum dressing percentage and highest profit to raise one bird indicated by the chicks maintained in G4 group reveals better feed combination. It clearly indicates that the feed combination with 3.5g enzyme/kg feed given to the chicks of G4 group showed better performance of the chicks as compared to other feed faced combinations involved under study.

REFERENCES

1. A.O.A.C. (1990). Official methods of Analysis 15th Ed. Association of official analytical chemists, Washington, D.C. pp 2004.
2. Baidya, N.; Mandal, L.; Sarkar, S.K. and Banerjee, G.C. (1994). "Combined feeding of antibiotic and probiotic on the performance of broiler". *Indian Journal of Poult. Sci.*, 29 (3): 228-231.
3. Bedford, M.R. (1994). "Mode of action of feed enzymes". *Poult. Abstr.* vol. 20 (2): pp 45.
4. Cowieson A.J., Singh, D.N., Adeola O. (2006). Prediction of ingredient quality and the effect of a combination of xylanase, amylase, protease and phytase in the diets of broiler chicks. 1. Growth performance and digestible nutrient intake.
5. Ermakova, V.; Petrina, Z.; Avdonin, B. and Skuya, M. (1993). An enzyme premix. *Poultry Abstr.* vol. 19 (11): 332.
6. Friesen, O.D.; Guenter, W.; Rotter, B.A. and Marquardt, R.R. (1991). The effects of enzyme supplementation on the nutritive value of rye grain (scale cereal) for the young broiler chicks. *Poult. Sci.* 70: 2501-2508.
7. Frigard, I.; Pettersson, D. and Aman, P. (1994). "Fibre degrading enzyme increases body weight and total serum cholesterol in broiler chickens fed a rye-based diet." *Journal of Nutrition.* 124 (12) : 2422-2430
8. Graham, H. and Petterson, D. (1993). "A note on the effect of a betaglucanase and multy enzyme on production in broiler chicks fed a barley based diet." *Poultry Abstr.* vol. 19 (3) : 67.
9. Jeroch, H.; Gruzauskas, R.; Siebecke-strempel, H. and Volker, L. (1994). "Effectiveness of enzyme addition in broiler diets based on wheat". *Poult. Abstr.* 20(9) : 282.
10. Jozefiak D, Rutkowski A, Jensen BB, Engberg RM. (2006) The effect of beta-glucanase supplementation of barley and oat-based diets on growth performance and fermentation in broiler chicken gastrointestinal tract. *Poult. Sci.* 2006.
11. Kumprecht, I.; Gasnarek, Z.; Robosova, E. and Zobac, P. (1992). "Effect of the enzyme preparation cellulase P-10 in feed mixtures on broiler performance". *Poultry Abstr.* 18(12) : 351.
12. Kadam, A.S.; Ranade, A.S.; Rajmane, B.V.; Dange, S.H. and Patil, S.S. (1994). "Effect of enzyme feed supplement on the performance of broilers". *Poultry Abstr.* vol. 20 (3): 74.
13. Petterson, D.; Graham, H. and Aman, P. (1991). "The nutritive value for broiler chickens of pelleting and enzyme supplementation of a diet containing barley, wheat and rye." *Animal Feed Sci. & Tech.* 33 : 1-14.
14. Randed, A.S. and Rajmane, B.U. (1994). "Effect of enzyme feed supplement on commercial broilers". *Poultry Abstr.* 20 (9): 284-285.
15. Richter, G.; Cyriaci, G. and Schwartz, J. (1993). "Effectiveness of enzymes in broiler diets". *Poultry Abstr.* 19 (J.) : 136.
16. Richter, G. (1996). "Broiler finishing with wheat and barley, enzymes improve performance". *Poult Abstr.* 22 (5): 146 (1254).
17. Richter, G.; Schurz, M. Ochrimenko, W.; Kohler, H.; Schubert, R. (ed.); Flachowsky, G. (ed.); Bitsch, R. (ed.) and Jahreis, G. (1999). "The effect of NSP-hydrolysing enzymes in diets for laying hens and broilers". 7-Symposium Jena, Thuringen, Germany, 22 and 23 September, 519-522.
18. Snedecor, M. and Cochran, W.G. (1967). "Statistical methods six edition". Oxford and IBH publication co. New Delhi.



Influence of Different Combination of Organic, Inorganic and Foliar Grade Fertilizer on Growth and Yield of Groundnut

P.V. Mahatale*, G.D. Chandankar, M.D. Yenppreddiwar, M.M. Raut and N.R. Palaspagar

College of Agriculture, Sonapur Gadchiroli, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola

*Email : mahatale1978@rediffmail.com

ABSTRACT

The optimization of the mineral nutrition is the key to optimize the production of groundnut, as it has very high nutrient requirement and the recently released high yielding groundnut varieties remove still more nutrients from the soil. On contrary groundnut farmers use very less nutrient fertilizer and sometime only one or two nutrients resulting in severe mineral nutrient deficiencies due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. India is the world's largest producer of groundnut where nutritional disorders cause yield reduction from 30-70 per cent depending upon the soil types. A field experiment entitled "Effect of water soluble foliar grade fertilizer in summer groundnut" was conducted at Oilseed Research Unit Dr. PDKV, Akola during summer season 2011-12 at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. The gross and net plot sizes were 3.60 X 3.0 m² and 3.0 X 2.80 m² respectively. The crop variety TAG 24 was sown at 30 x 10 cm². Eight treatments were compared which are as under T₁ (Absolute control), T₂ (100% RDF 25:75:25 NPK kg per ha), T₃ (Foliar application of starter dose (11:36:24 NPK + trace element) + foliar application of Booster dose (8:16:39 NPK + trace elements), T₄ (100 % RDNPK + T₃), T₅ (FYM @ 7.5 t ha⁻¹ + 100% RDNPK), T₆ (FYM @ 7.5 t ha⁻¹ + 100% RDNPK + T₃), T₇ (FYM @ 7.5 t ha⁻¹ + 85% RDNPK), T₈ (FYM @ 7.5 t ha⁻¹ + 85% RDNPK + T₃). Treatments compared to evaluate the effect of different combination of organic, inorganic and foliar grade fertilizer on growth and yield of groundnut. Experiment results revealed that the growth and yield attributes are enhanced significantly with combination of organic, inorganic and foliar grade fertilizers. The results revealed that plant growth characters, yield and benefit: cost ratio were significantly superior with application of FYM @ 7.5 t ha⁻¹ + 100% RDF 25:75:25 NPK kg ha⁻¹, Foliar application of starter dose (11:36:24 NPK + trace element) + foliar application of Booster dose (8:16:39 NPK + trace elements). This treatment recorded highest pod yield (28.90 qt ha⁻¹), net monetary return (84263 Rs. ha⁻¹) and Benefit: cost ratio (2.84). It was closely followed by treatment FYM @ 7.5 t ha⁻¹ + 100% RDNPK recorded significant pod yield (27.18 qt ha⁻¹), net monetary return (79464 Rs. ha⁻¹) and benefit: cost ratio (2.77). It was concluded that integration of organic (7.5 t ha⁻¹), inorganic fertilizer (100% RDF) and water soluble grade fertilizer recorded, highest dry pods yield and getting maximum economic return from summer groundnut.

Key words : Organic, inorganic, foliar grade fertilizer, groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is a species in the legume family (Fabaceae) is originated in the Northwest Argentina region in South America and is presently cultivated in 108 countries of the world. Asia with 63.4 per cent area produces 71.7 per cent of world groundnut production followed by Africa. In India, it is cultivated on 4.76 million ha with a production of 4.74 million tonnes and a productivity of 996 kg per ha. India ranks second in the world groundnut production (Anonymous, 2014). Groundnut is also known as earthnuts, Peanuts, jack nuts, g-nuts and monkey nuts. Groundnut is grown mainly in kharif and summer season in India. Groundnut (*Arachis hypogaea* L.) is a major oilseed crop in Maharashtra, India is the world's largest producer of groundnut where nutritional disorders cause yield reduction from 30-70 per cent depending upon the soil types. In spite of recommended application of fertilizer (NPK – nitrogen, phosphorus, potassium) the yield does not reach the

national target. Intensive cropping leads to deficiency of secondary and micronutrients. The optimization of the mineral nutrition is the key to optimize the production of groundnut, as it has very high nutrient requirement and the recently released high yielding groundnut varieties remove still more nutrients from the soil. On contrary groundnut farmers, most part of the semi-arid region use very less nutrient fertilizer and sometime only one or two nutrients resulting in severe mineral nutrient deficiencies due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. Thus it is time to look into the mineral nutrition aspects of groundnut for achieving high yield and advocate the suitable package of practices for optimization of yield (Singh 2004).

Groundnut is an unpredictable legume, since its response to nutrient application is always not optimistic. Excessive application of nitrogen and potassium often resulted in excessive vegetative growth. Considering the

Table-1 : Pooled Growth attributes as influenced by various treatments.

Treatments	Plant height (cm)	No. of Primary branches	No. of Secondary branches	No. of root nodules	Weight of shoots (g)	Weight of Roots (g)	Total dry weight (g)	Days to 50% flowering
T ₁ -Absolute control	12.09	5.05	29.85	25.57	19.11	0.67	19.78	43.17
T ₂ -100% RDF	13.53	5.53	28.71	27.50	19.67	0.66	20.33	42.68
T ₃ -Foliar application of starter dose and booster dose	13.20	5.42	32.24	26.43	19.87	0.67	20.54	40.66
T ₄ -100% RDF NPK + T ₃	12.53	5.53	30.58	26.63	19.80	0.66	20.46	40.15
T ₅ -FYM @ 7.5 t ha ⁻¹ + 100% RDNPK	13.62	5.67	31.14	28.44	22.61	0.74	23.35	40.54
T ₆ -FYM @ 7.5 t ha ⁻¹ + 100% RDNPK+ T ₃	15.07	6.13	34.70	30.43	22.67	0.78	23.45	39.31
T ₇ -FYM @ 7.5 t ha ⁻¹ + 85% RDNPK	15.00	5.87	32.48	28.60	22.33	0.65	22.98	41.30
T ₈ -FYM @ 7.5 t ha ⁻¹ + 85% RDNPK+ T ₃	12.77	5.49	30.12	27.23	19.70	0.67	20.37	40.70
S.E.(M) ±	0.44	0.19	1.07	0.87	0.68	0.023	0.71	0.55
C.D. at 5%	1.36	0.58	3.26	2.61	2.06	0.069	2.16	1.68
GM	13.47	5.59	31.23	27.60	20.72	0.69	21.41	41.06

availability of the major elements in the soil and quantum of losses due to leaching and or fixation of the individual elements expected, a proper method and the time of nutrient application are needs of the hour. These facts call for a concerted study on the possibility of more effective utilization of nutrients in divided dosages like basal and foliar spray. Looking to the above facts the experiment is planned to studies on “Effect of water soluble fertilizer in summer groundnut (*Arachis hypogaea* L.)” was initiated at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104 Maharashtra, India.

Materials and Methods

A field experiment was designed in Randomized Block Design with replicated thrice in Eight treatments of Soil application 20, 40 and 60 Kg/ha Multi micro nutrient fertilizer mixture (MMM) in Groundnut. The experiment was conducted during Summer season 2011-12 to 2013-14 at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. Soil of experimental site was clay loam in texture, low in available nitrogen (134.28 Kg/ha), medium in available phosphorus (12.10 Kg/ha), fairly rich in potassium (260 Kg/ha) and low to critical limit in Zinc (0.5 mg/Kg soil), Ferrous iron (4.4 mg/Kg soil), Boron (0.8 mg/Kg soil), sulphur (9.8 mg/Kg soil) and magnesium (1.89 mg/Kg soil) micro nutrients. The soil was slightly alkaline in reaction pH (8.10) and electrical conductivity (0.12 d/sm). It was low in organic carbon (0.46 %). Eight treatments were compared which are as under T₁ (Absolute control), T₂ (100% RDF 25:75:25 NPK kg per ha), T₃ (Foliar application of starter dose (11:36:24 NPK + trace element) + foliar application of Booster dose (8:16:39 NPK + trace elements), T₄ (100 % RDNPK + T₃), T₅ (FYM @ 7.5 t/ha + 100% RDNPK), T₆ (FYM @ 7.5 t/ha + 100% RDNPK + T₃), T₇ (FYM @ 7.5 t/ha + 85% RDNPK),

T₈ (FYM @ 7.5 t/ha + 85% RDNPK + T₃). The gross and net plot sizes were 3.60 X 3.0 m² and 3.0 X 2.80 m² respectively. The crop variety TAG 24 was sown at 30 x 10 cm². The Recommended Dose of fertilizer i.e 25:75:25 N.P.K Kg/ha was used. Nitrogen @ 25 Kg/ha, Phosphorus @ 75 Kg/ha and Muriate Potash @ 25 Kg/ha were applied as basal dose. Starter Dose 11:36:24 + trace elements soluble grade fertilizers used as starter dose @2% as foliar application at 30 DAS and Booster dose 8:16:39 + trace elements soluble grade fertilizers used as starter dose @2% as foliar application at 45 and 60 DAS. Accordingly Urea (46 % N) and SSP (16% P₂O₅) MOP (60 % K₂O) were used.

Results and Discussion

Results revealed that Plant height was significantly more at harvest under the treatments T₆ (FYM @ 7.5 t/ha + 100% RDNPK + foliar application of starter dose and Booster dose) followed by T₅ (FYM @ 7.5 t ha⁻¹ + 100% RDNPK) and T₇ (FYM @ 7.5 t/ha + 85% RDNPK). The mean number of branches (primary and secondary) per plant was significantly superior in treatment T₆ (FYM @ 7.5 t ha⁻¹ + 100 % RDNPK + foliar application of starter dose and Booster dose) followed by T₅, T₇, T₈ and T₂. Total dry matter up to harvest was significantly more in treatments T₆ followed by treatment T₅ and T₇. Nodules per plant were significantly more at 60, 90 DAS and at harvest was recorded under treatment T₆ and found comparable with T₅, T₇ and T₈. The numbers of root nodules were found to be highest at 90 DAS. Numbers of developed pods were significantly superior in the treatment T₆ applied with FYM @ 7.5 t/ha + 100 % RDNPK + foliar application of starter dose and Booster dose. While, in case of lowest number of undeveloped pod was recorded with application of FYM @ 7.5 t ha⁻¹ + 100 % RDNPK + foliar application of starter dose and Booster dose (T₆). Oil content, protein content, oil yield were observed to be

Table-2 : Pooled Yields attributes and economics as influenced by various treatments.

Treatments	No of developed pods	No of undeveloped pods	Dry pod yield (Kg ha ⁻¹)	Haulm yield (Kg ha ⁻¹)	Oil %	Total Uptake of N	Total Uptake of P	Total Uptake of K	Cost of cultivation	Gross return	Net return	B:C ratio
T ₁ -Absolute control	14.33	9.40	1732.78	2876.9	48.98	96.34	11.93	45.55	39124	68077	28953	1.78
T ₂ -100% RDF	17.53	9.40	2605.78	3849.2	49.94	163.23	24.3	77.55	42804	111718	68914	2.61
T ₃ -Foliar application of starter dose and booster dose	17.60	7.07	1984.10	3472.2	49.39	120.84	16.4	60.92	40904	98280	57376	2.40
T ₄ -100 % RDF NPK+T ₃	18.30	7.33	2658.69	3968.2	49.60	154.07	22.9	74.71	43704	119641	75937	2.73
T ₅ -FYM @7.5 t ha ⁻¹ + 100% RDFNPK	19.30	7.60	2718.22	4629.6	49.73	186.72	29.6	97.81	44895	124359	79464	2.77
T ₆ -FYM @7.5 t ha ⁻¹ + 100% RDFNPK+T ₃	21.20	6.20	2890.17	5290.9	51.60	209.63	35.0	112.18	45795	130058	84263	2.84
T ₇ -FYM @7.5 t ha ⁻¹ + 85% RDFNPK	17.80	6.87	2195.74	3571.4	50.20	137.47	20.6	70.29	44695	112844	68149	2.52
T ₈ -FYM @7.5 t ha ⁻¹ + 85% RDFNPK + T ₃	17.00	8.07	2262.65	3637.5	50.61	134.02	18.1	66.72	45595	115177	69582	2.52
S.E.(M) ±	0.61	0.26	80.10	350.15	0.41	4.79	0.67	2.38	-	3888	2365	-
C.D. at 5%	1.85	0.81	242.97	1049.80	1.24	14.54	2.06	7.22	-	11795	7175	-
GM	17.88	7.55	2381.02	3912.0	50.00	149.84	22.35	75.77	43439	68077	66579	2.52

maximum due to application of FYM @ 7.5 t/ha + 100 % RDNPK + Foliar application of starter dose and Booster dose (T₆). The second best treatment was application of FYM @ 7.5 t/ha +100%RDNPK (T₅). While, in case of shelling percentage, 100 kernels weight were observed to be highest with application of FYM @ 7.5 t/ha + 100 % RDNPK + Foliar application of starter dose and Booster dose (T₆). However, it was comparable with treatment T₅, T₇, T₂ and T₈. There was a significant difference in pods, haulm and biological yield due to various treatments. The maximum dry pod and haulm yield was recorded with application of FYM @ 7.5 t/ha + 100 % RDNPK + foliar application of starter dose and Booster dose (T₆) followed by treatment T₅ (FYM @ 7.5 t/ha +100%RDNPK). The maximum nitrogen, phosphorus, and potassium content were recorded with application of FYM @ 7.5 t/ha + 100 % RDNPK + foliar application of starter dose and Booster dose. The second best treatment was T₅ (FYM @ 7.5 t/ha +100% RDNPK). The total uptake of nitrogen (209.63 kg/ha), phosphorus (35.0 kg/ha), and potassium (112.18 kg/ha) were highest with application of FYM @ 7.5 t/ha + 100 % RDNPK + foliar application of starter dose and Booster dose (T₆) followed by treatment with application of FYM @ 7.5 t/ha +100% RDNPK (T₅).

The highest benefit: cost ratio and gross monetary return were recorded in the treatment T₆ (FYM @ 7.5 t/ha + 100 % RDNPK + foliar application of starter dose and Booster dose) followed by treatment T₅ (FYM @ 7.5 t/ha +100% RDNPK). Integration of organic (7.5 t/ha), inorganic fertilizer (100% RDF) and foliar grade fertilizer was found superior than the application of RDF only. This treatment recorded highest pod yield (28.90 q/ha) net monetary return (84263 Rs./ha) and Benefit: cost ratio (2.84) and followed by application of FYM @ 7.5 t/ha

+100% RDNPK (T₅) recorded significant pod yield (27.18 q/ha), net monetary return (79464 Rs./ha) and benefit: cost ratio (2.77).

Conclusion

It was concluded that integration of organic (7.5 t/ha), inorganic fertilizer (100% RDF) and water soluble grade fertilizer recorded, highest dry pods yield and getting maximum economic return from summer groundnut.

References

- Anonymous, 2014. Annual Report—Annual meeting of Groundnut Researchers Workshop University of TNAU, Coimbatore, pp. 1-3.
- Badole, S.B., S.N. More., P.B. Adsul., A.K., Shaikh., Dhamak. A.L 2003. Residual effect of integrated nutrient management system of cotton on yield and nutrient uptake of summer groundnut. *Journal of Soil and Crop*. 13(1) : 77-80.
- Chandrasekaran, R., Somsundaram, E., Thirukumaram, K., Sathyamoorthi. 2008. Effect of foliar application of DAP and ZnSO₄ on groundnut productivity. *International Journal of Agriculture Science* 4(2) : 548-550.
- Elayaraja, D., Singaravel, R. 2012. Zinc and boron application on groundnut yield and nutrient uptake in coastal sandy soils. *Asian Journal of Soil Science*, 7(1) : 50-53.
- Kumaran, S. 2000. Role of organic manure, fertilizer levels, split application of phosphorus and gypsum application on shelling percentage, harvest index, pod and oil yield of irrigated groundnut. *Research on Crops*. 1 : 344-347.
- Munda, G.C., D.P. Patel., Islam. M. 2004. Effect of macro and micronutrients on growth and yield of groundnut. *Annals of Plant Physiology*. 18(1) : 9-12.
- Nayak S.C., Sarangi D., Mishra .G.C., Rout. D.P. 2009. Response of groundnut to secondary and micronutrients.

Journal of Semi Arid Tropical Agricultural Research 7, 24-32.

8. Patil, C. V., Yaledahalli, N. A., Prakash, S.S., 2003, Integrated nutrient management for sustainable productivity of groundnut in India. *Paper presented at the National workshop on groundnut seed technology, Raichur, 6-7, February, 2003.*
10. Sahu S.K., Kabat B., Nayak SC., 1998. Available boron and molybdenum status of some lateritic and alluvial soils of Orissa growing groundnut and its response to molybdenum on lateritic soil. *Environment Ecology* 16 (4) : 772-775.
11. Subrahmaniyan, K., P. Kalaiselvan, G. Manickam, Arulmozhi. N. 2000. Spacing and fertilizer requirement for confectionery groundnut varieties. *Crop Research*, 19(2) : 210-212.
12. Singaravel R and Prasath V. 2006. Response of groundnut to micronutrients along with organics in coastal sandy soils. *Journal of Indian Society of Coastal Agricultural Research* 24(1) : 149-151.
13. Thorave, D. S., Dhonde. M. B., 2007. Morphological indices and yield attributes as influenced by integrated nutrient management in summer groundnut. *Annals of Plant Physiology*, 21(2) : 186-188.
14. Vijayasekhar, K., Kuligod, V.B., Basavaraj, P. K., Dasog, G.S., Salimath, S.B., 2000. Studies on the micronutrient status in the important black soil series of UKP command, Karnataka. *Andhra Agricultural Journal*, 47 : 141-143.



Yield and Nitrogen Use Efficiency of Maize (*Zea mays* L.) as Influenced by Green Seeker Based Nitrogen Management Practices

Prakasha G.^{1*}, Mudalagiriappa², Hanumanthappa D.C.³ and Somashekar K.S.⁴

¹Dept. of LFC, Veterinary College, Hebbal, Bengaluru-560 024

²AICRP for Dryland agriculture, UAS, GKVK, Bengaluru-560 065

³AICRP for Agro-forestry, UAS, GKVK, Bengaluru-560 065

⁴AICRP on Sunflower, UAS, GKVK, Bengaluru-560 065

*Correspondence author : prakugp@gmail.com

Abstract

Field experiment was conducted at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru to assess the Yield and nitrogen use efficiency of Maize (*Zea mays* L.) as influenced by GreenSeeker based nitrogen management practices with eight treatments and replicated thrice using RCBD during *kharif* 2016. The results revealed that, grain yield, stover yield and harvest index (104.87 q ha⁻¹ 127.66 q ha⁻¹ 0.45, respectively) were significantly higher when nitrogen fertilizer was applied 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS as compared to absolute control and other treatments but it was on par with 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS and 100 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS. Application of 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS recorded significantly higher nitrogen use efficiency (81.50 kg kg⁻¹), recovery efficiency (90.94 %), agronomic efficiency (46.49 kg kg⁻¹) and physiological efficiency (52.90 kg kg⁻¹) over rest of the treatments and there was no nitrogen use efficiency where the treatment was not applied with external source of nitrogen.

Key words : Maize, GreenSeeker, yield and nitrogen use efficiency.

Introduction

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world. It is called as “Queen of Cereals” because of its productive potential compared to any other cereal crop and “King of Fodder” due to its great importance in animal diet. Globally, it is grown over an area of 185.90 m. ha with an annual production of 1,075.49 m. t with a productivity of 5790 kg ha⁻¹ (Anon., 2016). In India, it stands third in area and production after rice and wheat. Currently it is cultivated in an area of 9.89 m. ha with a production of 25.90 m. t. and it contributes to nearly 9 per cent of the national food basket (Dass *et al.*, 2012). However, the productivity in India is much lower (2620 kg ha⁻¹) than world average (Anon., 2016). The states that contributes, more than 80 per cent of total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4%). In India, about 35 per cent of the maize produced is used for human consumption, 25 per cent each in poultry and cattle feed and 15 per cent in food processing industries for preparation of corn flakes, popcorn, starch, dextrose, corn syrup and corn oil etc. Karnataka is not only a major maize producing state but also a major seed producing state. In the state, maize is grown over an area of 1.18 m. ha with a production and productivity of 3.28 m. t and 2773 kg ha⁻¹, respectively

(Anon., 2015). During the last ten years, the area under maize in Karnataka has increased by 41 per cent.

Nitrogen is one of the most important factors for growth and development of plants and most limiting nutrient in the crop production particularly in cereals. The absorption of N by crops is variable among and between seasons, as well as between locations in the same field, even when the N supplies are high. The N supply from soil to crop varies spatially. Consequently, the demand for N by the crop also varies. As a result, the crop's nutritional status is a good indicator of the necessary N rate application. The current approaches to detect soil and plant N levels are soil-testing, visual diagnosis and foliar analysis. However, these conventional approaches are time consuming, expensive; require considerable effort for soil collection or plant sampling, processing and results are not immediately available. Therefore, to provide appropriate recommendations of spatial N applications, it is necessary to use several tools simultaneously, such as crop and soil sensors, to achieve reliable measurements of N availability from soil and crops need. The evaluation of nitrogen use efficiency (NUE) in agriculture is an important way to evaluate the density of N applied and its role in yield. Because crop responses to N application depend on the organic matter in the soil, strategies of N management in cereal crops that include reliable predictions of the response index in

Table-1 : Grain yield (q ha^{-1}), stover yield (q ha^{-1}) and harvest index of maize as influenced by GreenSeeker based nitrogen management practices.

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index
T ₁	89.99	123.21	0.42
T ₂	96.38	124.32	0.43
T ₃	104.43	126.36	0.45
T ₄	104.87	127.66	0.45
T ₅	101.64	127.01	0.44
T ₆	101.47	126.60	0.44
T ₇	73.62	109.35	0.40
T ₈	43.76	67.70	0.39
Mean	89.52	116.53	0.43
S.Em $\pm$	0.99	1.19	-
CD (P=0.05)	3.00	3.62	-

T₁: RDN (50 % N as basal + 50 % N as top dress @ 30 DAS)

T₂: 150 kg ha^{-1} N in three splits @ basal, 30 and 60 DAS

T₃: 25 kg ha^{-1} N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₄: 50 kg ha^{-1} N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₅: 75 kg ha^{-1} N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₆: 100 kg ha^{-1} N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₇: No nitrogen

T₈: Absolute control

RDF: 150:75:40 NPK kg ha^{-1} FYM: 10 t ha^{-1}

each season could increase NUE. In this scenario, sensors are becoming more prevalent in agricultural lands. Using variable rate equipment or application, it is possible to detect variability in crops and make rapid decisions in the field. Some sensors allow real time changes in agricultural practices by detecting variability and responding to that variability.

Sensors utilize the optical characteristics of plants and their associated vigor and health properties. Recent advances in precision agriculture technology have led to the development of ground-based active remote sensors (or crop canopy sensors) that calculate NDVI readings. Crop canopy sensors are relatively small in size and contain an integrated light source. They operate by directing visible light (VIS) (400–700 nm) as well as near infrared (NIR) (700–1300 nm) light at the plant canopy of interest. The amount of VIS and NIR light that is reflected by the plant canopy is measured and an NDVI value is calculated using suitable equations.

GreenSeeker is an integrated optical sensing and application system that measures crop nitrogen status and variably applies the crop's nitrogen requirements. Yield potential for a crop is identified using a vegetative index known as NDVI (normalized difference vegetative index) and an environmental factor. Nitrogen (N) is then recommended based on yield potential and the responsiveness of the crop to additional nitrogen. The SPAD meter or handheld chlorophyll meter provides a non-destructive method to access the nutrient status of the crop. It measures the quantity of light transmitted through the leaf. Increasing chlorophyll content results in

decreasing light transmittance. Chlorophyll readings from nutrient deficient plots are compared to readings from reference plants where nutrients are non-limiting. The main advantage of using a chlorophyll meter is its ability to detect the nutrient stress before the deficiency symptoms are visible

Maize has got wider adoptability under different agro-climatic condition. Precision agriculture technologies are becoming part of many farming operations and can play a key role in sustainable N fertilizer management. Addressing spatially variable fertilizer N requirements with variable rate management strategies can increase profitability. The purpose of this study was to develop crop sensors technologies and to improve growers' knowledge for effective nitrogen (N) management. The overall goal is to improve the nitrogen use efficiency and increase crop productivity and profitability in a sustained manner.

Materials and Methods

A field experiment was conducted at ZARS, UAS, Bengaluru during *Kharif* 2016. The site is located at 13° 05' 2" N latitude and 77° 34' 02" E longitudes with an altitude of 930 m above mean sea level. The soil of the experimental site was sandy loam. The initial pH was 5.97 and electrical conductivity was 0.18 dS m^{-1} . The available nitrogen, phosphorus and potassium were 310 to 243 kg ha^{-1} , 23.50 to 47.10 kg ha^{-1} and 250.80 to 273.70 kg NPK ha^{-1} , respectively. experiment was laid out in Randomized Complete Block Design (RCBD) with eight treatments and replicated thrice and the treatments includes: T₁: RDN (50 % N as basal + 50 % N as top dress @ 30 DAS), T₂: 150 kg

Table-2 : Nitrogen use efficiency (kg kg⁻¹) of maize as influenced by GreenSeeker based nitrogen management practices.

Treatments	Nitrogen use efficiency (kg grain kg ⁻¹ N applied)	Recovery efficiency (%)	Agronomic efficiency (kg grain kg ⁻¹ N applied)	Physiological efficiency (kg grain kg ⁻¹ N uptake)
T ₁	59.99	61.04	30.82	50.77
T ₂	62.92	68.21	33.74	49.52
T ₃	81.50	90.94	46.49	52.90
T ₄	68.29	75.19	39.12	52.07
T ₅	67.76	74.29	38.59	52.19
T ₆	57.98	66.10	32.98	49.94
T ₇	0.00	0.00	0.00	0.00
T ₈	0.00	0.00	0.00	0.00
Mean	49.80	54.47	27.72	38.30
S.E.m±	0.33	1.73	0.35	1.37
CD (P=0.05)	0.99	5.25	1.05	4.15

T₁: RDN (50 % N as basal + 50 % N as top dress @ 30 DAS)

T₂: 150 kg ha⁻¹ N in three splits @ basal, 30 and 60 DAS

T₃: 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₄: 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₅: 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₆: 100 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS

T₇: No nitrogen

T₈: Absolute control

RDF: 150:75:40 NPK kg ha⁻¹ FYM: 10 t ha⁻¹

ha⁻¹ in three splits @ basal, 30 and 60 DAS, T₃: 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS, T₄: 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS, T₅: 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS, T₆: 100 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS, T₇: No nitrogen and T₈: Absolute control. The land was brought to fine tilth before sowing by ploughing twice with tractor drawn disc plough and passing cultivator and two harrowing. Drip system including pump, filter units, main line and sub lines were installed. In line laterals of 16 mm size within lines spaced at 45 cm apart with 4 lph capacities were laid out at a distance of 60 cm apart and thereby lateral spacing of 60 cm was fixed. There were seven maize rows at a distance of 60 cm apart in each treatment extending to 4.2 meter length. Seeds of Hema (NAH-1137) maize hybrids (two seeds per hole) were dibbled at 30 cm interval in the furrows spaced at 60 cm apart. The required fertilizer were calculated and applied as per the treatments. 25 per cent of the recommended dose of nitrogen was applied as basal along with full dose of P₂O₅ and K₂O. Remaining nitrogen was supplied as per the treatments. Nitrogen was applied based on GreenSeeker guided dose for the treatment (T₃ to T₆). In case of recommended practices, nitrogen (150 kg ha⁻¹) was applied as per package of practices. Recommended dose of FYM (10 t ha⁻¹) was applied to all the treatments except in case of absolute control and mixed into the soil 15 days prior to sowing. Irrigation was scheduled at

weekly interval through drip based on the rainfall, soil and crop appearance during the crop periods. Irrigation was withheld 10 days before the crop attained maturity. Atrazine @ 1000 g a.i. ha⁻¹ was applied as pre-emergence spray at one day after sowing of maize followed by one hand weeding was attended at 30 days after sowing to control the weeds. During the season the earthing up was carried out at 30 days after sowing. Plant population was maintained in all the treatments by thinning out of excess seedlings at 15 DAS and leaving one seedlings per spot. Healthy crop stand was ensured by adopting need based crop protection and recommended packages of practices. Five plants were selected at random and tagged. These plants were used for recording grain yield and stover yield. The cobs from each net plot after drying were threshed and cleaned. The weight of kernels of net plot and the kernel yield of five plants selected for observations was weighed together to get yield per net plot. The yield per ha was calculated from the net plot yield and expressed in q ha⁻¹.

Nitrogen use efficiency (NUE) : Nitrogen use efficiency was calculated by using following formula and expressed in kg kg⁻¹ (Crasswell and Godwin, 1984). Different measures of nitrogen use efficiency - recovery efficiency (RE), agronomic efficiency (AE), physiological or internal efficiency (PE) and partial factor productivity (PFP) are calculated by following formula :

$$\text{NUE or PFP} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Nitrogen applied (kg ha}^{-1}\text{)}}$$

$$RE (\%) = \frac{(\text{Total N uptake in N fertilized plot} - \text{Total N uptake in no N plot})}{(\text{Quantity of N fertilizer applied in N fertilized plot})} \times 100$$

$$RE = \frac{(\text{Grain yield in N fertilized plot} - \text{Grain yield in no N plot})}{(\text{Quantity of N fertilizer applied in N fertilized plot})}$$

$$PE = \frac{(\text{Grain yield in N fertilized plot} - \text{Grain yield in no. N plot})}{(\text{Total N uptake in N fertilizer plot} - \text{Total N uptake in no N plot})}$$

Where,

NUE – nitrogen use efficiency (kg grain kg⁻¹ N fertilizer applied)

RE (%) - recovery efficiency

AE- Agronomic efficiency (kg grain kg⁻¹ N)

PE- Physiological efficiency (kg grain kg⁻¹ N uptake)

N uptake was the total N uptake in grain and stover

Results and Discussion

Yield : In the present study, results revealed that grain yield of maize differed significantly due to GreenSeeker based nitrogen management practices (Table-1). The data revealed that, significantly higher maize grain yield (104.87 q ha⁻¹) was recorded with the application of 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS and it was on par with application of 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (104.43 q ha⁻¹). Significantly lower grain yield of 43.76 q ha⁻¹ was recorded with absolute control treatment.

Significantly higher stover yield exhibited in pooled analysis by treatment receiving 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (127.66 q ha⁻¹) which was on par with all the treatments except treatments receiving no nitrogen (109.35 q ha⁻¹). Lower stover yield of maize was noticed in absolute control treatment (67.70 q ha⁻¹).

The higher grain and stover yield of maize was mainly due to better translocation of photosynthates from source to sink and higher growth attributing characters like higher number of leaves, leaf area and higher dry matter production and its accumulation into different parts of plant and yield attributing characters like grain weight per cob, number of seeds per cob, number of rows per cob, test weight and cob length and dry matter production per plant and its accumulation into various plant parts have an indirect influence on grain yield through the yield

components, which intern depends on different growth components namely plant height, number of leaves, leaf area and LAI. All these growth components could have been promoted by making more quantity of nutrients available by the treatments to maize crop. This was evidenced through higher uptake of nutrients; these findings are in conformity with the results of Doberman *et al.* (2002) and Daikho (2013).

Harvest index (HI) : Harvest index indicates the percentage of dry matter partitioned and accumulated in the economic portion. In the present investigation higher values of harvest index (0.45) was observed in application of 25 kg and 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS as compared to without fertilizer application treatment (0.39). As it is crop genetic makeup and thus plant not altered with external management.

Nitrogen use efficiency in maize as influenced by GreenSeeker based nitrogen management practices : Nitrogen use efficiency under different N management strategies for maize crop was estimated in terms of recovery efficiency (RE), agronomic efficiency (AE) and physiological efficiency (PE) are presented in Table-2.

According to Dobermann (2007) it was important to manage N supply from soil and other indigenous sources and fertilizer to maximum the fertilizer efficiency. Because the relation between the yield and N uptake is tight and losses of fertilizer N are the highest during the year of application, maximizing the first crop recovery of N from mineral fertilizer or organic amendments (RE) is of particular importance.

A perusal of pooled data in Table showed that, application of 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS recorded significantly higher nitrogen use efficiency (81.50 kg kg⁻¹) over rest of the treatments and it was followed by application of 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (68.57 kg kg⁻¹) and 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (67.59 kg kg⁻¹). No nitrogen use efficiency was observed under plot received no nitrogen fertilizers and absolute control without fertilizer application.

The recovery of any nutrient applied shows the soil supplying capacity and the inherent capacity of the plant to utilize nutrient. It is also dependent on the growing environment and method of application. Achievable level of recovery efficiency was registered with application of 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (87.04 %) over other treatments and it was followed by application of 50 kg ha⁻¹ N as basal

+ GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (72.56 %) and 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (70.42 %). Because of balanced application of nitrogen by GreenSeeker device at right stage of the crop led to increased recovery efficiency. Khurana *et al.* (2008) also reported significant increases in recovery efficiency of applied N (REN). Plot without N fertilizers records no recovery efficiency due to no application of N fertilizers and similarly, absolute control treatment also records no recovery efficiency due to nil application of fertilizer to control plot.

Agronomic efficiency is a product of nutrient recovery from mineral or organic fertilizer (RE) and the efficiency with which the plant uses each additional unit of nutrient (PE). It depends on management practices that affect RE and PE. Significantly higher agronomic efficiency (46.96 kg kg⁻¹) was obtained in application of 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS, followed by application of 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (39.79 kg kg⁻¹) and 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (38.81 kg kg⁻¹). Better timing and splitting of fertilizer N applications during the season was probably the major reason to the increase in agronomic N-use efficiency. Similar results were noticed by Khurana *et al.* (2008) and Pasuquin *et al.* (2010) reported that significant increases in agronomic efficiency of applied N (AEN) through the site-specific N management by 53 per cent compared to the FFP and average AEN under SSNM dose to 25.1 kg kg⁻¹, an increase of 53 per cent compared to the FFP (farmers fertilizer practices). No agronomic efficiency was observed under treatments received no N fertilizers and under absolute control amount of the nutrient applied is inversely related to agronomic efficiency. Due to this reason lower AE was observed. Similar result was also observed by Gilkes *et al.* (2010).

The PE of the nutrient shows the utilization capacity of the plant nutrient uptake. The higher the efficiency indicates more capacity of plant to increase yield with per unit nutrient uptake. In pooled analysis significantly higher physiological efficiency (55.46 kg kg⁻¹) was recorded under 25 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS and followed by application of 50 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (55.09 kg kg⁻¹) and 75 kg ha⁻¹ N as basal + GreenSeeker guided N application @ 15, 30, 45 and 60 DAS (55.43 kg kg⁻¹). This increased physiological efficiency was mainly due to balanced application of nitrogen by GreenSeeker device at right stage of the crop. Mahajan *et al.* (2013) also reported STCR-IPNS

technology ensures higher nutrient use efficiencies. Treatments without N application and absolute control recorded no physiological efficiency due to absence of external N fertilizer and all fertilizers, respectively.

Conclusion

From the study, it can be concluded that application of Nitrogen through GreenSeeker tool was found to be more useful in maize for realizing higher grain yield with higher nitrogen use efficiency.

References

1. Anonymous, 2015, Area, production and productivity of major cereals in India. <http://www.indiastat.com>.
2. Anonymous, 2016, Area, production and productivity of major cereals in India. <http://www.indiastat.com>.
3. Daikho, A., 2013, Performance of maize hybrids to varying fertilizer levels in the northern transitional zone of Karnataka. *M. Sc. (Agri.) Thesis, submitted to Univ. Agric. Sci., Dharwad (India)*.
4. Dass S., Jat, S.L., Chikkappa, G.K., Kumar, B., Kaul, Jyothi, Parihar, C.M., Kumar, A., Kumar, R., Kamboj, M.C., Singh, V., Yatish, K.R., Jat, M.L. and Singh, A.K., 2012, Genetic enhancement and crop management lead maize revolution in India. *Maize J.*, **1**(1): 7-12.
5. Dobermann, A. and Cassman, K. G. 2002. Plant nutrient management for enhanced productivity in intensive grain production systems of the United States and Asia. *Plant and Soil*. **247**: 153-175.
6. Doberman A. 2007. Nitrogen use efficiency-state of the art. IFA International Workshop on Enhanced Efficiency Fertilizers. *Frankfurt, Germany*, 28-30 June, pp: 1-18.
7. Gilkes, R. J. and Prakongkep, N. 2010. A new site-specific nutrient management approach for maize in the favorable tropical environments of Southeast Asia. Paper Presented at Symposium on "Soil solutions for a changing world". *19th World Congress of Soil Science*. Brisbane, Australia, 1-6 August 2010: 4-7.
8. Gomez, K.A. and Gomez, A.A., 1984, *Statistical Procedure for Agricultural Research* – An International Rice Research Institute, A Wiley Inter science, *John Wiley and Sons Inc.*, New York, USA.
9. Khurana, H.S., Phillips, S.B., Singh, B., Alley, M.M., Dobermann, A., Sidhu, A.S., Singh, Y. and Peng, S. 2008. Agronomic and economic evaluation of site-specific nutrient management for irrigated wheat in northwest India. *Nutr. Cycl. Agroecosyst.*, **82**:15–31.
10. Mahajan, G.R. Pandey, R.N. Datta, S.C. Kumar, D., Sahoo, R.N. and Parsad, R. 2013. soil test based fertilizer recommendation of nitrogen, phosphorus and sulphur in wheat (*Triticum aestivum* L.) in an alluvial soil. *Int. J. Agri. Environ. Biotechnol.*, **6**(2): 271-281.
11. Pasuquin J.M., Christian Witt and Mirasol Pampolino, 2010. A new site-specific nutrient management approach for maize in the favourable tropical environments of Southeast Asia. paper presented at symposium on "soil solutions for a changing world". *19th World Congress of Soil Science*. Brisbane, Australia, 1-6 August 2010: 15-18.



Growth, Multiplication Efficiency of Composting Earth Worms (*Eisenia fetida*) as Influenced by Substrata and Seasons.

Jagdish Prajapati, Sadhana Chaurasia and Ravindra Singh

M.G.C.G. Vishwa Vidyalay Chitrakoot, Satna, M.P.-485334

Abstract

A pot experiment was conducted at Rajaula Krishi Farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwa Vidyalaya Chitrakoot, Satna, (MP) during 2015-16 and 2016-17. Twelve treatment combinations consisted of four biowastes (Leaf litter, Ipomea, Water hyacinth and Vegetable market wastes) were tested under three seasons (rainy, winter and summer). These treatments were arranged in a randomized block design with three replications. Results reveal that among the different bio-wastes water hyacinth, decomposed faster as compare to other and congenial season is rainy as wastes decomposed faster (18.25%) over (10.87 and 13.25%) in winter and summer seasons. The maximum weight gain of 240.9 g was observed in leaf litter closely followed by water hyacinth. On the other hand higher multiplication ratio of worms (2.01) were recorded under leaf litter followed by 1.94 in water hyacinth. The rainy season proved more congenial for worm multiplication (2.0). Hence, worms multiply at faster rate in leaf litter during rainy season and recorded 2.21 ratio of multiplication.

Introduction

Both Farmers and researchers are concerned with the deterioration of soil fertility due to decreasing application of organic source of nutrients. This is because of agricultural produce are largely transported to urban centers without counter blow of organic matters to the farms. On the other hand, large quantity of weeds and agricultural biomass as well as water bodies are generated. These weeds and bio wastes are rich in organic matter and contains handsome amount of plant nutrients. Though, the much attention has not been paid in order to harness the potential of these bio wastes in order to supply plant nutrients. In the laboratory of nature, "earth", there are number of macro and micro -organisms are exist that have an ability to fragment, decompose as well as digest bio wastes and convert in to nutrient rich vermicompost Agrawal et al (2010). The ability and efficiency of earth worm species (*Eisenia fetida*) may be explore for the vermicomposting. This process will not only solve the problem of waste disposal but also save the natural resource which are being used to manufacture of synthetic fertilizers. Moreover, the produced vermi compost will also prove boon for farmers and organic farming.

Therefore, the study on growth, multiplication of composting earth worms (*Eisenia fetida*) and their efficiency to produces vermicompost as influenced by substrata and seasons were conducted.

Materials and Methods

A pot experiment was conducted during 2015-16 and 2016-17 at Rajaula Krishi Farm research farm with twelve treatment combinations consisted of four bio wastes (Leaf

litter, Ipomea, Water hyacinth and Vegetable market wastes) were tested under three seasons (Rainy, Winter, and Summer). These treatments were arranged in a randomized block design with three replications. The four bio wastes including the tree leaves, Ipomea, and water hyacinth and vegetable market wastes were collected from road side, ponds and vegetable market and dung from instructional dairy farm, respectively. These bio wastes were weighted as fresh and determined the dry matter percentage (Table-1).

Table-1 : Dry matter and nutrient content in different bio waste as Fresh.

Bio-wastes	Dry matter content (%)	Nutrient content(%)		
		Nitro-gen	Phos-phorus	Potas-sium
Leaf litter	38.45	0.23	0.11	0.21
Ipomea	28.57	0.15	0.13	0.23
Water hyacinth	17.54	0.18	0.15	0.24
Vegetable market waste	23.80	0.21	0.17	0.24
Fresh Dung	22.20	0.32	0.28	0.35

On the basis of dry matter, 5 kg of each bio waste mixed with 5kg of dung in the ratio of 1:1 and put together for partial decomposition for a period of 21 days. After partial decomposition, subsequently, partially decomposed matter was put in a earthen pot for digestion by earth worms, as per treatments separately. This process was repeated in each season (rainy, winter and summer) for two years. Earth worm species *Eisenia fetida* was used and inculcated @200g in each treatment, however counts of worms were varied in different treatments. Observations with respect to changes accrued in bio wastes during partial decomposition in terms of reduction in weight and status of major nutrients

(N P and K) were determined in laboratory. The increase in weight and number of earth worms as well as production of vermicompost were recorded and computed for weight gained by earth and multiplication ratio of worms. Recorded data were statistically analysed and presented for interpretation.

Change occurs in bio wastes during partial decomposition : Data in relation to changes in bio wastes with respect to weight (Table-2) shows that higher percentage (19%) reduction in weight was recorded in water hyacinth which was markedly higher over others. Different seasons also found significantly varied in reduction of dry weight of bio-wastes during partial decomposition period. The maximum reduction in weight of substrata was noted during rainy season (18.25%) and proved superior over winter and summer. Whereas the lowest reduction (10.87%) was noted during winter which was at par to 13.25% recorded in summer season. Different bio-wastes behaved in the same manner to varying seasons for reduction in dry matter weight. Hence, the interaction of bio wastes and seasons were found non-significant Table-2. Similar, results were reported by Smith (2006) and Singh (2007).

Table-2 : Change in dry weight of bio-wastes (g) under different season during partial decomposition.

Bio-wastes	Seasons				Percent reduction in weight
	Rainy	Winter	Summer	Mean	
Leaf litter	6.28	7.47	7.17	6.97	12.87
Ipomea	7.10	6.89	7.30	7.09	11.37
Water hyacinth	6.14	6.89	6.42	6.48	19.00
Vegetable market waste	6.66	7.30	6.88	6.94	13.25
Mean	6.54	7.13	6.94		
Percent reduction in weight	18.25	10.87	13.25		

	Biowaste	Season	Bio x Season
SEm±	0.19	0.14	0.33
CD(5%)	0.58	0.43	N.S.

The content of nutrients are presented in Table3, 4, 5 and 6. The analysis of data reveal that all the bio waste possessed higher value of nitrogen phosphors and potassium content in partially decomposed matter over fresh substrata (Table-3 and 4) and became more than double.

Table-3 : Chemical composition (N,P and K%) of various fresh bio-wastes.

Bio-wastes	Percent content		
	Nitrogen	Phosphorus	Potassium
Leaf litter	0.23	0.11	0.21
Ipomea	0.15	0.13	0.23
Water hyacinth	0.18	0.15	0.24
Vegetable market waste	0.21	0.17	0.24

Table-4 : Content of nitrogen in partially decomposed matter as influenced by various bio-wastes and seasons.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	0.44	0.41	0.38	0.410
Ipomea	0.36	0.34	0.34	0.346
Water hyacinth	0.36	0.38	0.36	0.366
Vegetable market waste	0.38	0.39	0.35	0.386
Mean	0.385	0.380	0.357	

	Biowaste	Season	Bio x Season
SEm±	0.029	0.024	0.035
CD(5%)	0.060	NS	NS

Nutrients content in terms of N,P and K are changed due to change of bio wastes, while, seasonal change did not influence these nutrients in partially decomposed matter. Further it was observed that all the three nutrient content increased markedly over content of initial fresh substrata. As regard to the substrata, leaf litter possessed the highest content (0.41%) of nitrogen over Ipomea but at par to water hyacinth. Vegetable market wastes recorded significantly higher phosphorus 0.27% (Table-5). Whereas potassium content (0.52%) was observed in leaf letter. The interaction of bio wastes and changes of seasons found to be non-significant (Table-6).

Table-5 : Content of Phosphorus (%) in partially decomposed matter as affected by various treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	0.26	0.24	0.23	0.243
Ipomea	0.23	0.22	0.22	0.223
Water hyacinth	0.25	0.24	0.22	0.236
Vegetable market waste	0.29	0.25	0.24	0.270
Mean	0.257	0.245	0.227	

	Biowaste	Season	Bio x Season
SEm±	0.01	0.019	0.030
CD(5%)	0.03	NS	NS

Table-6 : Content of Potassium in partially decomposed matter as affected due to various treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	0.54	0.53	0.49	0.520
Ipomea	0.43	0.45	0.40	0.426
Water hyacinth	0.49	0.51	0.43	0.476
Vegetable market waste	0.48	0.53	0.43	0.480
Mean	0.485	0.505	0.437	

	Biowaste	Season	Bio x Season
SEm±	0.021	0.024	0.045
CD(5%)	0.063	NS	NS

Weight of earthworm was measured at final stage of vermicomposting and recorded data were presented in Table-7a and 7b. The analysis of data found significantly differed due to the various bio-wastes as well as change of seasons. However, the interaction between bio-wastes

and seasons was found non-significant. Among the bio-wastes, leaf litter proved to be a significantly better substrata for the development of earthworms over rest of the wastes except water hyacinth. Leaf litter recorded 440.9g weight of worms followed by water hyacinth (421.8g.). However, water hyacinth found significantly superior over Ipomea but at par to vegetable market waste. Further, it was also noted that vegetable market waste recorded markedly higher weight of earthworms (409.1g) over Ipomea. The Ipomea bio-waste possessed the significantly lowest weight (335.2g) of earth worms.

Table-7a : Weight of earthworms (g) released in wastes under different seasons.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	488.0	402.6	432	440.9
Ipomea	366.0	317.3	322.3	335.2
Water hyacinth	468.0	380.6	417.0	421.8
Vegetable	435.6	392.6	401	409.1
Mean	414.4	373.3	393.0	409.1
Biowaste	Season	Bio x Season		
SEm±	7.3	9.2	26.7	
CD(5%)	21.8	28.2	NS	

Table-7b : Effect of different bio-waste on weight gained by earthworms under different seasons.

Treatments	Initial weight(g) of worms at inoculation	Weight gain(g) by earthworms
Biowastes		
Leaf litter	200	240.9
Ipomea	200	135.2
Water hyacinth	200	221.8
Vegetable market wastes	200	209.1
Seasons		
Rainy	200	214.4
Winter	200	173.3
Summer	200	193.0

The rainy season proved to be the congenial with respect to temperature and humidity for the growth and development of worms in terms of weight gain. The weight of earthworm was recorded significant higher during rainy (414.4g.) over winter season but at par to summer. The lowest weight of 373.3g was obtained during winter season which was significantly lower to rainy (414.4g) and summer (373.39) seasons.

Weight gained by earthworms : Weight gained by earthworm was computed by subtracting the initial weight (200g) from total weight of earthworms obtained at final stage of vermicomposting.

Data with respect to weight gained by earthworms are presented in Table 7b. It revealed from the data that

the maximum weight gain of 240.9 g. was recorded in the substrata of leaf litter followed by water hyacinth (221.8g) vegetable market wastes(209.1g) and Ipomea (135.2g). These findings are in close conformity with the findings of Nagavallema et al (2004). As regards to the season, the maximum weight gain of 214.4 g. was noted during rainy season followed by 193.0 and 173.3g. in summer and winter seasons, respectively.

Population of earthworm obtained at final stage of vermicomposting :

The earth worms were inoculated uniformly (200g) by weight in various substrata of bio-wastes after partial decomposition. However, they were differ in numbers, hence, worms were counted separately as per the treatments Table 8(a). The average counts of worms inoculated between 268 to 290, under different substrata. Hence, worms were kept almost similar in each substrata during all the three seasons. The increase in number of earthworms in different substrate indicates that there is a favorable environment for their activities. Population of earthworms were recorded at the time of final vermicomposting in a process are presented in Table 8(b) for interpretation. Data in relation to total population of earthworm received after maturity of vermicompost revealed that the significantly higher count of earth worm (548) were recorded under leaf litter closely followed by 526.3 and 525.7 under water hyacinth and vegetable market waste, respectively. While the significantly lowest count of 437.7 were recorded Ipomea. As regards to the change of season showed significant variations for count of worms. The rainy seasons proved to be the most favorable season and recorded on an average 559.25 earth worms which was significantly superior over summer and winter. The lowest count of earth worm (467.5) was recorded during the winter season. The different substrata exhibited differential response for different seasons. Rainy season proved better with all the substrata for multiplication of earth worms except Ipomia and recorded 632,591 and 567 count of worms with leaf litter, water hyacinth and vegetable market waste. Similar trend was observed in summer season. These results are in close conformity with the findings of various authors (Kale and Krishnamoorthy (1981), Amoji et al (1990).

Table-8(a) : Counts of worms inoculated at initial stage under different treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	285	261	269	271.6
Ipomea	268	259	271	266.0
Water hyacinth	279	255	277	270.3
Vegetable market waste	277	290	269	278.6
Mean	277.3	266.3	271.5	

Table 8(b) : Worms obtained at final stage of vermicomposting.

Bio-wastes	Seasons			Mean
	Rainy	Winter	Summer	
Leaf litter	632	488	524	548
Ipomea	447	419	447	537.7
Water hyacinth	591	459	529	526.3
Vegetable market waste	567	504	506	525.7
Mean	559.3	467.5	501.5	
Biowaste	Season	Bio x Season		
SEm±	7.32	7.11	14.38	
CD (5%)	22.10	21.80	43.40	

Table-8(c) : Multiplication ratio.

Bio-wastes	Seasons			Mean
	Rainy	Winter	Summer	
Leaf litter	2.21	1.87	1.95	2.01
Ipomea	1.66	1.62	1.65	1.64
Water hyacinth	2.11	1.80	1.91	1.94
Vegetable market waste	2.04	1.73	1.88	1.87
Mean	2.00	1.75	1.85	

Data on multiplication ratio of earth worm were computed and presented in Table-8(c). It is clear from the data that proliferation of earth worm recorded in leaf litter during rainy season were as the minimum multiplication was noted with Ipomea during all the three season. Thus it could be concluded that the leaf litter followed by water

hyacinth and vegetable market wastes are the good source of feeding materials when they were provided to the earth worm during rainy season. The results are in agreement with the findings of Singh (2007) and Sharma (2015).

References

1. Agrawal, SB; Singh Sarita and Jha, AK (2010) production of vermicompost and culture as influenced by various substrate and additives. *IJTA* 28(3-4): 481-485.
2. Amoji; SD Snagati UM and Biradar VA (1998). Selective preference for Agri-organic wastes under multiple choice by Epigamic earthworms. *J. Environ. Bio*, 19 (4): 375-380.
3. Kale, RD and Krishnamoorthy, RV (1981). Litter preference in earthworm *lampito mauritii*. *Acad. Sci.* 908 : 123-128.
4. Nagavallema, KP; Wani SP; Stephense L; Padamja VV, Vineeta C, Rao M Babu and Sahrawat, KL (2004) vermicomposting: recycling of waste into valuable organic fertilizer. *Global theme on agroecosystems*. 8: 6.
5. Sharma, Ankit, (2015) evaluation of enriched vermicompost on growth and yield of chickpea (*Cicer arietinum* L.). M.Sc. (Ag.) thesis submitted to JNKVV Jabalpur as in partial fulfillment of the requirement for the degree. 1-113.
6. Singh, Renu. (2007) Effect of additives on vermicomposting of obnoxious weeds. M.Sc. (Ag.) thesis submitted to JNKVV jabalpur as in partial fulfillment of the requirement for the degree. 1-73.
7. Smith, LW (2006). Dehydrated poultry excreta as a crude protein supplement for ruminants. *World animal review*: 1-10.



Assessment of Different Sesame (*Sesamum indicum* L.) Varieties under Different Agro Ecological Environments for Higher Yield

Varsha Thakur, Seema Paroha, S.B. Agrawal Archana Pandey and S.K. Singh

College of Agriculture, JNKVV, Jabalpur

Email : tiger_singh2007@yahoo.com

Abstract

Climate change is affecting agro ecological situations and in influencing the crop cultivars, soil and plants due to wide fluctuations in temperatures and rainfall also. So, in order to assess the performance of cultivars under different environments, a field experiment was conducted during Kharif seasons of 2014 and 2015. A total of 49 treatment combinations consisted of seven varieties (TKG-2, GT 10, PKVNT-11, Prachi, HT2, DSS9 and TMV-7) and seven agro ecological environments (Hissar, Raichur, Nagpur, Tikamgarh, Jabalpur, Dharwad and Bhubaneswar) were arranged in a randomized block design replicated thrice. The agro ecological environments of different locations were changed with the change of rainfall, temperature, Soil, PH, Ec, nutrient status with respect to macro and micro nutrients. The crop varieties were grown as per the recommended package of practices for the given environments. Results of study reveal that amongst the cultivars, Prachi proved significantly superior in terms of branches (5.69 and 5.99) and capsules/plant (60.59 and 61.59), seeds per capsules (48.48 and 50.23) as well as seed yield per plant (6.76 and 6.91g) during 2014 and 2015, respectively. The top ranking variety Prachi also produced highest seed yield of 709.57 and 762.87 kg/ha during first and second year respectively. Similarly, agro ecological & iterations of Tikamgarh and Dharwad proved to be more favorable to get sesame crop and these environments gave seed yield of 791.59 and 845.85 as well as 769.23 and 815.90 kg/ha during 2014 and 2015, respectively.

Introduction

Modern agriculture relies on high crop yield to meet the increasing demand of food for human being. The environment or agro ecological situations have directly influenced the crop-morphology phenology, flowering pattern grain filling rate etc. A number of studies have shown that growth and photo synthetic rate is widely affected due to concentration of Co₂ which is varied from place to place.

Sesame (*Sesamum indicum* L.), is an important annual oil seed crop and extensively cultivated on ranging from semiarid tropics to subtropics temperate regions and has lead to a wide diversity of genotype (Weiss 2000, Sogut, 2008). The major yield differences in terms of morphology as well as chemical composition of cultivars have been attributed to lack of suitable cultivars which can be widely accepted for high field and early maturing. The production and productivity of cultivar is directly associated with the photoperiodism. The variable photo period with climatic conditions can affect the percentage fertilized flower and it has direct correlation with capsules/branches, seeds/capsules, test weight, per plant seed production etc. In addition to these, seed length width and thickness may also vary considerably between genotypes under different environmental conditions. Therefore the present study was carried out to determine a suitable variety of sesame under different environments.

Materials and methods

Field experiments were conducted during Kharif seasons of 2014 and 2015 at seven agro environments viz Hissar, Nagpur, Tikamgarh, Jabalpur, Dharwad and Bhubaneswar having the variability in edaphic and climatic conditions. The climate of different locations with respect to temperature, rainfall and rainy days exist during crop seasons of two years are presented in Table-1.

The edaphic conditions of different locations where experiments were conducted in relation to soil PH, EC and nutrient status are given in Table-2.

Table shows that the soils having the acidic to alkaline in reaction while medium in nitrogen, phosphorus as well as potassium content. The seven cultivars (TKG22, GT10, PKVNT11, Prachi, HT2, DSS9 and TMV7) were assessed under given seven agro environments for two consecutive Kharif seasons of 2014 and 2015. The different cultivars taken under study were arranged for sowing at each location (Agro environment) in a randomized block design replicated thrice. The package of practices recommended for a particular location are given in Table-3.

Observations with respect to branches per plant, capsules/plant, seeds/capsule seed yield plant, test weight and yield kg/ha were recorded at vegetative growth stage and harvest of crop during both the years of study. Recorded data pertaining to each and every parameters were subjected to statistical analysis by

Table-1 : Meteorological parameter recorded during crop seasons of kharif 2014 and 2015 at different locations.

Agro environments	Rainfall (mm)		Number of rainy days		Temperature			
	2014	2015	2014	2015	Maximum		Minimum	
					2014	2015	2014	2015
Hissar	603.7	237.6	23.0	30.0	32.56	33.42	21.44	21.1
Raichur	566.7	660.2	34.0	29.0	31.3	32.0	21.38	23.04
Nagpur	1149.4	813.4	47.0	27.0	25.2	32.54	17.48	23.6
Tikamgarh	519.9	366.9	22.0	21.0	19.54	19.56	14.28	14.28
Jabalpur	798.8	929.2	46.0	36.0	31.26	31.72	20.56	20.92
Dharwad	466.8	307.6	43.0	21.0	28.7	29.64	17.98	21.38
Bhubaneswar	1499.4	756.6	34.0	55.0	32.32	32.52	22.96	23.72

Table-2 : Chemical properties with respect to soil of experimental field at different locations.

Agro environments	pH	EC (dS m ⁻¹)	N (kg/ha ¹)	P (kg/ha ¹)	K (kg/ha ¹)	Zn (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
Hissar	8.05	0.670	147.33	14.61	284.27	1.38	1.03	5.15	3.83
Raichur	8.46	0.87	229.4	37.97	403.0	0.35	1.37	5.65	3.9
Nagpur	7.95	0.351	225.3	17.17	388.47	0.84	1.65	5.19	8.73
Tikamgarh	5.94	0.296	175.77	11.97	313.2	0.47	1.17	5.16	4.3
Jabalpur	7.34	0.414	208.47	19.2	327.1	0.42	0.37	5.66	6.43
Dharwad	7.81	0.36	220.53	31.57	321.6	1.35	1.30	4.87	3.77
Bhubaneswar	5.57	0.25	369.3	25.53	144.23	1.26	2.15	8.02	7.33

following the statistical method for randomized block design.

Results and discussion

Performance of varieties : Performance of different varieties under different agro ecological environments (created with the change of locations) were studied and differences were observed in growth development and yield of crop. Data reveal that amongst the cultivars, Prachi proved statistically superior in terms of branches, capsules per plant, seed per capsule and seed yield per plant over rest of the cultivars except TMV 7 during both the years of study. On an overage, cultivar Prachi produced branches/plant (61.03) capsules/plant, (49.35) seeds/capsule and seed yield/plant (6.83g) closely followed by TMV7 and recorded 5.64, 58.42, 49.28 and 6.42g, respectively. Table-4. Where as the other cultivars VIZ, HT2 and DSS-9 did not perform well in all these parameters during both the years and possessed the lowest values with respect to all the yield attributing traits. As regards to the test weight and seed size, interms of length, breadth and thickness, the top-ranking varieties Prachi and TMV7 both were found statistically at par to each other and recorded the highest test weight of 3.58 and 3.71 g, seed length (2.81 and 2.82 mm) seed breadth (2.74 and 2.74 mm) as well as seed thickness (0.91 and 0.91 mm) respectively. The research findings reveal that plant yield in terms of seed is the resultant of different morphological and physiological parameters as these are quantitative traits which are governed by number of

genes. These findings are in close conformity with the findings of Ghungarde et al (1992) Sharma (1994) Dixit et al (1997) Raghuwanshi (2005) who reported that the branches/plant capsules/plant and seed yield/plant are the yield contributing traits for sesame. The most important outcome of the study is the yield of sesame per unit area was also showed similar trend with growth and yield attributes. Further the variety Prachi proved significantly the highest seed yield of 736.22 kg/ha closely followed by TKG-22 (729.83 kg/ha) GT10 (725.47 kg/ha) and TMV-7 (700.22 kg/ha).

Different agro environment also had significant effect on yield attributes seed test weight and yield as well as seed size (Table-4). On an average the environment of Tikamgarh and Dharwad found favorable with respect to branches (5.87 and 5.33 plant), capsules (56.68 and 58.94/plant) seeds (49.33 and 46.37/capsules) and seed yield (6.52 and 6.45 g/plant) respectively. The seed yield per hectare was also found to be higher at Tikamgarh (818.72 kg/ha) which was significantly superior over rest of the environments except Dharwad (792.50 kg/ha). However the lowest yield of 547.04 kg/ha was noted at Hissar followed by at Bhubaneswar 569.33 Kg/ha.

As regards to the seed quality with respect to test weight and seed size. The environment did not influence the test weight during both the years. While seed length, breadth and thickness of seed significantly changed due to change of environments. Higher values of seed length (2.84 mm) breadth (1.70 mm) and seed thickness of 0.90 mm were recorded at Tikamgarh. All the environments

Table-3 : Details of crop sown at different spacing's and fertility levels under different environments.

Agro environments	Spacing (Row to Row) cm)	Spacing (Plant to Plant) (cm)	Gross plot size (M ²)	Net plot size (M ²)	Fertilizer application (kg/ha)		
					N	P ₂ O ₅	K ₂ O
Hissar	30	15	4.5 x 3.0	3.9 x 2.70	30	0	0
Raichur	22.5	22.5	4.5 x 2.7	3.60 x 2.25	25	15	15
Nagpur	30	15	4.5 x 3.0	3.90 x 2.70	50	0	0
Tikamgarh	30	15	4.5 x 3.0	3.90 x 2.70	40	30	20
Jabalpur	30	15	4.5 x 3.0	3.90 x 2.70	40	30	20
Dharwad	30	15	4.5 x 3.0	3.90 x 2.70	37.5	25	25
Bhubaneswar	30	15	4.5 x 3.0	3.90 x 2.70	30	20	30

Table-4 : Performance of varieties for growth and yield attributes under different during 2014 and 2015.

Treatment	Growth parameters									
	Branches/plant		Capsules/plant		Seeds/capsules		Seed yield/plant (kg)		Yield kg/ha	
Varieties	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
TKG-22(NC)	5.29	5.65	56.52	58.59	44.37	46.61	6.07	6.17	717.80	741.86
GT-10	4.58	5.05	55.43	56.76	42.62	45.71	5.55	5.71	693.38	757.57
PKVNT-11	4.65	4.77	48.8	50.79	40.88	42.85	5.66	6.06	616.69	664.19
PRACHI	5.69	5.99	6.59	61.48	48.48	50.23	6.76	6.91	709.57	762.87
HT-2	3.36	3.69	48.80	51.13	39.57	41.33	5.06	5.19	553.19	620.71
DSS-9	3.65	3.88	45.18	45.67	39.55	39.52	5.50	5.60	602.33	596.86
TMV-7	5.49	5.90	57.81	59.04	48.19	50.38	6.17	6.67	692.67	707.77
SEm±	0.40	0.45	2.76	3.01	0.83	1.05	0.30	0.25	15.90	15.90
CD (5%)	1.21	1.40	8.22	9.09	2.50	3.20	0.93	0.76	48.20	48.20
Agro environments										
Hissar	4.19	4.85	48.76	50.05	41.57	43.04	5.54	5.87	533.47	560.61
Raichur	4.46	4.77	49.45	51.66	41.66	43.02	5.67	5.74	617.76	630.28
Nagpur	4.59	4.88	52.96	54.43	42.45	45.09	5.63	5.90	585.23	650.59
Tikamgarh	5.59	6.15	60.28	53.09	47.85	50.81	6.32	6.73	791.59	845.85
Jabalpur	4.87	5.55	54.67	56.47	43.42	44.38	5.88	5.79	741.94	754.41
Dharwad	5.09	5.57	58.37	59.52	45.28	47.47	6.29	6.62	769.23	815.90
Bhubaneswar	3.67	4.09	47.57	49.1	41.14	42.81	5.37	5.62	546.57	592.09
Mean	4.65	5.15	53.15	54.76	43.35	45.25	5.81	6.05	655.11	692.81
SEm±	0.40	0.45	2.76	3.05	0.82	1.05	0.39	0.25	12.7	12.7
CD (5%)	1.21	1.40	8.22	9.09	2.50	3.20	0.93	0.76	38.5	38.7

Table-5 :

Treatment	Seed study							
	Test weight (g)		Seed length (mm)		Seed birth (mm)		Seed Thickness (mm)	
Varieties	2014	2015	2014	2015	2014	2015	2014	2015
TKG-22(NC)	3.45	3.59	2.82	2.81	1.75	1.474	0.91	0.91
GT-10	3.50	3.50	2.82	2.82	1.64	1.67	0.89	0.89
PKVNT-11	3.27	3.37	2.82	2.82	1.68	1.68	0.89	0.89
PRACHI	3.58	3.59	2.82	2.82	1.75	1.74	0.91	0.91
HT-2	2.99	3.02	2.69	2.69	1.63	1.62	0.89	0.89
DSS-9	2.95	2.97	2.69	2.69	1.62	1.62	0.89	0.89
TMV-7	3.69	3.73	2.82	2.82	1.74	1.74	0.91	0.91
Mean	3.35	3.39	2.78	2.78	1.68	1.65	0.89	0.89
SEm±	0.09	0.06	0.012	0.017	0.012	0.017	0.04	0.03
CD (5%)	0.29	0.20	0.034	0.047	0.036	0.048	NS	NS
Agro environments								
Hissar	3.37	3.39	2.77	2.77	1.71	1.69	0.89	0.89
Raichur	3.39	3.38	2.79	2.89	1.69	1.67	0.90	0.90
Nagpur	3.37	3.39	2.79	2.81	1.70	1.70	0.90	0.90
Tikamgarh	3.37	3.47	2.80	2.89	1.70	1.71	0.90	0.90
Jabalpur	3.38	3.89	2.79	2.82	1.68	1.70	0.90	0.90
Dharwad	3.36	3.38	2.76	2.79	1.66	1.65	0.90	0.90
Bhubaneswar	3.34	3.37	2.70	2.71	1.68	1.69	0.89	0.89
Mean	3.36	3.46	2.76	2.81	1.68	1.68	0.89	0.89
SEm±	0.09	0.06	0.012	0.017	0.012	0.17	0.04	0.03
CD (5%)	NS	NS	0.034	0.047	0.036	0.48	0.12	0.10

showed equal performance except Dharwad in these traits.

References

1. Dixit J.P., Rao, R.S., Ambabatiya G.R. and Khan R.A. (1997). Productivity of sesame cultivars sown as semi-rabi under various plant densities and nitrogen levels. *Journal of Crop Research*, 13 (1): 27-31
2. Ghungarde S.R., Chavan D.A., Alse U.N., Yeagaonkar G.V. and Pangarkar V.N. (1992). Effect of plant density and variety on yield of sesame (*Sesamum indicum* L.). *Indian Journal of Agronomy*, 37(2): 385-386.
3. Raghuwanshi, JMS and Duhoon SS (2005) Genetic diversity and adaptability in grelian germplasm collection of (*Sesamum indicum* L.) *Journal of oilseeds Research* 22(1): 29-36.
4. Sogut T. (2008) effect of main and second cropping on seed yield oil and protein content of Sesame indicum L) genotypes, *Turkish J Field crops* 14 (2) : 64-71.
5. Weiss EA (2000) oilseed crops. Second Edition Black well Science, Oxford.



Effect of Foliar Application of Plant Growth Regulators on Growth and Yield Attributes of Linseed (*Linum usitatissimum* L.)

Harshit Kumar, Dhananjai Singh, V.K. Verma, Ram Pyare, Arvind Kumar Singh, Mandeep Kumar and Jaykar Singh

Department of Agronomy, C.S.A. University of Agriculture and Technology, Kanpur -208002 (U.P.) India

*Corresponding Author Email : harshit.kumar.csa.9531@gmail.com

Abstract

A field experiment entitled "Effect of foliar application of plant growth regulators in enhancing productivity and profitability of Linseed (*Linum usitatissimum* L.)" was conducted during *rabi* season of 2019-2020 at Oilseed Research Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experiment was carried out in Randomized Block Design with three replications with an object to observe the effect of PGRs on linseed growth and yield attributes. The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. The climate of the region is sub-tropical having semi-arid climate. The treatment comprised four different plant growth regulators of varied concentration and combination applied at vegetative and reproductive stage of linseed, the treatments were auxin @ 1.0 ppm, auxin @ 2.0 ppm, GA₃ @ 200 ppm, GA₃ @ 400 ppm, salicylic acid @ 75 ppm, tebuconazole @ 1000 ppm, auxin 1.0 ppm + GA₃ @ 200 ppm and control (water spray). Linseed variety "SHEKHAR" was sown as a test crop with a seed rate of 30 kg ha⁻¹ and row spacing of 25 cm. Among various treatments plant population and plant height were recorded maximum under application of tebuconazole @ 1000 ppm and minimum were recorded under control. No. of primary branches plant⁻¹ recorded maximum under application of GA₃ @ 400 ppm (4.04) and minimum were recorded under control (3.22). No. of secondary branches plant⁻¹ recorded maximum under application of auxin @ 1.0 ppm + GA₃ @ 200 ppm (20.16) and minimum were recorded under control (16.67). Dry matter plant⁻¹ recorded maximum under application of tebuconazole @ 1000 ppm (11.74 gm) and minimum were recorded under control (9.2 gm). Leaf area plant⁻¹ recorded maximum under application of tebuconazole @ 1000 ppm (28.74 cm²) and minimum were recorded under control (21.65 cm²). Leaf area index was recorded maximum under application of auxin @ 1.0 ppm + GA₃ @ 200 ppm (0.48) and minimum were recorded under control (0.33). On yield attributes no. of capsules plant⁻¹ (60.25), no of seed capsules⁻¹ (9.73) and 1000-seed weight (8.82 g) were recorded maximum under application of auxin @ 1.0 ppm + GA₃ @ 200 ppm and minimum values of above attributes were observed under water sprayed or control.

Key words : Plant growth regulators, growth attributes and yield attributes.

Introduction

Linseed or flax belongs to the family Linaceae. The generic name "Linum" comes from Celtic word *lin* means 'thread' and the species name "usitatissimum" given by Carl Linnaeus, means very useful. Linseed is popularly known as Alsi. Linseed is an erect annual herbaceous plant. Linseed seed contain 35-45% oil rich in unsaturated fatty acids (linolenic acid), 20-25% protein and vitamins. linseed oil used by industries for the manufacture of paints, varnish, oilcloth, linoleum and printing ink etc. Linseed fiber is used in making high quality writing paper, cigarette paper, currency paper. India's ranks 4th in terms of total area coverage and 3rd in total production followed by Canada and Russia (Annual Report, AICRP on linseed, 2019-20). The total area of linseed in Uttar Pradesh is 26 thousand hectares, production is 15.34 thousand tone and productivity is 590 kg ha⁻¹ (Annual report 2019-20). Plant growth regulators (PGRs) are organic substance produced naturally by plant to regulate their growth and development at very low concentration. It is produced by

plant itself but production of plant growth regulator is affected by biotic and abiotic factor, which cause constraint in the growth and development of plant through physiological process (Copur *et al.*, 2010). Plant growth regulators can be successfully working to enhance the yield in the economically important oil seed crops (Rastogi *et al.*, 2013).

Materials and Methods

A field experiment was conducted at the Oilseed Research Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP), India, during *rabi* seasons of 2019-20. The experiment comprising of eight treatments was laid out in a Randomized Block Design with three replications. The treatments were auxin @ 1.0 ppm (T₁), auxin @ 2.0 ppm (T₂), GA₃ @ 200 ppm (T₃), GA₃ @ 400 ppm (T₄), salicylic acid @ 75 ppm (T₅), tebuconazole @ 1000 ppm (T₆), auxin 1.0 ppm + GA₃ @ 200 ppm (T₇) and water spray (T₈). The linseed variety "Shekhar" was sown as a test crop with a seed rate of 30 kg ha⁻¹ and row spacing of 25 cm. The soil of experimental

Table-1 : Effect of different plant growth regulators on growth attributes of linseed.

Treatments	Plant Population (000 ha ⁻¹)	Plant height (cm)	No. of primary branches Plant ⁻¹	No. of Secondary Branches Plant ⁻¹	Dry matter Plant ⁻¹ (gm)	Leaf area Plant ⁻¹ (cm ²)	Leaf area index
1. Auxin @ 1.0 ppm	602.58	52.81	3.56	17.36	10.11	24.53	0.37
2. Auxin @ 2.0 ppm	605.47	53.77	3.68	17.55	10.37	25.80	0.43
3. GA ₃ @ 200 ppm	607.84	55.12	3.87	18.49	11.19	21.85	0.34
4. GA ₃ @ 400 ppm	606.15	59.95	4.06	18.36	11.17	22.83	0.34
5. Salicylic acid @ 75 ppm	608.01	59.98	3.66	17.60	10.43	27.54	0.45
6. Tebuconazole @ 1000 ppm	612.25	62.67	3.32	18.44	11.74	28.74	0.41
7. Auxin + GA ₃ @ 1.0 ppm + 200 ppm	609.93	60.68	3.40	20.16	11.54	22.60	0.48
8. Control @ water spray	589.93	49.28	3.22	16.67	9.2	21.65	0.33
SE(d) +	0.97	0.60	0.44	0.24	0.05	0.62	0.01
CD (P=0.05)	2.09	1.30	0.95	0.51	0.11	1.34	0.03

Table-2 : Effect of different plant growth regulators on yield attributes of linseed.

Treatments	No. of Capsules Plant ⁻¹	No. of Seeds Capsule ⁻¹	1000-seed weight (g)
Auxin @ 1.0 ppm	51.92	7.45	7.38
Auxin @ 2.0 ppm	52.66	7.59	7.86
GA ₃ @ 200 ppm	55.49	8.59	8.03
GA ₃ @ 400 ppm	56.62	8.00	8.11
Salicylic acid @ 75 ppm	53.73	8.05	7.81
Tebuconazole @ 1000 ppm	57.52	9.05	8.39
Auxin + GA ₃ @ 1.0 ppm + 200 ppm	60.25	9.73	8.82
Control @ water spray	47.60	6.96	7.09
SE(d) +	0.52	0.12	0.07
CD (P=0.05)	1.12	0.27	0.16

field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. Data recorded in respect of yield and attributes were analysed.

Results and Discussion

Effect of Foliar application of plant growth regulators on growth attributes of linseed : The data in table-1 revealed that the higher plant population of linseed were recorded maximum under the foliar application of Tebuconazole @ 1000 ppm. The minimum plant population were recorded in control. An observation of plant height application of Tebuconazole @ 1000 ppm recorded maximum plant height (62.67 cm) and minimum were recorded under control (49.28). PGRs foliar application of GA₃ @ 400 ppm was recorded higher number of primary branches plant⁻¹ (4.06) and minimum were recorded under control (3.22). While in case of secondary branches maximum were found under application of auxin @ 1 ppm + GA₃ @ 200 ppm (20.16) and minimum were under control (16.67). The highest dry matter was accumulated under foliar application of tebuconazole @ 1000 ppm (11.74 g plant⁻¹) and minimum were under control (9.2 g plant⁻¹). Among all

PGRs tebuconazole @ 1000 ppm produced the highest leaf area (28.74 cm²) and minimum were under control (21.65 cm²). Maximum leaf area index was obtained with the application of Auxin @ 1 ppm + GA₃ @ 200 ppm (0.48) and minimum under control (0.33).

Effect of different plant growth regulators on yield attributes of linseed : The data in Table-2 revealed that among various treatment auxin @ 1 ppm + GA₃ @ 200 ppm produced the highest capsule plant⁻¹ (60.25) and minimum under control (47.60). Number of seeds capsule⁻¹ (9.73) were recorded maximum under application of auxin @ 1 ppm + GA₃ @ 200 ppm and minimum under control (6.96). Maximum 1000-seed weight were recorded under treatment of auxin @ 1 ppm + GA₃ @ 200 ppm (8.82) and minimum under control (7.09).

References

1. Annual Progress Report (2019-2020). Linseed. All India Coordinated Research Project on Linseed.
2. Black, C.A. 1965. Methods of Soil Analysis, part II. *American Society of Agronomy*, Madison, Wisconsin.
3. Bouyoucos, G.J. 1936. Direction for mechanical analysis of soil by hydrometer method. *Journal of Soil Science*, 42: 225-228.

4. Ghosh, R.K., Mandal. B.K. and Chatterjee, B.N. 1991. Effect of growth regulators on the productivity of some major oilseed crops. *Journal of Agronomy and Crop Science*, 167 (4): 221-228.
5. Jadhav, S.H., Bhambudekar. S.B. and Patil, D.B. 2013. Effect of salicylic acid on fatty acid composition of groundnut seeds. National conference of plant physiology on current trend in plant biology research, P 4-2.
6. Khatun, S., Roy, T.S., Haque, M.N. and Alamgir, B. 2016. Effect of plant growth regulators and their time of application on yield attributes and quality of soybean. *International Journal of Plant and Soil Science*, 11: 1-9.
7. Piper, C.S. 1966. Soil and Plant Analysis. Hans Publishers, Bombay. Raipur p.230.
8. Solanke, A.P., Pawar, G.S., Dhadge, S.R. and Kamble, B.G. 2018. Effect of plant growth regulators on growth and yield of soybean (*Glycine max.* (L.) Merrill.) applied at different stages. *International Journal of Chemical Studies*, 6(5): 2962-2966.
9. Upadhyay, R.G. and Rajeev, R. 2015. Effect of growth hormones on morphological parameter, yield and quality of soybean. *International Journal of Tropical Apiculture*, 33(2).
10. Walkley, A.J. and Black, I.A. 1934. Estimation of organic carbon by chromic acid titration method. *Soil Science*, 37: 29-38.



Effect of Foliar Application of Plant Growth Regulators on Oil Content, Yield and Economics of Linseed (*Linum usitatissimum* L.)

Harshit Kumar, Dhananjai Singh, V.K. Verma, Ram Pyare, Arvind Kumar Singh, Mandeep Kumar and Jaykar Singh

Department of Agronomy, C.S.A. University of Agriculture and Technology, Kanpur -208002 (U.P.) India

*Corresponding Author Email : harshit.kumar.csa.9531@gmail.com

Abstract

A field experiment entitled "Effect of foliar application of plant growth regulators in enhancing productivity and profitability of Linseed (*Linum usitatissimum* L.)" was conducted during *rabi* season of 2019-2020 at Oilseed Research Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experiment was carried out in Randomized Block Design with three replications with an object to observe the effect of PGRs on linseed growth and yield attributes. The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. The climate of the region is sub-tropical having semi-arid climate. The treatment comprised four different plant growth regulators of varied concentration and combination applied at vegetative and reproductive stage of linseed. The treatments were auxin @ 1.0 ppm, auxin @ 2.0 ppm, GA₃ @ 200 ppm, GA₃ @ 400 ppm, salicylic acid @ 75 ppm, tebuconazole @ 1000 ppm, auxin 1.0 ppm + GA₃ @ 200 ppm and control (water spray). Linseed variety "SHEKHAR" was sown as a test crop with a seed rate of 30 kg ha⁻¹ and row spacing of 25 cm. Among various plant growth regulators, the application of GA₃ @ 400 ppm gave significantly the highest oil content (37.14%). Control @ water spray recorded the lowest oil content (35.03%). Maximum linseed oil yield (539.79 kg ha⁻¹) was recorded using auxin @ 1.0 ppm + GA₃ @ 200 ppm while minimum was recorded in control (432.27 kg ha⁻¹). Maximum seed yield (14.99 q ha⁻¹), stover yield (31.64 q ha⁻¹), biological yield (46.63 q ha⁻¹) and harvest index (32.14 %) were recorded maximum under the application of auxin @ 1.0 ppm + GA₃ @ 200 ppm. In economic terms, the highest gross returns (Rs. 67555 ha⁻¹) was reported under the application of auxin @ 1.0 ppm + GA₃ @ 200 ppm. While the maximum net return (Rs. 45963 ha⁻¹) obtained from application of auxin @ 1.0 ppm + GA₃ @ 200 ppm. However, B:C ratio of auxin @ 1.0 ppm + GA₃ @ 200 ppm was the highest (3.14).

Key words : Plant growth regulators, oil content, seed yield and economics.

Introduction

Linseed or flax belongs to the family Linaceae. The generic name "Linum" comes from Celtic word *lin* means 'thread' and the species name "*usitatissimum*" given by Carl Linnaeus, means very useful. Linseed is popularly known as Alsi. Linseed is an erect annual herbaceous plant. Linseed seed contain 35-45% oil rich in unsaturated fatty acids (-linolenic acid), 20-25% protein and vitamins. linseed oil used by industries for the manufacture of paints, varnish, oilcloth, linoleum and printing ink etc. Linseed fiber is used in making high quality writing paper, cigarette paper, currency paper. India's ranks 4th in terms of total area coverage and 3rd in total production followed by Canada and Russia (Annual Report, AICRP on linseed, 2019-20). The total area of linseed in Uttar Pradesh is 26 thousand hectares, production is 15.34 thousand tone and productivity is 590 kg ha⁻¹ (Annual report 2019-20). Plant growth regulators (PGRs) are organic substance produced naturally by plant to regulate their growth and development at very low concentration. It is produced by plant itself but production of plant growth regulator is affected by biotic and abiotic factor, which cause

constraint in the growth and development of plant through physiological process (Copur *et al.*, 2010). Plant growth regulators can be successfully working to enhance the yield in the economically important oil seed crops (Rastogi *et al.*, 2013).

Materials and Methods

A field experiment was conducted at the Oilseed Research Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP), India, during *rabi* season of 2019-20. The experiment comprising of eight treatments was laid out in a Randomized Block Design with three replications. The treatments were auxin @ 1.0 ppm (T₁), auxin @ 2.0 ppm (T₂), GA₃ @ 200 ppm (T₃), GA₃ @ 400 ppm (T₄), salicylic acid @ 75 ppm (T₅), tebuconazole @ 1000 ppm (T₆), auxin 1.0 ppm + GA₃ @ 200 ppm (T₇) and water spray (T₈). The linseed variety "Shekhar" was sown as a test crop with a seed rate of 30 kg ha⁻¹ and row spacing of 25 cm. The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. Data recorded in respect of yield and attributes were analysed.

Table-1: Effect of different plant growth regulators on oil content and yield of linseed.

Treatments	Oil content (%)	Oil yield (Kg ha ⁻¹)	Seed yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index %
Auxin @ 1.0 ppm	36.01	465.60	12.93	28.78	41.71	30.99
Auxin @ 2.0 ppm	36.00	470.16	13.06	29.13	42.19	30.95
GA ₃ @ 200 ppm	35.97	486.31	13.52	30.14	43.66	30.96
GA ₃ @ 400 ppm	37.14	487.28	13.12	29.34	42.46	30.89
Salicylic acid @ 75 ppm	36.89	474.26	13.04	29.20	42.24	30.87
Tebuconazole @ 1000 ppm	36.37	490.63	13.49	30.61	44.10	30.58
Auxin + GA ₃ @ 1.0 ppm + 200 ppm	36.01	539.79	14.99	31.64	46.63	32.14
Control @ water spray	35.03	432.27	12.34	26.76	39.10	31.56
SE(d) +	0.16	0.60	0.07	0.20	0.20	0.21
CD (P=0.05)	0.35	1.28	0.17	0.43	0.43	0.45

Table-2 : Effect of plant growth regulators on Economics and B:C ratio of linseed.

Treatments	Cost of Cultivation (Rs ha ⁻¹)	Gross Return (Rs ha ⁻¹)	Net Return (Rs. ha ⁻¹)	B:C Ratio
Auxin @ 1.0 ppm	20832	58185	37353	2.79
Auxin @ 2.0 ppm	20881	58770	37889	2.81
GA ₃ @ 200 ppm	21443	60840	39397	2.84
GA ₃ @ 400 ppm	22103	59040	36937	2.67
Salicylic acid @ 75 ppm	20993	58680	37687	2.80
Tebuconazole @ 1000 ppm	31583	60705	29122	1.92
Auxin + GA ₃ @ 1.0 ppm + 200 ppm	21492	67455	45963	3.14
Control @ water spray	20783	55530	34747	2.67

Results and Discussion

Effect of foliar application of plant growth regulators on oil content and yield of linseed :

The data in table-1 revealed that among various plant regulators, the application of GA₃ @ 400 ppm gave significantly the highest oil content (37.14 %). Maximum linseed oil yield (539.79 kg ha⁻¹) was recorded using auxin @ 1 ppm + GA₃ @ 200 ppm while minimum was recorded in control (432.27 kg ha⁻¹). It is clear from that among application of various PGRs, foliar application of auxin @ 1 ppm + GA₃ @ 200 ppm recorded maximum seed yield (14.99 q ha⁻¹) where as minimum was recorded in control (12.34 q ha⁻¹). Maximum stover yield was recorded under application of auxin @ 1 ppm + GA₃ @ 200 ppm (31.64 q ha⁻¹) and minimum was recorded with treatment control (26.76 q ha⁻¹). Maximum biological yield was recorded under application of auxin @ 1 ppm + GA₃ @ 200 ppm (46.63 q ha⁻¹) and minimum was recorded in control (39.56 q ha⁻¹). Maximum harvest index (32.14 %) was recorded under application of of auxin @ 1 ppm + GA₃ @ 200 ppm and minimum was recorded under application of tebuconazole @ 1000 ppm (30.58 %).

Economics : It is clear from the table-2 that the foliar application of tebuconazole @ 1000 ppm recorded the highest cost of cultivation (Rs. 31583 ha⁻¹) and lowest

was noted under application of water spray (Rs. 20783 ha⁻¹). In gross return, maximum was noted under application of auxin @ 1 ppm + GA₃ @ 200 ppm (Rs. 67455 ha⁻¹) and lowest was noted under application of water spray (Rs. 55530 ha⁻¹). Highest net return was noted under application of auxin @ 1 ppm + GA₃ @ 200 ppm (Rs. 45963 ha⁻¹) and lowest was noted under application of tebuconazole @ 1000 ppm (Rs. 29122 ha⁻¹). Maximum B: C ratio (3.14) was obtained under application of auxin @ 1 ppm + GA₃ @ 200 ppm and lowest was noted under application of tebuconazole @ 1000 ppm (1.92).

References

1. Anitha, R., N, Sriharan., Vanangamudi, M. and Jeyakumar, P. 2007. Effect of certain plant growth regulators on growth and yield of sunflower. *Plant Archives*, 7: 309-312.
2. Annual Progress Report (2016-17). Linseed. All India Coordinated Research Project on Linseed.
3. Bouyoucos, G.J. 1936. Direction for mechanical analysis of soil by hydrometer method. *Journal of Soil Science*, 42: 225-228.
4. Garai, A.K., Jana, P.K and Mandal, B.B. 1990. Effect of growth regulators on yield attributes, yield and oil content of oilseeds mustard and sesame. *Indian Agriculturist*, 34 (3): 145-150.
5. Ghosh, R.K., Mandal. B.K. and Chatterjee, B.N. 1991. Effect of growth regulators on the productivity of some major

- oilseed crops. Journal of Agronomy and Crop Science, 167 (4): 221-228.
6. Kalarani, M.K., Thangaraj, M., Siva, K.R. and Mallika, V. 2002. Effect of salicylic acid on tomato (*Lycopersicon esculentum*) productivity. Crop Research, 23: 486-492.
 7. Kothule, V.G., Bhalerao, R.EL and Sathe, B.V. 2003. Effect of exogenous application of growth regulators on growth, biomass and yield in soybean. *Annual of Plant Physiology*, 17(1): 95-99.
 8. Nazim Pasha, M. 2016. Physiological effect of salicylic acid on pod setting and yield of groundnut (*Arachis hypogaea* L.). M.Sc. Thesis, Acharya N.G. Ranga Agricultural University, AP: p146.
 9. Singh, M., Kumawat, N., Tomar, I., Dudwe, T., Yadav, R. and Sahu, Y. 2018. Effect of gibberellic acid on growth, yield and economics of maize (*Zea mays* L.). Journal of Agri Search, 5(1): 25-29.
 10. Subbaiah, B.V. and Asija, C.L. 1956. A rapid procedure estimation of available nitrogen in soil. Current Science, 25: 259-260.



Assessment of Weed Management Practices on Seed Yield and Economics of Irrigated Linseed (*Linum usitatissimum* L.)

Jaykar Singh, Dhananjai Singh, Ram Pyare, V.K. Verma, Arvind Kumar Singh, Ashish Kumar Yadav, Harshit Kumar

Department of Agronomy, C.S.A. University of Agriculture and Technology, Kanpur- 208 002

Email : jaykar6697@gmail.com

Abstract

A field experiment was conducted during *Rabi* 2019-20 at Oilseed Research Farm, Kalyanpur, Kanpur of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208002 (U.P.). In order to study the effect of weed management practices on weed density, dry weight and yield of irrigated linseed (*Linum usitatissimum* L.). The soil of experimental site was sandy loam in texture, low in organic carbon, available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. The experiment was conducted in Randomized Block Design, 10 treatments with three replications. The treatments comprised of weedy check, hand weeding twice at 25 and 45 DAS, metribuzin 75% @ 250 g a.i. ha⁻¹ + oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹, pendimethalin 30 EC @ 1 kg a.i. ha⁻¹, oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹, oxadiargyl 80 WP @ 80 g a.i. ha⁻¹ as pre-emergence, imazethapyr 10 EC @ 75 g a.i. ha⁻¹, metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹, clodinafop 15 WP @ 60 g a.i. ha⁻¹, clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed. However, among the all treatments hand weeding twice at 25 and 45 DAS was found superior in terms of reducing weed density, weed dry matter and higher yield attributes and seed yield (1823kg ha⁻¹). It was followed by application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ applied at 2-3 leaf stage of weed and recorded highest net monetary return (Rs 50,840 ha⁻¹) and B:C ratio (2.64).

Key words : Weed management, seed yield and economics.

Introduction

Oilseed crop has been one of the most dynamic components of world agriculture. Linseed (*Linum usitatissimum* L.) is an important crop and is a member of Linaceae family commonly known as Alsí, chikna or linseed in India. Linseed plant is considered to be native to India, eastern Mediterranean region and gain significant importance because of nutritional content oil varies from 33-47%, protein 20-30%, dietary fiber 28%, moisture 7.7% and ash 3.4%.

India is one of the leading oilseeds growing country in the world. It is estimated that nine oilseeds, accounted for an area of 23.44 million hectares with the production of 35.3 million tones. Linseed oil is a rich source of linolenic acid (40-60%), an Omega-3 fatty acid which has anti-inflammatory action in the treatment of arthritis. "Omega eggs" from hens fed linseed are produced and sold in the U.S. and Canada for their high omega-3 fatty acid. Linseed has poor foliage and never forms a canopy; therefore it remains a poor weed competitor throughout its life. Because of slow initial growth and small sized leaves, the crop is highly infested by weeds causing 30-40% yield losses Pali *et al.*, (1997). The linseed plants characterised with small leaves and short, upright growth habit make linseed a good companion crop for establishing grass or legume stands but make it a poor competitor with weeds.

Owing to poor initial growth and small sized leaves, the crop of linseed is highly infested with weeds causing 30-40% loss in seed yield (Mahere *et al.*, (2000). Though, hand weeding is most common method of weed control but it involves more cost which reduces profit gain. Therefore, the use of herbicides may be a suitable alternative for managing the weeds for higher returns. To find out a suitable herbicide and their dose for linseed grown under irrigated conditions in order to harness yield potential of higher yielding cultivar is important issue. Keeping above facts in view, the present investigation was carried out to evaluate the efficacy of pre and post emergence herbicides on weed density, biomass and seed yield as well as economics of linseed under irrigated condition of Central Plain Zone of Uttar Pradesh.

Materials and Methods

The present investigation was conducted during *Rabi* 2019-20 at the Oilseed Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The experiment was conducted in Randomized Block Design consisting 10 treatments with three replications. The treatments comprised of weedy check, hand weeding twice at 25 and 45 DAS, metribuzin 75% @ 250 g a.i. ha⁻¹ + oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹ as pre-emergence, pendimethalin 30 EC @ 1 kg a.i. ha⁻¹ as pre-emergence, imazethapyr 10 EC @ 75 g a.i.

Table-1 : Effect of management practices on growth and yield of linseed.

S.N.	Treatments	Plant population (no. m ⁻²)	Plant height (cm)	No. of branches plant	No. of capsule plant ⁻¹	No. of seed capsule ⁻¹	Test weight (g)	Grain yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest Index (%)
1.	Weedy check	25.83	48.92	17.95	50.32	6.5	6.56	1165	4363	26.70
2.	Hand weeding twice at 25 and 45 DAS	37.79	65.04	29.37	59.23	8.32	8.11	1823	5290	34.46
3.	Metribuzin 75% @ 250 g a.i. ha ⁻¹ + Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	29.93	47.26	22.58	53.7	7.03	6.99	1433	4760	30.10
4.	Pendimethalin 30 EC @ 1 kg a.i. ha ⁻¹ as pre-emergence	35.81	62.18	28.45	58.31	8.07	7.97	1751	5186	33.76
5.	Imazethapyr 10 EC @ 75 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	33.95	59.26	27.63	56.18	7.84	7.5	1675	5098	32.85
6.	Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	32.72	54.32	25.91	55.33	7.69	7.27	1606	5009	31.18
7.	Metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	35.53	52.36	28.06	57.31	7.91	7.9	1690	5135	33.00
8.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30.31	49.13	23.41	54.17	7.32	7.18	1516	4912	30.86
9.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	36.04	64.11	29.08	58.86	8.23	8.03	1778	5235	33.96
10.	Oxadiargyl 80 WP @ 80 g a.i. ha ⁻¹ as pre-emergence	28.75	45.13	21.73	52.11	6.92	6.87	1419	4736	29.96
11.	SE(m) ±	0.844	1.431	0.657	1.430	0.195	0.192			
12.	C.D. at 5%	2.528	4.284	1.967	4.281	0.584	0.574			

ha⁻¹ at 2-3 leaf stage of weed, oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹ as pre-emergence, metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed, clodinafop 15 WP @ 60 g a.i. ha⁻¹ at 2-3 leaf stage of weed, clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed and oxadiargyl 80 WP @ 80 g a.i. ha⁻¹ as pre-emergence. The soil of experimental field was slightly alkaline in reaction, low in organic carbon (0.44%) available nitrogen (183.0 kg ha⁻¹), available phosphorus (16.5 kg ha⁻¹) and medium potassium in (256 kg ha⁻¹). The seeds of linseed variety 'Shekhar' was sown @ 25 kg ha⁻¹, in shallow furrow behind desi plough with the help of manual labour at a row to row spacing of 30 cm and plant to plant 10 cm. The number of weeds was counted and the data were presented m⁻². The original value of weed density has been transformed.

The gross return of a treatment was divided by cost of cultivation respective treatment and outcome obtained was recorded as B:C ratio for respective treatments.

$$\text{Benefit : Cost ratio} = \frac{\text{Gross monetary return (Rs / ha)}}{\text{Cost of cultivation (Rs / ha)}}$$

The efficient utilization of assimilation and CO₂ fixation i.e. photosynthesis is expressed in terms of harvest index. The harvest index was worked out with the help of following formula :

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (q / ha)}}{\text{Biological yield (q / ha)}}$$

Results and Discussion

Weed density, weed dry weight and Weed control efficiency : The experimental field infested with *Cynodon dactylon*, *Phalaris minor*, *Chenopodium album* L., *Melilotus indica* L., *Anagallis arvensis* L. and *Convolvulus arvensis* as dominant weeds. The data presented in (Table-1) showed that the total weed density, dry matter and weed control efficiency at 30, 60 and 90 DAS. It was significantly noticed that hand weeding was most effective treatment as it recorded less weed density 11.22, 10.64 and 12.30 m⁻² at 30, 60 and 90 DAS followed by clodinafop + metsulfuron-methyl 17.65, 18.37 and 22.48 m⁻². The maximum weed density 44.6, 51.14 and 59.49 m⁻² was observed with the weedy check treatment alone at 30, 60 and 90 DAS. However, all the treatments were significantly superior to weedy check in reducing the weed density and weed dry matter of weeds. Data revealed that hand weeding was most effective treatment as it recorded significantly minimum weed dry matter 1.73, 3.76 and 5.63 g m⁻² at 30, 60 and 90 DAS followed by Clodinafop + metsulfuron-methyl 10.09, 17.60 and 19.42 g m⁻². The weedy check plot recorded maximum weed dry matter 32.15, 61.83 and 71.56 g m⁻² at 30, 60 and 90 DAS. However, all the treatments were significantly superior to weedy check in reducing the dry matter of total weeds. The

Table-2 : Effect of weed management practices on economics.

S.N.	Treatments	Total cost (Rs ha ⁻¹)	Gross monetary return (Rs ha ⁻¹)	Net monetary return (Rs ha ⁻¹)	B:C
1.	Weedy check	28,963	53,590	24,627	1.85
2.	Hand weeding twice at 25 and 45 DAS	41,023	83,858	42,835	2.04
3.	Metribuzin 75% @ 250 g a.i. ha ⁻¹ + Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	31,298	65,918	34,620	2.10
4.	Pendimethalin 30 EC @ 1 kg a.i. ha ⁻¹ as pre-emergence	31,365	80,546	49,181	2.56
5.	Imazethapyr 10EC @ 75 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30,565	77,050	46,485	2.52
6.	Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre emergence	30,668	73,876	43,208	2.40
7.	Metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30,615	77,740	47,125	2.53
8.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30,698	69,736	39,038	2.27
9.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30,948	81,788	50,840	2.64
10.	Oxadiargyl 80 WP @ 80 g a.i. ha ⁻¹ as pre-emergence	29,740	65,274	35,534	2.19

maximum weed control efficiency 82.35% was recorded with hand weeding twice at 25 and 45 DAS followed by the application of Clodinafop + metsulfuron- methyl 72.86%. This result confirms the finding of Singh *et al.*, (2019).

Growth attributes of linseed : The result of the present study indicated that growth parameters of the linseed plant such as plant height, number of branches per plant of linseed crop were significantly influenced by different herbicides (Table 2). Among the all herbicidal treatments, application of Clodinafop + metsulfuron- methyl recorded maximum plant height, number of branches per plant was at par to pendimethalin 30 EC @ 1 kg a.i. ha⁻¹ at 30, 60 and 90 DAS. The reason for higher values of growth had comparatively less weed competition for nutrient and moisture, and thereby more availability of nutrients than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. Weedy check plots produced significantly minimum plant height, number of branches per plant and dry matter accumulation of linseed. This result confirms the finding of Hussein *et al.*, (2002) and Mishra *et al.*, (2005).

Yield attributes of linseed : Yield attributes viz. number of capsules per plant, number of seed per capsule and test weight (g) was significantly influenced by weed control treatments (Table-2). All the herbicidal treatments significantly influenced the yield attributes as compared to weedy check. Critical appraisal of data revealed that maximum number of capsules per plant, number of seed per capsule and test weight was recorded with hand weeding twice at 25 and 45 DAS at 90 DAS which was at par the application of clodinafop + metsulfuron-methyl. The reason for higher values of growth parameter had comparatively less weed competition for nutrient and moisture, and thereby more availability of nutrients than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. Weedy check

plots produced significantly minimum number of capsules per plant, number of seed per capsule and test weight. As a result, these conditions enabled the crop to make maximum use of inputs for the crop growth, and thereby for the formation and development of yield attributes. Similar findings were supported by Kalal *et al.*, (2019), Punia *et al.*, (2005) and Singh *et al.*, (2001)

Seed yield of linseed : Yield is the result of co-ordinate interplay of various growth characters like number of capsules per plant, number of seed per capsule and test weight (Table-2). Seed and stover yield were significantly influenced by different weed control treatments. An appraisal of data revealed that the hand weeding recorded maximum seed (1823 kg ha⁻¹) and stover yield (3467 kg ha⁻¹) and statistically at par with application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ seed (1778 kg ha⁻¹) and stover yield (3457 kg ha⁻¹). Minimum yield was recorded in weedy check plot which was attributed due to more weed growth, total weed dry weight and poor yield attributing characters. These results were finding out by Mahere *et al.*, (2000), Marwat *et al.*, (2005), Meena *et al.*, (2011) and Puhup *et al.*, (2017).

Economics : Data presented in (Table-2) exhibit that cost of cultivation was recorded maximum and minimum with hand weeding twice at 25 and 45 DAS (Rs 41,023 ha⁻¹) and weedy check (Rs 28,963 ha⁻¹). The maximum and minimum gross monetary return (Rs 83,858 ha⁻¹) was recorded in hand weeding plot and with weedy check (Rs 53,990 ha⁻¹). Among the herbicides application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ was recorded maximum gross income (Rs 81,788 ha⁻¹). The maximum and minimum net return was recorded with the application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ (Rs 50,840 ha⁻¹) was closely followed by the application

of pendimethalin (Rs 49,141 ha⁻¹). The minimum net return (Rs 28,963 ha⁻¹) was recorded in weedy check plot. B:C Ratio among the all weed management practices maximum B:C ratio (2.64) was observed with the application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ which was closely followed by the application of Pendimethalin (2.56). The minimum B:C ratio was found under weedy check plot (1.85).

Conclusion

On the basis of results summarized it is concluded that the application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed was the most effective herbicide under irrigated linseed for achieving maximum seed yield and net monetary returns under agro-climatic condition of Kanpur, (U.P.).

References

1. Hussein, H.F., El-Hariri, D.M. and Hassanein, M. S. (2002). Response of some flax (*Linum usitatissimum* L.) cultivars associated weeds to weed treatments. *Egyptian J. Agronomy*. 24, 23-42.
2. Kalal, P.H., Desai, L.J., Mitra, S. and Chaudhari, D.I. (2019). Effect of Integrated Weed Management on Growth, Yield, Yield Attributes and Economics of Linseed (*Linum usitatissimum* L.) under South Gujarat Condition *Int.J.Curr.Microbiol.App.Sci* (2019) 8(7): 1265-1271.
3. Khare, J. P., Dubey, M. P., Khare, A. and Kurmvanshi, S. M. (1996). Effect of weed management in linseed. *World Weeds*. 3(3/4), 145-147.
4. Pali, G.P., Patel, S.P. and Tripathi, R.S. (1997). Integrated weed management in irrigated linseed (*Linum usitatissimum* L.). *Indian J. Agron*. 42(1), 177-180.
5. Puhup, C. S., Dwivedi, S.K. and Gupta, S.K. (2017). Effect of weed management practices on growth on weeds, yield and economics of linseed (*Linum usitatissimum* L.) *International Journal of Chemical Studies* 2018; 6(1): 1159-1161.
6. Reddiex, S.J., Wratten, S.J., Hill, Bourdoyt, S.J. and Frampton., S. J. (2001). Evaluation of mechanical weed management techniques on weed and crop population. *New Zealand Plant Protection*. 54,174-178.
7. Singh, D., Kumar, P., Verma, V.K., Pyare, R. and Verma, C.B. (2019). Effect of weed management practices on weed density and yield of linseed (*Linum usitatissimum* L.). *IJCS* 2019; 7(5): 165-167.



Effect of Weed Management Practices on Weed Density, Weed Dry Weight and Yield of Irrigated Linseed (*Linum usitatissimum* L.)

Jaykar Singh, Dhananjai Singh, Ram Pyare, V.K. Verma, Arvind Kumar Singh, Ashish Kumar Yadav, Harshit Kumar

Department of Agronomy, C.S. A. University of Agriculture and Technology, Kanpur-208 002

Email : jaykar6697@gmail.com

Abstract

A field experiment was conducted during *Rabi* 2019-20 at Oilseed Research Farm, Kalyanpur, Kanpur of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208002 (U.P.). In order to study the effect of weed management practices on weed density, dry weight and yield of irrigated linseed (*Linum usitatissimum* L.). The soil of experimental site was sandy loam in texture, low in organic carbon, available nitrogen, medium in available phosphorus and potash with slightly alkaline in reaction. The experiment was conducted in Randomized Block Design, 10 treatments with three replications. The treatments comprised of weedy check, hand weeding twice at 25 and 45 DAS, metribuzin 75% @ 250 g a.i. ha⁻¹ + oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹, pendimethalin 30 EC @ 1 kg a.i. ha⁻¹, oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹, oxadiargyl 80 WP @ 80 g a.i. ha⁻¹ as pre-emergence, imazethapyr 10 EC @ 75 g a.i. ha⁻¹, metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹, clodinafop 15 WP @ 60 g a.i. ha⁻¹, clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed. However, among the all treatments hand weeding twice at 25 and 45 DAS was found superior in terms of reducing weed density, weed dry matter and higher yield attributes and seed yield (1823kg ha⁻¹). It was followed by application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ applied at 2-3 leaf stage of weed and recorded highest net monetary return (Rs 50,840 ha⁻¹) and B:C ratio (2.64).

Key words : Weed density, weed dry weight, yield

Introduction

Oilseed crop has been one of the most dynamic components of world agriculture. Linseed (*Linum usitatissimum* L.) is an important crop and is a member of Linaceae family commonly known as Alsi, chikna or linseed in India. Linseed plant is considered to be native to India, eastern Mediterranean region and gain significant importance because of nutritional content oil varies from 33-47%, protein 20-30%, dietary fiber 28%, moisture 7.7% and ash 3.4%.

India is one of the leading oilseeds growing country in the world. It is estimated that nine oilseeds, accounted for an area of 23.44 million hectares with the production of 35.3 million tones. Linseed oil is a rich source of linolenic acid (40-60%), an Omega-3 fatty acid which has anti-inflammatory action in the treatment of arthritis. "Omega eggs" from hens fed linseed are produced and sold in the U.S. and Canada for their high omega-3 fatty acid. Linseed has poor foliage and never forms a canopy; therefore it remains a poor weed competitor throughout its life. Because of slow initial growth and small sized leaves, the crop is highly infested by weeds causing 30-40% yield losses Pali *et al.*, (1997). The linseed plants characterised with small leaves and short, upright growth habit make linseed a good companion crop for establishing grass or

legume stands but make it a poor competitor with weeds. Owing to poor initial growth and small sized leaves, the crop of linseed is highly infested with weeds causing 30-40% loss in seed yield (Mahere *et al.*, (2000). Though, hand weeding is most common method of weed control but it involves more cost which reduces profit gain. Therefore, the use of herbicides may be a suitable alternative for managing the weeds for higher returns. To find out a suitable herbicide and their dose for linseed grown under irrigated conditions in order to harness yield potential of higher yielding cultivar is important issue. Keeping above facts in view, the present investigation was carried out to evaluate the efficacy of pre and post emergence herbicides on weed density, biomass and seed yield as well as economics of linseed under irrigated condition of Central Plain Zone of Uttar Pradesh.

Materials and Methods

The present investigation was conducted during *Rabi* 2019-20 at the Oilseed Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The experiment was conducted in Randomized Block Design consisting 10 treatments with three replications. The treatments comprised of weedy check, hand weeding twice at 25 and 45 DAS, metribuzin 75% @ 250 g a.i. ha⁻¹ + oxyfluorfen 23.5% @ 125 g a.i.

Table-1 : Effect of weed management practices on weed control efficiency, density (no. m⁻²), dry matter (g m⁻²) of total weeds and weed control efficiency at 30, 60 and 90 DAS.

S.N.	Treatments	Density (no. m ⁻²)			Dry matter (g. m ⁻²)			WCE (%)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1.	Weedy check	6.72 (44.69)	7.19 (51.14)	7.75 (59.49)	5.71 (32.15)	7.89 (61.83)	8.49 (71.56)			
2.	Hand weeding twice at 25 and 45 DAS	3.42 (11.22)	3.34 (10.64)	3.58 (12.30)	1.49 (1.73)	1.49 (3.76)	2.48 (12.63)	94.61	93.91	82.35
3.	Metribuzin 75% @ 250 g a.i. ha ⁻¹ + Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	5.58 (30.63)	6.30 (39.13)	6.65 (43.75)	4.00 (15.49)	5.97 (35.11)	6.81 (45.89)	51.81	43.21	35.87
4.	Pendimethalin 30 EC @ 1 kg a.i. ha ⁻¹ as pre-emergence	4.26 (17.66)	4.76 (22.16)	5.02 (24.73)	3.05 (8.83)	4.30 (18.00)	4.92 (23.74)	72.51	70.88	66.82
5.	Imazethapyr 10 EC @ 75 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	5.21 (26.67)	5.48 (29.57)	5.69 (31.91)	4.23 (17.42)	5.46 (29.30)	5.57 (30.57)	45.8	52.61	57.27
6.	Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre emergence	4.94 (23.87)	5.69 (31.82)	6.00 (35.56)	3.47 (11.51)	4.99 (24.40)	5.60 (30.90)	64.19	60.53	56.81
7.	Metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	4.92 (23.74)	4.96 (24.06)	5.37 (28.31)	3.77 (13.74)	5.02 (24.71)	5.39 (28.53)	57.26	60.03	60.13
8.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	5.02 (24.68)	5.96 (35.04)	6.32 (39.49)	4.10 (16.34)	5.56 (30.41)	5.87 (33.90)	49.16	50.81	52.62
9.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	4.26 (17.65)	4.34 (18.37)	4.79 (22.48)	3.25 (10.09)	4.25 (17.60)	4.46 (19.42)	68.59	71.53	72.86
10.	Oxadiargyl 80 WP @ 80 g a.i. ha ⁻¹ as pre-emergence	5.60 (30.81)	6.71 (44.53)	7.08 (49.65)	4.08 (16.13)	5.70 (32.04)	6.22 (38.13)	49.81	48.18	46.71
11.	SE(m) ±	0.128	0.142	0.151	0.097	0.134	0.147			
12.	C.D. at 5%	0.383	0.425	0.452	0.289	0.402	0.440			

$\sqrt{x}$ 0.5 Transformation. Value in parenthesis are original value.

ha⁻¹ as pre-emergence, pendimethalin 30 EC @ 1 kg a.i. ha⁻¹ as pre-emergence, imazethapyr 10 EC @ 75 g a.i. ha⁻¹ at 2-3 leaf stage of weed, oxyfluorfen 23.5% @ 125 g a.i. ha⁻¹ as pre-emergence, metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed, clodinafop 15 WP @ 60 g a.i. ha⁻¹ at 2-3 leaf stage of weed, clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ at 2-3 leaf stage of weed and oxadiargyl 80 WP @ 80 g a.i. ha⁻¹ as pre-emergence. The soil of experimental field was slightly alkaline in reaction, low in organic carbon (0.44%) available nitrogen (183.0 kg ha⁻¹), available phosphorus (16.5 kg ha⁻¹) and medium potassium in (256 kg ha⁻¹). The seeds of linseed variety 'Shekhar' was sown @ 25 kg ha⁻¹, in shallow furrow behind desi plough with the help of manual labour at a row to row spacing of 30 cm and plant to plant 10 cm. The number of weeds was counted and the data were presented m⁻². The original value of weed density has been transformed.

The weed control efficiency was calculated on the basis of reduction in dry matter production in treated plot in comparison with the under control plot and expressed in percentage.

$$WCE\% = \frac{DMC - DMT}{DMC} \times 100$$

Where,

WCE – Weed control efficiency (%).

DMC – Weight of dry matter of weeds in control plot.

DMT – Weight of dry matter of weeds in treated plot.

Results and Discussion

Weed density, weed dry weight and Weed control efficiency : The experimental field infested with *Cynodon dactylon*, *Phalaris minor*, *Chenopodium album* L., *Mellilotus indica* L., *Anagallis arvensis* L. and *Convolvulus arvensis* as dominant weeds. The data presented in (Table 1) showed that the total weed density, dry matter and weed control efficiency at 30, 60 and 90 DAS. It was significantly noticed that hand weeding was most effective treatment as it recorded less weed density 11.22, 10.64 and 12.30 m⁻² at 30, 60 and 90 DAS followed by clodinafop + metsulfuron-methyl 17.65, 18.37 and 22.48 m⁻². The maximum weed density 44.6, 51.14 and 59.49 m⁻² was observed with the weedy check treatment alone at 30, 60 and 90 DAS. However, all the treatments were significantly superior to weedy check in reducing the weed density and weed dry matter of weeds. Data revealed that hand weeding was most effective treatment as it recorded significantly minimum weed dry matter 1.73, 3.76 and 5.63 g m⁻² at 30, 60 and 90 DAS followed by Clodinafop + metsulfuron-methyl 10.09, 17.60 and 19.42 g m⁻². The weedy check plot recorded maximum weed dry matter

Table-2 : Effect of weed management practices on growth and yield of linseed.

S.N.	Treatment.	Plant population (no. m ⁻²)	Plant height (cm)	No. of branches plant ⁻¹	No. of capsule plant ⁻¹	No. of seed capsule ⁻¹	Test weight (g)	Grain yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest Index (%)	NMR (Rs. ha ⁻¹)	B:C Ratio
1.	Weedy check	25.83	48.92	17.95	50.32	6.5	6.56	1165	4363	26.70	24,627	1.85
2.	Hand weeding twice at 25 and 45 DAS	37.79	65.04	29.37	59.23	8.32	8.11	1823	5290	34.46	42,835	2.04
3.	Metribuzin 75% @ 250 g a.i. ha ⁻¹ + Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	29.93	47.26	22.58	53.70	7.03	6.99	1433	4760	30.10	34,620	2.10
4.	Pendimethalin 30 EC @ 1 kg a.i. ha ⁻¹ as pre-emergence.	35.81	62.18	28.45	58.31	8.07	7.97	1751	5186	33.76	49,181	2.56
5.	Imazethapyr 10 EC @ 75 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	33.95	59.26	27.63	56.18	7.84	7.5	1675	5098	32.85	46,485	2.52
6.	Oxyfluorfen 23.5% @ 125 g a.i. ha ⁻¹ as pre-emergence	32.72	54.32	25.91	55.33	7.69	7.27	1606	5009	31.18	43,208	2.40
7.	Metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	35.53	52.36	28.06	57.31	7.91	7.90	1690	5135	33.00	48,125	2.61
8.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	30.31	49.13	23.41	54.17	7.32	7.18	1516	4912	30.86	39,038	2.27
9.	Clodinafop 15 WP @ 60 g a.i. ha ⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha ⁻¹ at 2-3 leaf stage of weed	36.04	64.11	29.08	58.86	8.23	8.03	1778	5235	33.96	50,840	2.64
10.	Oxadiazyl 80 WP @ 80 g a.i. ha ⁻¹ as pre-emergence	28.75	45.13	21.73	52.11	6.92	6.87	1419	4736	29.96	35,534	2.19
11.	SE(m) ±	0.844	1.431	0.657	1.430	0.195	0.192					
12.	C.D. at 5%	2.528	4.284	1.967	4.281	0.584	0.574					

32.15, 61.83 and 71.56 g m⁻² at 30, 60 and 90 DAS. However, all the treatments were significantly superior to weedy check in reducing the dry matter of total weeds. The maximum weed control efficiency 82.35% was recorded with hand weeding twice at 25 and 45 DAS followed by the application of Clodinafop + metsulfuron-methyl 72.86%. This result confirms the finding of Singh *et al.*, (2019).

Growth attributes of linseed : The result of the present study indicated that growth parameters of the linseed plant such as plant height, number of branches per plant of linseed crop were significantly influenced by different herbicides (Table-2). Among the all herbicidal treatments, application of Clodinafop + metsulfuron-methyl recorded maximum plant height, number of branches per plant was at par to pendimethalin 30 EC @ 1 kg a.i ha⁻¹ at 30, 60 and 90 DAS. The reason for higher values of growth had comparatively less weed competition for nutrient and moisture, and thereby more availability of nutrients than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. Weedy check plots produced significantly minimum plant height, number of branches per plant and dry matter accumulation of linseed. This result confirms the finding of Hussein *et al.*, (2002) and Mishra *et al.*, (2005).

Yield attributes of linseed : Yield attributes viz. number of capsules per plant, number of seed per capsule and test weight (g) was significantly influenced by weed control treatments (Table-2). All the herbicidal treatments significantly influenced the yield attributes as compared to weedy check. Critical appraisal of data revealed that maximum number of capsules per plant, number of seed per capsule and test weight was recorded with hand weeding twice at 25 and 45 DAS at 90 DAS which was at par the application of clodinafop + metsulfuron-methyl. The reason for higher values of growth parameter had comparatively less weed competition for nutrient and moisture, and thereby more availability of nutrients than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. Weedy check plots produced significantly minimum number of capsules per plant, number of seed per capsule and test weight. As a result, these conditions enabled the crop to make maximum use of inputs for the crop growth, and thereby for the formation and development of yield attributes. Similar findings were supported by Kalal *et al.*, (2019), Punia *et al.*, (2005) and Singh *et al.*, (2001).

Seed yield of linseed : Yield is the result of co-ordinate interplay of various growth characters like number of capsules per plant, number of seed per capsule and test

weight (Table-2). Seed and stover yield were significantly influenced by different weed control treatments. An appraisal of data revealed that the hand weeding recorded maximum seed (1823 kg ha⁻¹) and stover yield (3467 kg ha⁻¹) and statistically at par with application of clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ seed (1778 kg ha⁻¹) and stover yield (3457 kg ha⁻¹). Minimum yield was recorded in weedy check plot which was attributed due to more weed growth, total weed dry weight and poor yield attributing characters. These results were finding out by Mahere *et al.*, (2000), Marwat *et al.*, (2005), Meena *et al.*, (2011) and Puhup *et al.*, (2017).

Economics : The gross return obtained by yield of crop varied markedly due to different treatments, which ultimately influenced the net return and B:C ratio. The treatment clodinafop 15 WP @ 60 g a.i. ha⁻¹ + metsulfuron-methyl 20 WP @ 4 g a.i. ha⁻¹ recorded the maximum net return (Rs 50,840 ha⁻¹) and B:C ratio (2.64). However, all the herbicides were more profitable than hand weeding. The lowest benefit cost ratio was obtained with weedy check (1.85).

Conclusion

On the basis of results summarized it is concluded that the application of Clodinafop + Metsulfuron-methyl at 2-3 leaf stage of weed was the most effective herbicide under irrigated linseed for achieving effective weed management as well as maximum seed yield and net returns under agro-climatic condition of Kanpur, (U.P.).

References

1. Hussein, H. F., El-Hariri, D. M. and Hassanein, M. S. (2002). Response of some flax (*Linum usitatissimum* L.) cultivars associated weeds to weed treatments. *Egyptian J. Agronomy*. 24, 23-42.
2. Kalal, P.H., Desai, L.J., Mitra, S. and Chaudhari, D.I. (2019) Effect of Integrated Weed Management on Growth, Yield, Yield Attributes and Economics of Linseed (*Linum usitatissimum* L.) under South Gujarat Condition *Int.J.Curr.Microbiol.App.Sci* (2019) 8(7): 1265-1271.
3. Mahere, J., Yadav, P.K., and Sharma, R.S. (2000). Chemical weed control in linseed with special reference to *Cuscuta*. *Indian J. Weed Sci.* 32(3 &4), 216-217.
4. Marwat, K. B., Khan, I. A., Khan, M. I. and Khan, Z. H. H. (2005). Herbicides evaluation for weed control in chickpea. *Pak. J. of Weed Science Research*. 11 (3/4), 147-150.
5. Meena, D.S., Ram, B., Jadon, C. and Tatarwal, J.P. (2011). Efficacy of imazethapyr on weed management in soybean. *Indian Journal of Weed Science* 43 (3&4), 169-171.
6. Pali, G. P., Patel, S. P. and Tripathi, R. S. (1997). Integrated weed management in irrigated linseed (*Linum usitatissimum* L.). *Indian J. Agron.* 42(1), 177-180.
7. Puhup, C. S., Dwivedi, S.K. and Gupta, S.K. (2017). Effect of weed management practices on growth on weeds, yield and economics of linseed (*Linum usitatissimum* L.) *International Journal of Chemical Studies* 2018; 6(1): 1159-1161.
8. Singh, D., Kumar, P., Verma, V.K., Pyare, R. and Verma, C.B. (2019) . Effect of weed management practices on weed density and yield of linseed (*Linum usitatissimum* L.). *IJCS* 2019; 7(5): 165-167.



Effect of Nitrogen Levels and its Application Methods in Late Sown Wheat (*Triticum aestivum* L.)

Rahul Yadav and Udham Singh Tiwana

School of Agricultural Science and Technology, RIMT University, Mandi Gobindgarh, Punjab, India.

Abstract

A field experiment was conducted during the rabi season of 2020-21 at Agricultural Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the effect of nitrogen levels and its application methods in late sown wheat (*Triticum aestivum* L.). The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments comprised of two application methods viz. nitrogen applied before irrigation and nitrogen applied after irrigation: and four nitrogen levels viz. control, 100, 125, 150% of recommended dose of nitrogen (RDN). All the growth and yield attributing characters significantly increased in nitrogen applied before irrigation over nitrogen applied after irrigation. The grain yield was significantly higher when nitrogen applied before irrigation (51.1 q/ha) over nitrogen applied after irrigation (42.5 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by application methods. The application of 150, 125 and 100% of recommended dose of nitrogen recorded significantly higher growth and yield attributes except ear length over control. The 150% of recommended dose of nitrogen recorded significantly higher grain yield (53.7 q/ha) over 100% (46.3 q/ha) and control (40.0 q/ha) but was par with 125% of recommended dose of nitrogen (43.3 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by nitrogen levels. Interaction between application methods and nitrogen levels was found non-significant in all the parameters.

Key Words : Nitrogen levels, application methods, growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) has the highest importance among all the crops grown for the grain purpose worldwide. In India wheat alone covers about 25% of the total area covered by cereal crops. Wheat flour mostly, used for making chapati and bread (Singh et al.2007).Wheat is major cereal crop in Punjab. Presently, in Punjab wheat crop occupies 35.20 lakh hectares during 2020-21 with the production of 176.2 lakh tones and average yield of 50.04 quintal per hectares (Anonymous, 2021). There were various factors involved in low production of wheat including application of nitrogen fertilizer in improper amount, edaphic properties, method of sowing, quality of irrigation water, prevailing climate condition and management of field operation by the farmer due to lack of knowledge and awareness. Nitrogen is main component and major constitute of plants for formation of living tissues. It is necessary to apply nitrogen fertilizer in the soil for bumper yield of wheat (Ullah et al. 2018).

Material and Methods

The experiment was carried out during the *rabi* season 2020-21 at the Agricultural Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.6642°N latitude and 76.2914°E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and

available nitrogen (144.6 kg N ha⁻¹), medium in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of two methods of N application viz. Before irrigation and after irrigation and four nitrogen levels viz. control, 100, 125 and 150 % of recommended dose of nitrogen. The seed at the rate of 112.5 kg was used irrespective. The nitrogen in the form of urea (46% N) was applied as per the treatments. The gross plot size was 4.5 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on December 11, 2020 and harvested on May 15, 2021. All the other practices were applied uniformly to the treatments.

Result and Discussion

Growth Parameter : The plant height of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). Among different application methods, the significantly higher plant height was observed when nitrogen was applied before irrigation (92.3 cm) over the nitrogen applied after irrigation (67.2 cm). The nitrogen level of 150% of recommended dose of nitrogen recorded significantly higher plant height (84.7 cm) over 100% of recommended dose of nitrogen (80.8 cm) and control (75.5 cm) but was par with 125% of recommended dose of nitrogen (82.9 cm). The interaction between nitrogen levels and application methods was found to be non-significant. Yousaf, M. (2015) Plant height

Table-1 : Effect of Nitrogen levels and its application methods in late sown wheat (*Triticum aestivum* L.).

Treatments	Plant height (cm)	Ear length (cm)	Test weight (g)	No of tiller/ m row length	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Nitrogen levels (kg N/ha)							
Control	75.5	6.0	31.1	82.1	40.0	75.2	42.4
100	80.8	7.0	32.2	84.1	46.3	80.7	43.0
125	82.9	7.8	33.6	87.1	47.3	86.4	43.5
150	84.7	8.8	36.1	90.6	53.7	92.7	44.8
SEM	2.8	0.5	1.1	2.8	0.2	0.4	0.4
CD at 5%	6.1	1.1	2.5	5.9	4.5	10.8	0.6
Methods of application							
Before irrigation	92.31	8.66	37.0	111.8	51.1	89.6	44.3
After irrigation	67.22	6.16	29.5	83.2	42.5	77.7	42.0
CD at 5%	4.32	0.78	1.7	5.93	3.2	7.69	0.9
CD interaction at 5%	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.1	11.9	6.0	6.7	7.0	10.8	1.7

SEM–Standard Error of Mean, CD–Critical Difference, CV–Coefficient of Variation

was significantly affected by different nitrogen levels and irrigation methods maximum plant height (96.6 cm) was recorded from 150kg N/ha and irrigated 30 days after germination treatments as compare with other treatments. The results of nitrogen doses of 120 kg/ha were applied and irrigated 20 days after germination were statistically at par with those treatments where 150 kg nitrogen was applied and 30 days after germination.

Yield Attributes : The ear length of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The nitrogen applied before irrigation recorded significantly higher ear length (8.6 cm) over nitrogen applied after irrigation (6.1 cm). The application of 150% of recommended dose of nitrogen (8.8 cm) was significantly higher over 100% of recommended dose of nitrogen (7.0 cm) and control (6.0 cm) but was par with 125% of recommended dose of nitrogen (7.8 cm). The interaction between nitrogen levels and application methods was found non significant. Patel and Upadhyay (1993) observed that the application of 120 kg N ha⁻¹ increased ear length significantly over 90 kg N ha⁻¹ and further increase of nitrogen levels 150 kg N ha⁻¹ did not influence the ear length significantly.

Test weight of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). Among different application methods, the significantly higher test weight was observed where nitrogen was applied before irrigation (37.0 g) over nitrogen applied after irrigation (29.5 g). The application 150% of recommended dose of nitrogen recorded significantly higher test weight (36.1 g) over 100% of recommended dose of nitrogen (32.2 g) and control (31.1 g) but was par with 125% of recommended dose of nitrogen (33.6 g). Non-significant interaction effect was noticed between nitrogen levels and application methods. Parihar and Tripathi (1990) also revealed that test weight

increased significantly with increasing nitrogen rates up to 100 kg N/ha and further increase in nitrogen to 150 kg/ha did not show considerable increase in grain weight.

Number of tillers/m row length of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The significantly higher number of tillers was observed when nitrogen applied before irrigation (111.8) over nitrogen applied after irrigation (83.2). The application of 150% of recommended dose of nitrogen (90.6) recorded significantly higher number of tillers over 100% of recommended dose of nitrogen (84.12) and control treatments (82.1) but was par with 125% of recommended dose of nitrogen (87.1). Non-significant interaction effect was noticed between nitrogen levels and application methods. Yousaf. M. (2015) number of tillers were significantly affected by nitrogen levels and irrigation application. All the treatments receiving nitrogen produced a significantly more total number of tillers/m row length after those treatments where no nitrogen was applied. where nitrogen was applied at the rate of 150 kg/ha and irrigated 20 and 25 days after germination.

Yield Parameter : Grain yield of late sown wheat was influenced significantly by nitrogen levels and application methods (Table-1). The nitrogen applied before irrigation recorded significantly higher grain yield (51.1 q/ha) over nitrogen applied after irrigation (42.5 q/ha). The magnitude of increase in grain yield was 20.06 percent. The application of 150% of recommended dose of nitrogen recorded significantly higher grain yield (53.7 q/ha) over 100% of recommended dose of nitrogen (46.3 q/ha) and control (40.0 q/ha) but was par with 125% of recommended dose of nitrogen (43.3 q/ha). Interaction between nitrogen levels and application methods was found to be non-significant. Beheraa and Rautaray (2010) reported the higher grain yield obtained with increased

nitrogen levels up to (165kg N ha⁻¹) which was might be due to its favourable effect on yield attributing characters.

Straw yield of late sown wheat was influenced by nitrogen levels and application methods (Table-1). The nitrogen applied before irrigation (89.6 q/ha) recorded significantly higher straw yield than the nitrogen applied after irrigation (77.7 q/ha) by margin of 15.31 per cent higher respectively. The highest straw yield (92.7 q/ha) was observed with 150% of recommended dose of nitrogen which was significantly higher over 100% of recommended dose of nitrogen (80.7 q/ha) and control (75.2 q/ha) but was par with 125% of recommended dose of nitrogen (86.4 q/ha). Non-significant interaction between nitrogen levels and application methods was observed. However, nitrogen levels and application methods failed to affect the harvest index of late sown wheat. Ghobadi *et al.* (2010) also observed the taller plants, greater number of tiller per unit and total dry matter which collectively resulted in higher straw yield. However, nitrogen levels and application methods failed to affect the harvest index of late sown wheat.

Conclusion

It may be concluded that 150% of recommended dose of nitrogen (53.7 q/ha) should be applied to wheat before irrigation to get the higher yield (51.1 q/ha).

References

1. Anonymous (2021). Packages of practices for crops of Punjab, Rabi, *Punjab Agriculture University, Ludhiana*, 38(2):1-7.
2. Beheraa, U.K., and Rautaray, S.K., (2010). Effect of biofertilizer and chemical fertilizers on productivity and quality parameters of durum wheat (*Triticum durum*) on vertisol of central India. *Arch Agron Soil Sci*, 56(1):65-72.
3. Ghobadi, M., Ghobadi, M.E., and Sayah, S.S., (2010). Nitrogen application management in triticale under post-anthesis drought stress. *Word Acad. Sci. Eng. Technol*, 70:252-254.
4. Patel, R.M., and Upadhyay, P.N., (1993). Response of wheat to irrigation under varying levels of nitrogen and phosphorus. *Indian J. Agron* 36 (1): 113-115.
5. Parihar, S.S., and Tripathi, R.S., 1990. Yield, water use and nutrients uptake of wheat as influenced by irrigation and nitrogen levels. *Madras Agric* 77(7-8): 309-16.
6. Singh, H., Singh, A.K., Kushwaha, H.L., and Singh, A., (2007). Energy consumption pattern of wheat production in India. *Energy* 32: 1848-54.
7. Ullah, I. Ali, N., Durrani, S. Shabaz, A.M., Hafeez, A., Ameer, H., Isfaq, M., Fayyaz, N.S., Rehman, A., and Waheed, A., (2018). Effect of nitrogen levels on growth, yield contributing attributes of wheat. *Inter. J. of Sci. and engine. Res* 9: 2229-5518.
8. Wysocki, D.J., M. corp, D.A.H., and L.K. Lutch. (2007). Nutrient management guide: Irrigated and dryland canola. *Oregon State University* 8943.
10. Yousaf, M., Shaaban, M., Suliman, A., and Ali, I., (2015). The effect of nitrogen application rates and timings of first irrigation on wheat growth and yield. *International Journal of Agriculture Innovations and Research* 2(4): 2319-473.



Effect of Sowing Methods and Seed Rates on the Grain Yield of Late Sown Wheat (*Triticum aestivum* L.)

Ravinder Kumar and Udham Singh Tiwana

School of Agriculture Science and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

A field experiment was conducted during the rabi season of 2020-21 at Agricultural Research Farm of School of Agricultural Science and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the effect of sowing methods and seed rates on grain yield of wheat. The experiment was laid out in a randomized complete block design (RCBD) in three replications. The treatments comprised of three methods of sowing i.e. uni-directional (E-W), uni-directional (N-S) and bi-directional (N-S & E-W); and three seed rates viz. 75, 100 and 125% of recommended. All the growth and yield attributing characters significantly increased in bi-directional (N-S & E-W) sowing method over uni-directional (E-W) sowing method but was par with uni-directional (N-S) sowing method. The grain yield was significantly higher in bi-directional (N-S & E-W) sowing methods (48.8 q/ha) over uni-directional (E-W) sowing method (42.57 q/ha) but was par with uni-directional (N-S) sowing method (42.9 q/ha). Straw yield also followed the same trend but harvest index was not influenced significantly by seed rates. The 125% and 100% recommended seed rates recorded significantly higher growth and yield attributes over 75% of recommended seed rates. The 125% of recommended seed rate recorded significantly higher grain yield (46.1 q/ha) over 75% of recommended seed rate (40.0 q/ha) but was par with 100% of recommended seed rate (43.7 q/ha). The application of 125% recommended seed rate recorded 5.49 percent and 9.25 percent higher grain yield of late sown wheat over 100 and 75% of recommended seed rate respectively. Straw yield also followed the same trend but harvest index was not influenced significantly by seed rates. Interaction between sowing methods and seed rates was found non-significant in all the parameters.

Key Words : *Sowing methods, seed rates, growth parameters, yield attributes and yield.*

Introduction

Wheat (*Triticum aestivum* L.) has the highest importance among all the crops grown for the grain purpose worldwide. In India wheat alone covers about 25% of the total area covered by cereal crops. Wheat flour mostly used for making chapati and bread Singh *et al.* (2007). Wheat is major cereal crop in Punjab and occupied 35.20 lakh hectares during 2019-20 with the production of 176.2 lakh tones and average yield of 50.04 quintal per hectares (Anonymous, 2021). Wheat is generally sown in straight uni-directional row i.e., line sowing (22.5 cm apart) where in plants are usually over crowded. They suffer from mutual shading and lower leaves do not get full sunlight. Thus, the plant does not make sufficient use of resources for photosynthesis. However in the recent past, research have indicated superiority of bi-directional sowing compared to present recommendation of uni-directional one. It has been reported that even distribution of plants over cropped area through bi-directional sowing at appropriate geometry facilitate greater availability of growth input particularly light and nutrients with least competition which result in realization of higher productivity over conventional/unidirectional sowing in row 22.5 cm apart (Singh, 1993).

Seed rate plays a vital role for optimum plant densities which is a pre-requisite for increased seed yield.

It influences the yield attributes and yield of wheat. Seed rate depends on seeding method. The broadcasting method requires more seeds than line sowing. Higher seed rate produces more plants in unit area resulting in less intra-crop competition here by affecting the yield and production cost. On the other hand, lower seed rate may reduce the yield drastically (Singh and Singh, 1987).

Material and Methods

The experiment was carried out during *rabi* season of 2020-21 at Agricultural Research Farm of School of Agriculture Science and Technology, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of three methods of sowing i.e. uni-directional (N-S), uni-directional (E-W) and bi-directional (N-S & E-W); and three seed rates viz. 75, 100 and 125% of recommended. The nitrogen in the form of urea (46% N) was applied in 2 splits i.e. half at sowing and half at 30 day after sowing. The gross plot size was 4.5 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown on

Table-1: Effect of sowing methods and seed rates on the grain yield of late sown wheat (*Triticum aestivum* L.).

Treatments	Plant height (cm)	Ear length (cm)	Test Weight (g)	Number of tillers/m row length	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Sowing methods							
Uni-directional (E-W)	88.2	5.6	26.3	64.7	38.0	55.3	41.8
Uni-directional (N-S)	92.8	7.7	29.5	83.2	42.9	62.5	43.5
Bi-directional (E-W & N-S)	98.7	9.5	33.4	111.8	48.8	77.0	45.2
CD at 5%	0.8	0.8	2.20	5.93	2.57	2.97	0.63
Seed rates							
75% of recommended	91.7	7.2	28.7	82.1	40.0	61.5	43.2
100% of recommended	93.5	7.4	29.0	87.1	43.7	64.1	43.4
125% of recommended	94.5	8.3	31.5	90.6	46.1	67.2	44.0
SEM	3.358	0.720	1.262	3.399	0.336	0.462	0.209
CD at 5%	0.8	0.8	2.20	5.93	2.57	2.97	0.63
CD interaction at 5%	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.2	11.5	6.0	6.7	9.5	11	1.4

SEM–Standard Error of Mean, CD–Critical Difference, CV–Coefficient of Variation

December 11, 2020 and harvested on May 15, 2021. All the other practices were applied uniformly to all the treatments.

Result and Discussion

Growth Parameters : The plant height of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). Among different sowing methods, the significantly higher plant height was observed in bi-directional (N-S & E-W) sowing method (98.3 cm) over uni-directional (E-W) sowing method (88.2 cm) but was par with uni-directional (N-S) sowing methods (92.8 cm). Dhingra *et al.* (1986) reported that the higher plant height in bi-directional due to uniform distribution of the plants per unit area and better establishment of seedling. The 125% of recommended seed rate recorded significantly higher plant height (94.5 cm) over 75% of recommended seed rate (91.7 cm) but was par with 100% of recommended seed rate (93.5 cm). The interaction between sowing methods and seed rates was found to be non-significant. Pandey *et al.* (2004) also reported higher plant height under 125% seed rate might be due to more number of plants which would have struggled for sunlight and grew in upward direction resulting increase in plant height.

Yield Attributes : The ear length of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing method recorded significantly higher ear length (9.55 cm) over uni-directional (E-W) sowing method (5.66 cm) but was par with uni-directional (N-S) sowing method (7.77 cm). Panda *et al.* (1996) reported maximum ear length under bi-directional due to more or less equal-distance among the plant which in better light interception and air circulation around the lower canopies and probably

carried their conducive effect on the photosynthetic activity of the crop to remarkable degree and helped in increased ear length. The 125% of recommended seed rate produced significantly higher ear length (8.33 cm) over 75% of recommended seed rate (7.22 cm) but was par with 100% of recommended seed rate (7.44 cm). The interaction between sowing methods and seed rates was found non significant.

Test weight of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). Among different sowing methods, the significantly higher test weight was observed in bi-directional (N-S & E-W) sowing method (33.4 g) over uni-directional (E-W) sowing method (26.3 g) but was par with uni-directional (N-S) sowing method (29.5 g). Jain *et al.* (1991) also reported that maximum test weight under bi-directional was probably due to better growth and development of crop which increased uptake of nutrient and better nourishment of grains resulting in bold size of grain, ultimately increase in test weight. The 125% of recommended seed rate recorded significantly higher test weight (31.5 g) over 75% of recommended seed rate (28.7 g) but was par with 100% of recommended seed rate (29.0 g). Non-significant interaction effect was noticed between sowing methods and seed rates.

Number of tillers/m row length of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The significantly higher number of tillers was observed in bi-directional (N-S & E-W) sowing methods (111.8) over uni-directional (E-W) sowing method (64.7) but was par with uni-directional (N-S) sowing method (83.2). The 125% of recommended seed rate recorded significantly higher number of tillers (90.66) over 75% of recommended seed rate (82.11) but was par

with 100% of recommended seed rate (87.11). Non-significant interaction effect was noticed between sowing methods and seed rates. Iqbal *et al.* (2010) reported that increasing seed rate increased the fertile tillers and total tillers significantly.

Yield Parameter : Grain yield of late sown wheat was influenced significantly by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing methods recorded significantly higher grain yield (48.8 q/ha) over uni-directional (E-W) sowing method (42.57 q/ha) but was par with uni-directional (N-S) sowing method (42.9 q/ha). Singh *et al.* (1994) and Singh (1996) reported bi-directional sowing in increase grain and straw yield could be attributed to the fact that bi-directional had the advantage of more or less equal-distance among plants, better utilization of moisture and nutrients as well as solar radiation due to better orientation of the leaves. The 125% of recommended seed rate recorded significantly higher grain yield (46.1 q/ha) over 75% of recommended seed rate (40.0 q/ha) but was par with 100% of recommended seed rate (43.7 q/ha). The interaction between sowing methods and seed rates was found non-significant. Hameed *et al.* (2003) reported that grain yield increased as seed rates increased. Sandhu *et al.* (2010) also reported that increasing trend in grain yield of wheat with increasing in seed rates.

Straw yield of late sown wheat was influenced by sowing methods and seed rates (Table-1). The bi-directional (N-S & E-W) sowing method recorded significantly higher straw yield (77.0 q/ha) over uni-directional (E-W) sowing method (55.3 q/ha) but was par with uni-directional (N-S) sowing methods (62.5 q/ha). The highest straw yield (67.2 q/ha) was observed with 125% of recommended seed rate which was significantly higher over 75% of recommended seed rate (61.5 q/ha) but was par with 100% of recommended seed rate (64.1 q/ha). Non-significant interaction between sowing methods and seed rates was recorded. Pandey I.B *et al.* (1999) also reported that increased straw yield with increased seed rates kg/ha. However, sowing methods and seed rates failed to affect the harvest index of late sown wheat.

Conclusion

It may be concluded that wheat should be sown by bi-directional (N-S & E-W) and uni-directional (N-S) methods with a seed rate of 100% of the recommended seed.

References

1. Anonymous (2021). Packages of practices for crops of Punjab, Rabi, *Punjab Agriculture University*, Ludhiana, 38(2):1-7.
2. Dhillon, K.K., Dhillon, M.S., Grewal, D.S., and Sharma, K., (1986). Effect of row orientation on growth, yield and yield attribute of wheat sown on the three dates. *Agrie. Sci. Eng*, 70: 252-54.
3. Singh, G., Singh, O. P., and Singh, R. S., (1993) Response of wheat (*Triticum aestivum* L.) to planting method, seed rate and fertility in late sown condition. *Indian Journal of Agronomy*, 38 (2): 195-99.
4. Singh, G., Singh, O.P., Yadav, R.A., Singh, R.S., and Singh, B.B., (1994). Effect of seedling methods, seed rate and fertility levels on yield and economics of late sown wheat after rice in flood prone area. *Ann. Agri. Res*, 15(4): 448-51.
5. Panda, S.C., Pattanaik, A., Rath, B.S., and Behera, B., (1996). Response of wheat to crop geometry and weed management. *Indian. Agron*, 41 (4)553-57.
6. Jain, M.P., Khan, R.A., and Dubey, O.P., (1991). Effect of crop geometry and seed rate on late sown wheat. *Indian. Agron*, 36(4): 479-81
7. Pandey, I.B., Bharti, V., and Mishra, S.S., (2004). Effect of fertilizer levels and seed rates on growth and yield of surface-seeded wheat under low land rice ecosystem of north Bihar. *Indian Agron*, 49 (1):43-5.
8. Hameed, H., and T., Muhammand (2003). Effect of different planting dates, seed rates and nitrogen levels on wheat. *Asian .J. Plant Sci*, 2(6): 464-74.
9. Pandey, I.B., Thakur, S.S., and Singh, S.K., (1999). Response of timely sown wheat varieties to seed rate fertility levels. *Indian J Agronomy*, 44(4): 745-49.
10. Sandhu, R.S., Gill, B.S., and Chahal, P.S., (2010). Competitive ability of wheat against wild oats as influenced by date of sowing, seed rate and spacing. *Indian Journal of Ecology*, 37(1): 97-100.
11. Iqbal, N., Akbar, N., and Ali, L., (2010). Effect of seed rate and row spacing on yield and yield component of wheat. *Journal of Agriculture Research*, 48: 151-56.



Application of Nitrogen in Late Sown Wheat (*Triticum Aestivum* L.) Through Leaf Colour Chart

Ankur Gaba and Udham Singh Tiwana

School of Agriculture Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

The field experiment was carried out at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during *rabi* season of 2019-20 to study the "Application of nitrogen in late sown wheat (*Triticum aestivum* L.) through leaf colour chart". The experiment was laid out in a randomized complete block design (RCBD) with eight treatments viz. control, 30, 60, 90, 120, 150, 180 kg N/ha and leaf colour chart replicated thrice. PBW 550 variety of late sown wheat was used for sowing. Other crop management practices were followed as per the recommendation of the area. The grain yield was significantly higher with the application of 120 kg N /ha over control (27.3 q/ha), 30 kg N /ha (34.9 q/ha), 60 kg N/ha (39.2 q/ha), 90 kg N/ha (44.6 q/ha) but was at par with par with 150 kg N /ha (48.5 q/ha), 180 kg N /ha (46.7 q/ha) and nitrogen application through leaf colour chart (46.3 q/ha). The application of 120 kg N /ha recorded 12.33, 27.80, 39.55 and 61.12 per cent of higher grain yield over 90 kg N/ha, 60 kg N/ha, 30 kg N/ha and control. Similar trend also observed in straw yield but the harvest index was not influenced significantly by nitrogen levels.

Key words : Nitrogen level, Leaf colour chart, growth parameters, yield attributes and yield.

Introduction

Agriculture is the primary source of food and nutrients to sustain human life. There are various crops which provide the major food demand of the people globally; Wheat (*Triticum aestivum* L.) is responsible up to 70% of daily caloric intake of the population living in rural regions (Cakmak, 2008). Wheat is one of strategic cereal crop for the majority of world's populations and occupied about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Gaur, 1995). Wheat is grown in India over an area of about 30.55 million hectare with production 107 mt (Anonymus, 2020). In Punjab, it is grown on an area of 35.20 lakh hectares with the production of 176.2 lakh tonnes with average yield of 50.04 quintal per hectare (Anonymous, 2021). Among the critical nutrients for plant growth, nitrogen plays a significant role. It is constituent of nucleic acids, amino acids, enzymes, and photosynthetic pigments. Use of optimum amount of nitrogen is considered as a key to obtain bumper and quality crop of wheat. Plants take up most of their nitrogen as the ammonium (NH_4^+) or nitrate (NO_3^-) form. Nitrogen occupies a conspicuous place in plant metabolism. Nitrogen fertilizer is known to affect on the various growth attributes, yield attributes and yield. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Therefore, it need to increase the nitrogen content or protein content

through improving, nitrogen translocated from the vegetative parts of the plant to reproductive parts *i.e.* grains. Thus, nitrogen should be applied at optimum dose. Consequently to get more crop production, nitrogen application is essential in the form of chemical fertilizer. Appropriate management of N fertilization has the potential to improve the yield and nutritional quality of wheat (Shi *et al.*, 2010). The leaf colour chart (LCC) has been emerged as diagnostic tool which can determine the insitu crop N requirement by estimating indirectly crop N status in the field taking into account the variation in soil N supply and define time of N application when it needed. It helps farmers to optimize N application with crop demand or to improve the existing fixed N recommendation for higher N use efficiency. The use Leaf Colour Chart (LCC) has been reported by several researchers as reliable tools to increase N use efficiency in wheat crop. In India, compared with traditional local nitrogen management practices, LCC based nitrogen management in wheat crop can increase yield, nitrogen use efficiency, and net return reported in different part of country (Reena *et al.*, 2017). As the information particularly in relation to nitrogen fertilization through LCC in late sown wheat is available very less under Punjab condition and keeping this fact in mind, the present investigation on "Application of Nitrogen in late sown wheat through leaf colour chart" was carried out at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during *rabi* season of 2019-20.

Table-1 : Effect of different nitrogen levels on growth parameters, yield attributes and yield of late sown wheat.

Treatments	Plant height (cm)	Ear length (cm)	1000-grain weight (g)	No. of grains/ear	No. of tillers/m row length	Grain yield (q/ha)	Straw Yield (q/ha)	Harvest index (%)
Control	49.8	5.6	38.7	31.2	96.1	27.3	39.4	40.93
30 Kg N/ha	58.0	6.7	39.4	33.5	111.6	34.9	49.9	41.16
60 Kg N/ha	66.2	7.8	39.9	34.7	127.1	39.2	56.5	40.96
90 Kg N/ha	74.5	8.9	40.3	36.8	142.6	44.6	63.1	41.41
120 Kg N/ha	84.9	10.2	41.6	41.6	165.4	50.1	74.5	40.21
150 Kg N/ha	81.4	10.0	41.1	40.1	162.8	48.5	71.7	40.35
180 Kg N/ha	79.6	9.7	40.9	39.7	157.3	46.7	69.8	40.09
LCC	77.8	9.3	40.6	38.9	152.4	46.3	67.9	40.54
C.D at 5%	8.21	1.02	NS	3.81	15.41	4.21	6.51	NS
C.V.	6.74	6.48	7.29	6.51	6.73	7.21	6.87	5.14

Materials and Methods

The experiment was carried out during the *rabi* season 2019-20 at the Agricultural Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental field is located at 30.66420 N latitude and 76.29140 E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N/ha), medium in available phosphorus (17.3 P₂O₅/ha) and potassium (168 kg K₂O/ha). The experiment was laid out in a randomized complete block design (RCBD) with eight treatments viz. control, 30, 60, 90, 120, 150, 180 kg N/ha and leaf colour chart replicated thrice. The seed at the rate of 112.5 kg per hectare was used for sowing the experiment. The gross plot size was 3.5 m × 4.5 m and net plot size was 3 m × 4 m. The crop was sown on 26th December, 2019 at a row spacing of 15 cm and harvested on May 5th, 2020. All the other cultural practices were uniformly followed.

Results and Discussion

Growth Parameters

Plant height : The plant height of late sown wheat was influenced significantly by sowing methods and nitrogen levels (Table-1). The variations in plant height were recorded due to different nitrogen levels in the late sown wheat. Among the nitrogen levels, 120 kg N /ha recorded significantly higher plant height (84.9 cm) over control (49.8 cm), 30 kg N/ha (58 cm), 60 kg N/ha (66.2 cm), 90 kg N/ha (74.5 cm) but was at par with 150 kg N/ha (81.4 cm), 180 kg N/ha (79.6 cm) and nitrogen application through leaf colour chart (77.8 cm). While, least plant height was recorded with control. Chaturvedi (2006) also reported

similar result thus the increase in plant height with the application of N fertilizers was probably due to enhanced availability of nitrogen which increase more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation.

Tillers m⁻¹ row length : The number of tillers m⁻¹ row length of late sown wheat was significantly influenced by nitrogen levels (Table-1). Number of tillers m⁻¹ recognized as crucial determinant that markedly affects the yield of wheat. Significantly higher number of tillers m⁻¹ row length was exerted with application of 120 kg N/ha (165.4) over control (96.1), 30 kg N/ha (111.6), 60 kg N/ha (127.1), 90 kg N/ha (142.6) but was at par with 150 kg N/ha (162.8), 180 kg N/ha (157.3) and nitrogen application through leaf colour chart (152.4). Singh *et.al* (2001) also observed the same results this may be due to the enhancement in tiller number with increase in fertilizer dose was attributed to the rapid conversion of synthesized carbohydrates into protein and consequent to increase in the number and size of growing cells, resulting ultimately in increased number of tillers.

Yield Attributes

Ear length : The ear length of late sown wheat was significantly influenced by nitrogen levels (Table-1). The data indicates that nitrogen levels had significantly affected ear length of wheat. Significantly highest ear length (10.2 cm) was recorded with the application of 120 kg N/ha over control (5.6 cm), 30 kg N/ha (6.7 cm), 60 kg N/ha (7.8 cm), 90 kg N/ha (8.9 cm) but was at par with 150 kg N/ha (10 cm), 180 kg N/ha (9.7 cm) and nitrogen application through leaf colour chart (9.3 cm). However, least ear length (5.6 cm) was observed with control.

Pasha *et al.* (2007) also reported similar result. The increase in ear length was might be due to higher photosynthetic activity of the plant as a result of higher level of nitrogen applied.

Grains/ear : The number of grains ear⁻¹ of late sown wheat significantly influenced by the nitrogen levels. The number of filled spikelets (seeds) are the real number of seeds that ultimately contributes to grain yield. The data in (Table-1) indicates the effect of different nitrogen levels on number of grains ear⁻¹. Higher number of grains ear⁻¹ was observed with application of 120 kg N/ha (41.6) over control (31.2), 30 kg N/ha (33.5), 60 kg N/ha (34.7), 90 kg N/ha (36.8) but was at par with 150 kg N/ha (40.1), 180 kg N/ha (39.7) and nitrogen application through leaf colour chart (38.9). However, least number of grains ear⁻¹ (25.1) was obtained with control. Chaturvedi (2006) observed similar results this was might be due to the role of nitrogen in crop maturation, flowering and fruiting, including seed formation.

1000-grain weight : The perusal of data in (Table-1) indicates the effect of nitrogen levels on 1000-grain weight. Different nitrogen levels applied to late sown wheat crop failed to exhibit difference in 1000-grain weight. The 1000-grains (g) weight was not influenced significantly by N levels, however the more 1000 grain weight was observed with the higher N levels. The weight of 1000-grains (g) indicates the nature and extent of seed development.

Yield Parameters

Grain yield : The grain yield of late sown wheat was significantly influenced by the application of nitrogen (Table-1). The data showed that grain yield of late sown wheat continued to increase significantly with increase in nitrogen levels upto 120 kg N/ha and thereafter grain yield was declined with increasing nitrogen levels upto leaf colour chart. The higher grain yield of 50.1 q/ha was observed with the application of 120 kg N /ha over control (27.3 q/ha), 30 kg N/ha (34.9 q/ha), 60 kg N/ha (39.2 q/ha), 90 kg N/ha (44.6 q/ha) but was at par with par with 150 kg N/ha (48.5 q/ha), 180 kg N/ha (46.7 q/ha) and nitrogen application through leaf colour chart (46.3 q/ha). However, least grain yield was observed under control treatment (27.3 q ha⁻¹). The application of 120 kg N /ha recorded 12.33, 27.80, 39.55 and 61.12 per cent of higher grain yield over 90 kg N/ha, 60 kg N/ha, 30 kg N/ha and control. Abedi *et al.* (2011) also reported similar result this is due to higher concentration of N in the leaves which increased and prolonged the photosynthesis ability of the plant leads to an increase in grain yield.

Straw yield : The straw yield of late sown wheat was significantly influenced by the application of nitrogen (Table-1). The straw yield of late sown wheat followed a similar trend of observations as observed in respect of grain yield with different nitrogen levels. Significantly higher (74.5 q ha⁻¹) straw yield of late sown wheat was recorded with application of 120 kg N/ha than rest of the treatments during experimentation. Application of 120 kg N/ha was being at par with 150 kg N/ha and 180 kg N/ha and nitrogen application through leaf colour chart. However, least straw yield was observed under control treatment (39.4 q ha⁻¹). The application of 120 kg N/ha recorded 18.06, 31.86, 49.30 and 89.08 per cent of higher straw yield over 90 kg N/ha, 60 kg N/ha, 30 kg N/ha and control, respectively. Datt *et al.* (2003) also reported the same result this is due to increased uptake of the nutrients was due to added supply of nutrient and well developed root-system resulting in better absorption of water and nutrients.

Harvest index : Harvest index is an important criteria which determines the proportion of economic yield expressed in percentage of biological yield. The data regarding harvest index are embodied in (Table-1). In general highest (41.41%) value of harvest index was observed with application of 90 kg N /ha 180 kg N/ha recorded the lowest (40.09%) harvest index during experimental year. However, treatments were failed to show any significant variation amongst themselves.

Conclusion

On the basis of this experiment, it may be concluded that significantly higher grain yield (50.1 q/ha) of late sown wheat was observed with the application of 120 Kg N/ha.

References

1. Abedi, T., Alemzadeh, A. and Kazemeini, S.A. (2011). Wheat yield and grain protein response to nitrogen amount and timing. *Australian Journal of Crop Science*, 5(3): 330-36.
2. Anonymous (2021). Packages of Practices for Crops of Punjab, Rabi, Punjab Agriculture University, Ludhiana, 38 (2): 1-7.
3. Anonymous (2021). Progress report of all India coordinated Research Project on wheat and barley 2019-20, Social Sciences.
4. Breiman, A. and Graur, B. (1995). Wheat Evolution. *Israel Journal of Plant Science*, 43: 85-98.
5. Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic biofortification, *Plant and Soil*, 302: 1-17.
6. Chaturvedi, I. (2006). Effects of different nitrogen levels on growth, yield and nutrient uptake of wheat (*Triticum*

- aestivum L.). *International Journal of Agricultural Sciences*, 2(2): 372-74.
7. Datt, N., Sharma R. P. and Sharma G. D. (2003). Effect of supplementary use of farmyard manure along with chemical fertilizers on productivity and nutrient uptake by vegetable pea (*Pisum sativum var arvense*) and buildup of soil fertility in Lahaul valley of Himachal Pradesh. *International Journal of Agriculture Sciences*, 73: 266-68.
 8. Pasha, A., Chittapur, B. M., Patil, B. N. and Hiremath, S. M. (2007). Effect of Prolonged Nitrogen Application and Sulphur Nutrition on Grain Quality and Nutrient Uptake of Wheat and Soil Available Nutrient Dynamics. *Karnataka Journal of Agriculture Sciences*, 20(2): 224-27.
 9. Reena, V.C.D., Sumit, C. and Shikha. (2017) Dynamics of yield, nitrogen uptake and nitrogen use efficiency in wheat (*Triticum aestivum*) crop as influenced by leaf colour chart and chlorophyll meter based real time nitrogen management. *International Journal of Agriculture Sciences*, 9(54): 4930-33.
 10. Shi, R., Zhang, Y., Chen, X., Sun, Q., Zhang, F., Romheld, V. and Zou, C. (2010). Influence of long-term nitrogen fertilization on micronutrient density in grain of winter wheat (*Triticum aestivum* L.). *Journal of Cereal Science*, 51: 165-70.
 11. Singh, R. and Agarwal S. K. (2001). Analysis of growth and productivity of wheat in relation to levels of FYM and nitrogen. *Indian Journal of Plant Physiology*, 6: 279-83.



Power and Functions, Board and Revenue Officers Under U.P. Revenue Code 2006 and U.P. Revenue Code Rules 2016

Youdh Vir Singh

Head, Faculty of Law, N.A.S. College, Meerut, U.P.

Board and the revenue officers

1. Board of Revenue—[1] There shall be a Board of Revenue for Uttar Pradesh consisting of a Chairman and such other members as the state Government may, from time to time appoint :

Provided that the Board as constituted and functioning immediately before the commencement of this Code shall deemed to be the Board constituted under this section.

[2] ¹[***]

[3] No person shall be qualified for appointment as :

[a] an Administrative Member of the Board, unless he has held an office not lower in rank than that of a Commissioner.

[b] a Judicial Member of the Board ²[Unless he has held an office not below the rank of a Collector.]

2. Jurisdiction of the Board—[1] The Board shall be the Chief Controlling Authority—

³[(a) in all matters relating to disposal of cases, appeals or revisions; and]

(b) subject to the superintendence, direction and control of the State Government, in all other matters provided in this code.

[2] Subject to the provisions of sub-section [1]. The Board shall exercise, perform and discharge powers, functions and duties conferred upon it by or under this Code or any other law for time being in force.

[3] The State Government may authorise any Member of the Board to exercise, perform and discharge either generally or in respect of any particular locality or matter, all or any of the powers, functions and duties conferred or imposed on the board.

3. Power to distribute business—[1] Subject to such rules or orders as the State Government may make or issue, the Board may distribute its business amongst its members as the Board may deem fit. Chairman may constitute bench or benches consisting of more than one member for disposal of a particular case or class of cases.

[2] All orders made or decrees passed by a Member

of the Board in accordance with such distribution shall be deemed to be orders or decrees, as the case may be, of the Board.

4. Decision of the Board—[1] Where any proceeding coming under the consideration of the Board on appeal or in revision is heard by a Bench composed of two or more members, the case shall be decided in accordance with the opinion of such members or of the majority, if any of such members.

[2] Where the Members of the Board constituting the Bench are equally divided in opinion as to the decision of a case, it shall be heard by a larger Bench to be constituted by the Chairman, and the case shall be decided in accordance with the opinion of the members constituting such Bench or of the majority, if any of such members.

[3] All decisions given by a member sitting singly, or by a Division Bench comprising two members or a larger Bench constituted as aforesaid shall be deemed to be decisions of the Board.

5. Commissioners and Additional Commissioners—

[1] the State Government shall appoint in each division a Commissioner, who shall, within his division, exercise the powers and discharge the duties conferred and imposed on a Commissioner by or under this Code or any other law for the time ⁴[being in force, and shall exercise authority over all the revenue officers in his division.]

[2] The State Government may appoint one or more Additional Commissioners in one or more Divisions.

[3] An additional Commissioner shall exercise such powers and discharge such duties of Commissioner in such cases or classes of cases as the State Government or, in the absence of any direction from the State Government, the Commissioner of the division may direct.

[4] The provisions of this Code and every other law for the time being applicable to a Commissioner shall apply to the Additional commissioner when exercising powers or discharging any duties under this section, as if he were the Commissioner of the division.

⁵[(5) The State Government may, at the time of

making the appointment or at any time subsequent thereto, designate any Additional Commissioner, as Additional Commissioner (Judicial), and any such Additional Commissioner(Judicial) shall be allotted only judicial business. Such an Additional Commissioner exercise such powers and discharge such duties of Commissioner in such cases or classes of cases as the State Government, or in the absence of any direction from the State Government the Commissioner of the Division, may direct.]

6. Collectors and Additional Collectors.—[1] The State Government shall appoint, in each district, a Collector who shall be in charge of the revenue administration thereof and shall exercise all the powers and discharge all the duties conferred and imposed on a Collector by or under this Code or any other law for time being in force.

[2] The State Government may appoint one or more Additional collectors in a district.

[3] An Additional Collector shall, subject to the direction and control of the State Government or of the collector, exercise all powers and discharge all duties of Collector.

[4] The provisions of this Code and every other law for the time being applicable to the Collector shall apply to the Additional Collector when exercising powers or discharging any duties under this section, as if he were the Collector of the district.

⁶[5] The State Government may, at the time of making the appointment or at any time subsequent thereto, designate any Additional Collector, as Additional Collector (Judicial) and any such Additional Collector (Judicial) shall be allotted only judicial business. Such an Additional Collector(Judicial) shall exercise such powers and discharge such duties of Collector in such cases or classes of cases as the State Government, or in the absence of any direction from the State Government, the Collector of the district, may direct.]

7. Sub-Divisional officers and Additional Sub-Divisional Officers.—⁷[(1) The State Government may appoint in each district as many persons as it thinks fit to be Assistant Collectors of the first or second class.]

⁸[(2) The State Government may place an Assistant Collector first class incharge of one or more sub-divisions of a district, and such an officer shall be called the Assistant Collector first class incharge of a sub-division or a Sub-Divisional Officer.]

[3] The officers referred to in sub-section [1] or sub-section [2] shall exercise all the powers and discharge all the duties conferred and imposed upon

them by or under this Code or any other law for the time being in force, subject to the control of the Collector.

[4] The State Government may designate an 9[Assistant Collector first class] appointed to a district to be an Additional Sub-Divisional Officer for one or more tahsils of the district.

[5] Subject to the provisions of this Code, the Additional Sub-Divisional Officer shall exercise such powers and discharge such duties of a Sub-Divisional Officer in such cases or classes of cases as the State Government, or in the absence of any direction from the State Government, the Collector may direct.

¹⁰[6] The State Government may, at the time of making the appointment or at any time subsequent thereto, designate any Assistant Collector first class, as Sub-Divisional Officer(Judicial) for one or more tahsils, and any such Sub-Divisional Officer(Judicial) shall be allotted only judicial business. Such a Sub-Divisional Officer(Judicial) shall exercise such powers and discharge such duties of a Sub-Divisional Officer in such cases or classes of cases as the State Government, or in the absence of any direction from the State Government, the Collector, may direct.]

8. Tahsildars and Tahsildars (Judicial).—[1] The State Government may appoint in each district as many persons as it thinks fit to be Tahsildars and Tahsildar (Judicial).

[2] Subject to the provisions of this Code, the Tahsildar and Tahsildar(Judicial) shall exercise such powers and discharge such duties as the State Government or the Board, and in the absence of any directions from the State Government or the Board, the Collector may direct.

9. Naib Tahsildars.—The State Government may appoint in each district as many persons as it thinks fit to be Naib-Tahsildars who shall exercise the power and perform the duties conferred or imposed on them by or under this Code or under any other law for the time being in force.

10. Revenue Inspectors and Lekhpals.—[1] The Collector may appoint in each tahsil one or more Revenue Inspectors for the proper supervision, maintenance and correction the village records, and for such other duties as the State Government may, from time-to-time by general or special order specify.

[2] The Collector may appoint in each tahsil, as many Lekhpals for the preparation, maintenance and correction of the village records, and for such other duties

as the State Government may from time-to-time by general or special order, specify.

11. Combination of Offices.—It shall be lawful for the State Government or the authority competent to appoint, as the case may be, to appoint one and the same person, being otherwise competent according to law for any two or more of the offices provided in this chapter or to confer upon an officer of one denomination all or any of the powers or duties of any other officer or officer or officers within certain local limits or otherwise, as it may deem expedient.

12. Recovery of money, papers and other Government property.—[1] The Collector may in cases in which there is claim outstanding on any revenue officer or on any person formerly employed as such in his district for public money or papers or other property of the State Government in his charge., by order, for reasons to be recorded, require the money, or the particular papers or property detained to be delivered either immediately to the bearer of the said order or to such person on such date and at such place as the order may specify.

¹¹[(2) If the officer or other person aforesaid does not comply as directed. The Collector shall impose a penalty of two hundred and fifty rupees each day till the direction is complied with, so however, total amount of such penalty shall not exceed twenty-five thousand rupees.

Provided that the officer or other person, as the case may be, shall be given a reasonable opportunity of hearing before any penalty is imposed on him.

[3] Imposition of penalty under sub-section [2] shall not bar the prosecution for any offence or recovery of money, papers and other government property under any law for the time being in force.]

13. Other power of Revenue Officers.—[1] When any power is exercisable or any duty is dischargeable by any officer or authority under this code , such power of duty may be exercised or discharges by any superior officer or authority as well.

[2] The Revenue officers appointed under this Code shall, subject to the control of the State Government, exercise such other powers and discharge such other duties as the State Government may, by any general or special order, direct.

References

1. Omitted by U.P. Act No. 4 of 2016 (w.e.f 16.12.2015) Prior to omission it read as under :
“(2) The principal seat of business of the Board shall be at Lucknow and the judicial member may hold their Courts at Allahabad or Lucknow as the Chairman from time-to-time directs.”
2. Subs.for “unless he has been a revenue officer” by U.P. Act No 4 of 2016 (w.e.f. 16.12.2015)
3. Subs. U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015). Prior to substitution it read as follows(a) in all matters relating to disposal of cases, appeals, references or revision; and”
4. Subs.for “being in force” by U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015)
5. Ins. By U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015)
6. Ins. by U.P. Act No. 4 of 2016(w.e.f. 16.12.2015)
7. Subs. By U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015). Prior to substitution it read as under
“(1) The State Government may appoint in each district as many person as it thinks fit to be Assistant Collectors.”
8. Subs. By U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015). Prior to substitution it read as under:
“(2) The State Government may place as Assistant Collector in charge of one or more sub-divisions of a district , and such an officer shall be called the Assistant Collector incharge of a sub-division or a Sub-Divisional Officer.
9. Subs. For “Assistant Collector” by U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015)
10. Ins. by U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015)
11. Subs. for sub-section (2) by U.P. Act No. 4 of 2016 (w.e.f. 16.12.2015). Prior to substitution it read as under:
“(2) If the officer or other person aforesaid does not comply as directed, the Collector may cause him to be apprehended and may send him with a warrant in the prescribed form to be confined in the civil prison till he complies with the orders: Provided that no person shall be detained in confinement by virtue of any such warrant for a period longer than thirty days.”



Correlation and Path Analysis for Yield Contributing Parameters for Grain Yield of Maize (*Zea mays* L.) Genotypes

Vipin Kumar and Ashvani Panwar*

Deptt. Genetics and Plant Breeding, Gochar Mahavidhalaya, Rampur Maniharan, Saharanpur, (UP) 247451

*Corresponding author & Supervisor

Abstract

The present study was undertaken to carry out correlation and path analysis for yield and yield contributing traits in F₁ lines of maize. These lines were collected from the gene bank of Chandra Shekhar Azad, University of Agriculture and Technology, Kanpur and planted with recommended package & practices at Gochar Mahavidhalaya, Rampur Maniharan, Saharanpur (U.P.) during *kharif* season 2011. Correlation coefficients between yield and its contributing characters as well as themselves have worked out at phenotypic and genotypic levels. Grain yield was found to be positively significant with number of kernel per row, cob length, number of kernel row per cob, cob width, cob per plant and positively association with 100 kernel weight, plant height and days to 50% silking. Path coefficient analysis has taken to determine the direct or indirect effect on grain weight per plant and exerted by days to 50% anthesis, days to 50% silking, days to 75% dry husk, plant height (cm), cob height (cm), cob per plant, cob length (cm), number of kernel row per cob, cob width (cm), number of kernel per row, 100 kernel weight (gm), leaf length (cm), leaf width (cm) and grain yield per plant (gm). Path analysis gives a clear on picture and understanding than that of correlation analysis alone. It is evident in many cases that the information obtained through both analyses are more helpful to a breeder than that of the result of correlation analysis. The path coefficient analysis is a specific one and generally measures the relative importance of characters which is more useful relationship on cause and effect for better selection. In the present study the path coefficient analysis indicated that the characters, number of kernels per row followed by number of kernel row per cob, 100 kernel weight, plant height, leaf width, cob per plant and days to 50% anthesis had higher magnitude of positive direct effect on grain yield per plant while leaf length followed by cob width, cob length, days to 50% silking, cob height and days of 50% dry husk showed higher value of negative direct effect on grain yield per plant.

Key Words : F₁ lines, maize, correlation, path analysis.

Introduction

Maize (*Zea mays* L.) grows over a wider geographical and environmental range than any other cereals. It is grown at latitudes varying from the equator to slightly north and south of latitude 50°, from sea level to over 3000 meters elevation, under heavy rainfall and semi-arid conditions, cool and very hot climates (Abdemula *et al.* 2007). Maize is one of the most important cereal crops and occupies prominent position in global agriculture after wheat and rice. Maize being a C₄ plant is physiologically more efficient, has higher grain yield and wider adaptation over wide range of environmental conditions. The crop has assumed a place of prominence in Indian agriculture owing to its varied usage. Globally, 67% of maize is used for livestock feed, 25% for human consumption and rest for industrial purposes. Yield is quantitative character controlled by polygenes and it is the result of combined effect of several component characters and environment. Maize is one of the most important grown plants in the world. Superior position of maize is due to its very wide and variety utilization. During the centuries maize plant was known for its multifarious use. Maize is used like a

human food, livestock feed, for producing alcohol and no alcohol drinks, built material, like a fuel, and like medical and ornamental plant (Bekriæ and Radosavljeviæ, 2008). Because of very wide utilization of maize, the main goal of all maize breeding programs is to obtain new inbreds and hybrids that will outperform the existing hybrids with respect to a number of traits. In working towards this goal, particular attention is paid to grain yield as the most important agronomic characteristic. Grain yield is a complex quantitative trait that depends on a number of factors. Besides that, knowing the correlations between the traits is also of great importance for success in selections to be conducted in breeding programs, and analysis of correlation coefficient is the most widely used one among numerous methods that can be used (Yagdi and Sozen, 2009). Because correlation coefficient measures the mutual association only between a pair of variables, when more than two variables are involved, the correlations per se may not provide a clear picture of the importance of each component in determining grain yield. Path coefficient analysis provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield

components on yield, and indirect effects via other yield components (Garcia Del Moral *et al.*, 2003). The objective of this paper was to submit correlative relationship between grain yield and morphological traits of plant and cob. Also, one of the goals of this study was founding the direct and indirect effects of morphological traits on grain yield.

Materials and Methods

The experiment material for the present investigation comprised of thirty two genotypes obtained from the gene bank of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. These genotypes were diverse in nature from the view of yield contributing traits. The material was sown in complete Randomized Block Design with 3 replications during *kharif* season 2011 at agriculture field of Gochar Mahavidyalaya, Rampur Maniharan, Saharanpur (U.P.). Data were recorded on five randomly selected plants in each entry in each replication for the days to 50 % anthesis, days to 50 % silking, days to 75 % dry husk, plant height (cm), cob height (cm), cob per plant, cob length (cm), number of kernel row per cob, cob width (cm), number of kernel per row, 100 kernel weight (gm), leaf length (cm), leaf width (cm) and grain yield per plant (gm) and averages were computed. Correlation coefficient measures the degree of mutual association between two variables without employing any cause and effect relationship. All possible correlation coefficient among fourteen characters were calculated at genotypic and phenotypic level the procedure given by Robinson *et al.* (1951). To obtain a relevant and clear understanding of the association, the genotypic and phenotypic correlation of yield with other traits were partitioned into direct and indirect effects through path coefficient analysis as per method suggested by Wright (1921) and Dewey and Lu (1959). Path analysis is simply standardized partial regression coefficient analysis which split the correlation coefficients into direct and indirect effects of a set of independent variables on the dependent.

Results and Discussion

The phenotypic & genotypic correlations coefficients are presented in lower half of correlation matrix (table 1). Phenotypic correlation indicated that days to 50 % anthesis had positive and highly significant correlation with days to 50 % silking (0.983**) while it showed positive non-significant correlation with cob height (0.218), 100 kernel weight (0.191), plant height (0.187), cob length (0.027), cob width (0.014), leaf length (0.013), grain yield per plant (0.006), number of kernel per row (0.003) and negative non-significant correlation with cob per plant

(-0.027), number of kernel row per cob (-0.041), days to 75 % dry husk (-0.051) and leaf width (-0.157). Days to 50 % silking showed positive and non-significant correlation with cob height (0.207), 100 kernel weight (0.197), plant height (0.175), cob length (0.034), leaf length (0.024), cob width (0.023), number of kernel per row (0.016), grain yield per plant (0.006), whereas negative and non-significant correlation with cob per plant (-0.004), days to 75 % dry husk (-0.040), number of kernel row per cob (-0.042) and leaf width (-0.158). Days to 75 % dry husk, showed positive and non-significant correlation with plant height (0.139), cob width (0.139), 100 kernel weight (0.081), leaf length (0.072), number of kernel row per cob (0.030), leaf width (0.008), grain yield per plant (0.005), whereas negative and non-significant correlation with number of kernel per row (-0.010), cob length (-0.025), cob per plant (-0.086) and cob height (-0.130). Plant height had positive followed by highly significant with cob height (0.691**), and leaf length (0.474**), whereas positive non-significant correlation with leaf width (0.224), 100 kernel weight (0.010), number of kernel per row (0.004), grain yield per plant (0.003) and negative non-significant correlation with cob width (-0.004), kernel row per cob (-0.036), cob length (-0.056) and cob per plant (-0.214). Similar observations were reported by Bhole and Patil (1984). Cob height showed positive highly significant correlation with leaf length (0.399**) and positive significant with leaf width (0.248*), while is showed positive non-significant correlation with cob width (0.006) and negative non-significant correlation with 100 kernel weight (-0.006), number of kernel row per cob (-0.031), number of kernel per row (-0.043), grain yield per plant (-0.052), cob per plant (-0.055) and cob length (-0.082). Cob per plant showed the positively non-significant correlation with cob length (0.252), grain yield per plant (0.245), number of kernel per row (0.216), leaf width (0.211), cob width (0.178), number of kernel row per cob (0.172) and negative non-significant correlation with 100 kernel weight (-0.002), leaf length (-0.057). Cob length showed positive highly significant correlation with number of kernel per row (0.896**), cob width (0.614**), grain yield per plant (0.588**), number of kernel row per cob (0.488**) and negative non-significant correlation with leaf width (-0.079), 100 kernel weight (-0.111), leaf length (-0.321). Number of kernels row per cob showed positive highly significant correlation with cob width (0.726**), grain yield per plant (0.537**), number of kernel per row (0.444**) while it showed negative non-significant correlation with 100 kernel weight (-0.086), leaf width (-0.104) and leaf length (-0.225). Cob width showed positive and highly significant correlation with number of kernel per row

Table-1 : Phenotypic and Genotypic correlation for Grain yield and its components in Maize (*Zea mays* L.).

Characters	Days to 50% Anthesis	Days to 50% Silking	Days to 75% dry husk	Plant Height (cm)	Cob Height (cm)	Cob par plant	Cob length (cm)	No. of kernel row per cob	Cob. Width (cm)	No. of kernel row	100 Kernel weight (gm)	Leaf Length (cm)	Leaf Width (cm)	Grain Yield per plant (gm)
Days to 50% Anthesis	1.000	0.983**	-0.051	0.187	0.218	-0.027	0.027	-0.041	0.014	0.003	0.191	0.013	-0.157	0.006
Days to 50% Silking	1.000	0.997**	-0.224	0.202	0.246	-0.093	-0.024	-0.143	0.060	-0.042	0.210	0.019	-0.210	-0.005
Days to 75% dry husk	1.000	1.000	-0.040	0.175	0.207	-0.004	0.034	-0.042	0.023	0.016	0.197	0.024	-0.158	0.006
Plant Height (cm)	1.000	1.000	-0.220	0.190	0.233	-0.072	-0.047	-0.144	0.054	-0.040	0.201	0.033	-0.176	0.001
Cob Height (cm)	1.000	1.000	1.000	0.139	-0.130	-0.086	-0.025	0.030	0.139	-0.010	0.081	0.072	0.008	0.005
Cob par plant	1.000	1.000	1.000	0.239	-0.227	-0.220	-0.181	-0.247	-0.680**	-0.114	0.107	0.024	-0.082	-0.002
Cob length (cm)	1.000	1.000	1.000	1.000	0.691**	-0.214	-0.056	-0.036	-0.004	0.004	0.010	0.474**	0.224	0.003
No. of kernel row per cob	1.000	1.000	1.000	1.000	0.710**	-0.239	-0.125	-0.099	-0.070	0.038	0.023	0.489**	0.341*	0.004
Cob Width (cm)	1.000	1.000	1.000	1.000	1.000	-0.055	-0.082	-0.031	0.006	-0.043	-0.006	0.399**	0.248*	-0.052
No. of kernel per row	1.000	1.000	1.000	1.000	1.000	-0.081	-0.197	-0.034	0.035	-0.082	0.005	0.415**	0.303*	-0.051
100 Kernel weight (gm)	1.000	1.000	1.000	1.000	1.000	1.000	0.340*	0.453**	0.440**	0.216	-0.002	-0.057	0.211	0.245
Leaf Length (cm)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.488**	0.614**	0.896**	-0.111	-0.321	-0.079	0.588**
Leaf Width (cm)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.451**	0.807**	0.875**	-0.223	-0.697**	-0.109	0.627**
Grain Yield per plant (gm)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.726**	0.444**	-0.086	-0.225	-0.104	0.537**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.737**	0.463**	-0.148	-0.621**	-0.505**	0.547**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.591**	-0.175	-0.199	-0.022	0.430**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.768**	-0.620**	-0.850**	-0.495**	0.490**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-0.135	-0.245	-0.071	0.616**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-0.210	-0.581**	-0.015	0.678**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.190	0.142	0.149
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.249	0.126	0.170
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.595**	-0.340*
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.808**	-0.354**
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-0.105
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

*Significant at 5% probability level

**Significant at 1% probability level

(0.591**), grain yield per plant (0.430**) and negative non-significant correlation with leaf width (-0.022), 100 kernel weight (-0.175), leaf length (-0.199). Number of kernel per row showed positive highly significant correlation with grain yield per plant (0.616**) whereas negative non-significant correlation with leaf width (-0.071), 100 kernel weight (-0.135), leaf length (-0.581). 100 kernel weight showed positive non-significant correlation with leaf length (0.190), grain yield per plant (0.149), leaf width (0.142). Leaf length showed positive highly significant correlation with leaf width (0.595**) and negative significant with grain yield per plant (-0.340*). Leaf width showed negative non-significant correlation with weight per cob (-0.064). Similar results on correlation coefficient for different character were reported by XU and Wen (1988), Anglov (1992), Saha and Mukherjee (1993), Krishnan and Natarajan (1995), Packiaraj (1995), Firoza *et al.* (1999), Umakant and Khan (2000), Pradeep Kumar and Satyanarana (2001), Wannows *et al.* (2010), Bahoush *et al.* (2010), Jawaharlal *et al.* (2011), P. Arsode *et al.* (2018), D. O. Olawamide *et al.* (2020).

Grain yield was found to be positively significant with number of kernel per row (0.616**/0.678**), cob length (0.588**/0.627**), number of kernel row per cob (0.537**/0.547**), cob width (0.430**/0.490**), cob per plant (0.245*/0.304) and positively association with 100 kernel weight, plant height and days to

Table-2 : Phenotypic (P) and Genotypic (G) Estimation of Path coefficient between Grain yield and its components in Maize (*Zea mays* L.).

Characters	Days to 50% Anthesis	Days to 50% Silking	Days to 75% dry husk	Plant Height (cm)	Cob Height (cm)	Cob par plant	Cob length (cm)	No. of kernel row per cob	Cob. Width (cm)	No. of kernel per row	100 Kernel weight (gm)	Leaf Length (cm)	Leaf Width (cm)	'R' with grain Yield per plant (gm)
Days to 50% Anthesis	(P) 0.065 (G) -0.694	-0.097 0.956	0.000 0.022	0.040 -0.212	-0.007 0.062	-0.003 0.064	-0.003 0.004	-0.016 -0.243	-0.002 -0.074	0.002 -0.092	0.053 -0.084	-0.005 0.042	-0.021 0.244	0.006 -0.005
Days to 50% Silking	(P) 0.064 (G) -0.692	-0.098 0.959	0.000 0.021	0.038 -0.200	-0.007 0.059	0.000 0.050	-0.003 0.009	-0.017 -0.245	-0.004 -0.067	0.009 -0.089	0.055 -0.081	-0.009 0.072	-0.021 0.205	0.006 0.001
Days to 75% dry husk	(P) -0.003 (G) 0.156	0.004 -0.211	-0.001 -0.097	0.030 -0.252	0.004 -0.057	0.009 0.151	0.002 0.034	0.012 -0.421	-0.023 0.839	-0.006 -0.251	0.022 -0.043	-0.028 0.054	0.001 0.096	0.005 -0.002
Plant Height (cm)	(P) 0.012 (G) -0.140	-0.017 0.182	0.000 -0.023	0.214 -1.054	-0.023 0.178	-0.023 0.165	0.006 0.023	-0.014 -0.169	0.001 0.086	0.002 0.084	0.003 -0.009	-0.185 1.077	0.029 -0.396	0.003 0.004
Cob Height (cm)	(P) 0.014 (G) -0.171	-0.020 0.224	0.000 0.022	0.148 -0.749	-0.034 0.251	0.006 0.056	0.008 0.037	-0.012 -0.058	-0.001 -0.043	-0.024 -0.180	-0.002 -0.002	-0.156 0.914	0.032 -0.352	-0.052 -0.051
Cob par plant	(P) -0.002 (G) 0.064	0.000 -0.069	0.000 0.021	-0.046 0.252	0.002 -0.020	0.108 -0.688	-0.025 -0.063	0.068 0.771	-0.030 -0.542	0.120 0.840	0.000 0.037	0.022 -0.110	0.028 -0.189	0.245 0.304*
Cob length (cm)	(P) 0.002 (G) 0.017	-0.003 -0.045	0.000 0.018	-0.012 0.131	0.003 -0.049	0.027 -0.234	-0.099 -0.185	0.194 0.790	-0.103 -0.996	0.496 2.202	-0.031 0.178	0.125 -1.327	-0.010 0.127	0.588** 0.627**
No. of kernel row per cob	(P) -0.003 (G) 0.099	0.004 -0.138	0.000 0.024	-0.008 0.105	0.001 -0.009	0.019 -0.312	-0.048 -0.195	0.398 1.703	-0.122 -1.650	0.246 1.642	-0.024 0.059	0.088 -1.368	-0.014 0.587	0.537** 0.547**
Cob Width (cm)	(P) 0.001 (G) -0.042	-0.002 0.052	0.000 0.066	-0.001 0.073	0.000 0.009	0.019 -0.303	-0.061 -0.150	0.289 2.277	-0.168 -1.234	0.327 0.789	-0.049 0.251	0.078 -1.874	-0.003 0.576	0.430** 0.490**
No. of kernel per row	(P) 0.000 (G) 0.029	-0.002 -0.039	0.000 0.011	0.001 -0.040	0.001 -0.021	0.023 -0.263	-0.089 -0.185	0.177 1.112	-0.099 -0.948	0.554 2.201	-0.038 0.084	0.096 -1.280	-0.009 0.017	0.616** 0.678**
100 Kernel weight (gm)	(P) 0.013 (G) -0.145	-0.019 0.193	0.000 -0.010	0.002 -0.024	0.000 0.001	0.000 0.063	0.011 0.041	-0.034 -0.252	0.029 0.765	-0.075 -0.463	0.278 -0.401	-0.074 0.548	0.019 -0.146	0.149 0.170
Leaf Length (cm)	(P) 0.001 (G) -0.013	-0.002 0.031	0.000 -0.002	0.102 -0.515	-0.014 0.104	-0.006 0.034	0.032 0.129	-0.090 -1.057	0.033 1.049	-0.136 -1.279	0.053 -0.100	-0.391 2.204	0.078 -0.939	-0.340* -0.354**
Leaf Width (cm)	(P) -0.010 (G) 0.146	0.016 -0.169	0.000 0.008	0.048 -0.359	-0.008 0.076	0.023 -0.112	0.008 0.020	-0.041 -0.860	0.004 0.611	-0.039 -0.033	0.040 -0.050	-0.232 1.780	0.131 -1.163	-0.064 -0.105

Phenotypic residual effect = 0.0125, Genotypic residual effect = 0.0315, *Significant at 5% probability level, **Significant at 1% probability level

50% silking (Table 1.). Similar result was found by Umakanth *et al.* (2000). Negative association was observed for grain yield through leaf width, cob height, days to 50 % anthesis and days to 75% dry husk. Leaf length exhibited significant negative genotypic correlation with grain yield (-0.340*/-0.354**). Similar results were reported earlier in maize by several workers on different characters viz., for the association of grain yield with plant height (Moradi *et al.*, 2011; Raghu *et al.*, 2011), cob height (Raghu *et al.*, 2011), cob length (Selvaraj and Nagarajan, 2011), number of kernels per row, number of kernel rows per cob (Sofi and Rather, 2007) and 100 grain weight (Rafiq *et al.*, 2010; Raghu *et al.*, 2011). The results indicated that number of kernel per row, cob length, number of kernel row per cob, cob width and cob per plant and highly correlated with grain yield per plant and need to be considered for selection.

Path coefficient analysis (table 2) showed that number of kernels per row (0.554) had exhibited the largest direct effect on grain yield per plant followed by number of kernel row per cob (0.398), 100 kernel weight (0.278), plant height (0.214), leaf width (0.131), cob per plant (0.108) and days to 50 % anthesis (0.065) indicating the effectiveness of direct selection, whereas direct and negative effects were exhibited by leaf length (-0.391), cob width (-0.168), cob length (-0.099), days to 50% silking (-0.098), cob height (-0.034) and days of 50 % dry husk (-0.001) indicating that selection for these traits result in less grain yield. The high positive direct effect of the number of kernels per row on yield was also reported by Geetha and Jayaraman (2000) and Jabeen (2005), the high positive direct effect of 100 kernel weight and the high positive direct effect of a number of kernel rows per cob was also observed by Raghu *et al.*, (2011). Similar results on Path coefficient for different character were reported by Singh *et al.* (1999), Viola, *et al.* (2003), NehaSinghal *et al.* (2006), Srivas and Singh (2007), Jaya kumar *et al.* (2007), Shi *et al.* (2008), Selvaraj and Pothiraj (2011), Hefny (2011), D. S. Jakhar *et al.* (2017), J. Tadesse *et al.* (2019).

The results indicated that the high direct effect of the number of kernels per row followed by number of kernel row per cob, 100 kernel weight, plant height, leaf width, cob per plant and days to 50 % anthesis on grain yield per plant while leaf length followed by cob width, cob length, days to 50% silking, cob height and days of 50 % dry husk showed higher value of negative direct effect on grain yield per plant. Hence, direct selection for these traits would be effective. Knowledge of interaction among the characters is very essential in plant breeding to determine the extent and nature of relationship between yield and yield components. Path Coefficient analysis enables a

plant breeder to separate direct and their indirect effects through attributes by partitioning the correlations. Thus Correlation and Path coefficient analysis form a basis for selection and helps in understanding yield contributing characters affecting yield in Maize (*Zea mays* L.).

References

1. Abdelmula AA, Sabiel SAI. (2007). Genotypic response of growth and yield of some maize (*Zea mays* L.) genotypes to drought stress. Conference on International Agricultural Research for Development, *University of Kassel-Witzenhausen and University of Göttingen*, October 9-11, Tropentag.
2. Anglov, K., (1992). Correlation between grain yield and certain plant and ear characteristics in maize hybrids. *Rasteniyedni Nauki, Bulgaria*. 29(5-6): 17-22.
3. Bahoush, M. M. Rabiei, B. Dokht, H. A. Ghasemi, A. K. and Jahandideh, (2010). Analysis of correlation coefficients between grain yield and yield components in maize hybrids [Persian] *Iranian Journal of Field Crop Science*; 2010. 41: 2, 215-223
4. Bekriæ, V., Radosavljeviæ, M. (2008): Savremeni pristupi upotrebe kukuruza. *PTEP* 12:93-96.
5. Bhole, G.R. and Patil, R.C. (1984). Genotypic and phenotypic correlations in maize. *Journal of Maharashtra Agricultural Universities*. 9: 250-251.
6. D.O. Olawamide and L. S. Fayeun (2020). Correlation and path coefficient analysis for yield and yield components in late maturing pro-vitamin A synthetic maize (*Zea mays* L.) breeding lines, *Journal of Experimental Agriculture International*, vol. 42, no. 1, pp. 64–72, View at: Publisher Site Google Scholar
7. D.S. Jakhar, R. Singh, and A. Kumar, (2017) Studies on path coefficient analysis in maize (*Zea mays* L.) for grain yield and its attributes, *International Journal of Current Microbiology and Applied Science*, vol. 6, no. 4, pp. 2851–2856.
8. Dewey, D.R. and Lu, K.H., (1959). A correlation and path coefficients analysis of components of crested wheat grass seed production. *Agron. J.*, 51: 515-518.
9. Firoza, Khatun; Sajeda Begum; Abdul Motin; Suraiya Yasmin; Islam M.R.; Khatun F.; Gegum, S.; Motin, A. and Yasmin, S., (1999) Correlation coefficient and path analysis of some maize (*Zeamays*) hybrids. *Bangladesh Journal of Botany*, 28(1): 9-15.
10. G. Beulah, S. Marker, and D. Rajasekhar, (2017) Assessment of quantitative genetic variability and character association in maize (*Zea mays* L.), *Journal of Pharmacogenetics and Phytochemistry*, vol. 7, no. 1, pp. 2813–2816.
11. Garcia Del Moral, L. F., Rharrabti, Y., Villegas, D., Royo, C. (2003): Evaluation of Grain Yield and Its Components in Durum Wheat under Mediterranean Conditions. An Ontogenic Approach. *Agron. J.*, 95: 266–274.
12. Geetha, K. and Jayaraman, N. (2000). Path analysis in maize (*Zea mays* L.). *Agricultural Science digests*. 20: 60-61.
13. Hefny, M., (2011). Genetic parameters and path analysis of yield and its components in inbred lines (*Zea mays* L.)

- at different sowing dates. *Asian Journal of Crop Science*; 3: 3, 106-117. 33 ref.
14. J. Tadesse and T. Leta, (2019) Association and path coefficient analysis among grain yield and related traits in Ethiopian maize (*Zea mays* L.) inbred lines," *African Journal of Plant Science*, vol. 13, no. 9, pp. 264–272.
 15. Jabeen, F. (2005). Studies on genetic divergence, combining ability and stability for protein, oil and grain yield in maize (*Zeamays* L.) genotypes. Ph.D. Thesis, *Acharya N.G. Ranga Agricultural University*, Hyderabad.
 16. Jawaharlal, J. Reddy, G. L. and Kumar, R. S., (2011). Genetic variability and character association studies in maize. *Agricultural Science Digest*; 2011. 31: 3, 173-177. 15 ref.
 17. Jayakumar, J. Sundaram, T. Raguramarajan, A. and Kannan, S., (2007). Studies on path analysis in maize (*Zea mays* L.) for grain yield and other yield attributes. *Plant Archives*; 2007. 7: 1, 279-282. 18 ref.
 18. Krishnan, V. and Natarajan, N., (1995). Correlation and component analysis in maize. *Madras Agric. J.*, 82: 391-393.
 19. Moradi, M. and Azarpour, E. (2011). Determination of most important part of yield components by Path Analysis in corn. *The Journal of American Science*. 7 (5): 646-650.
 20. Nataraj, V.; Shahi, J.P.; Vandana, D. (2015). Character association and path analyses in maize (*Zea mays* L.). *Environment and Ecology*; 33(1):78-81. 14 ref.
 21. NehaSinghalVerma, S. S. Baskheti, D. C. and Anil Kumar., (2006). Heritability, genetic advance, correlation and path-coefficient estimation in high quality protein maize (*Zea mays* L.). *Asian Journal of Bio Science*; 1: 2, 54-56. 11 ref
 22. P. Arsode, M. Krishna, N. Sunil, and S. Vani Sree, (2018). Correlation studies for grain yield and its components in hybrids of quality protein maize (*Zea mays* L.). *The Journal of Research PJTSAU*, vol. 46, no. 2-3, pp. 85–88.
 23. Packiaraj, D., (1995). Genetic studies of yield and its components in maize (*Zea mays* L.). *Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore, India*.
 24. Pradeep Kumar, P. and Satyanarayana, E., 2001. Variability and correlation studies of full season inbred lines of maize. *J. Res., ANGRAU, Hyderabad, India*, 29: 71-75.
 25. Rafiq, C.M.; Rafique, M.; Hussain, A. and Altaf, A. (2010). Studies on heritability, correlation and path analysis in maize (*Zea mays* L.). *Journal of Agricultural Research*. 48 (1): 35-38.
 26. Raghu, B.; Suresh, J.; Kumar, S.S. and Saidaiah, P. (2011). Character association and path analysis in maize (*Zea mays* L.). *Madras Agricultural Journal*. 98 (1/3): 7-9.
 27. Robinson, H.F, Comstock, R.E. and Harvey, P.H. (1951) Genotypic and phenotypic correlation in corn and their implication in selection. *Agron J.* 43 : 282-287.
 28. Saha, C. and Mukherjee, B.K., (1993). Grain yield of maize in relation to grain farming potential and other traits. *J. Res. Birsa Argil. Univ.*, 5 (1): 27-31.
 29. Selvaraj, C. I. and Pothiraj Nagarajan., (2011). Interrelationship and path-coefficient studies for qualitative traits, grain yield and yield attributes among maize (*Zea mays* L.). *International Journal of Plant Breeding and Genetics*; . 5: 3, 209-223.
 30. Shi Guan Zheng, Zhao Zhi Zhang, and WeiXing Yuan YuQing., (2008). Path analysis of stay-green trait in maize. *Southwest China Journal of Agricultural Sciences*; 21: 3, 570-574. 8 ref.
 31. Singh, P. K., Prasad, M. K. and Chaudary, L. B., (1999). Association analysis in winter maize. *J. Appl. Biol.*, 9(2): 133-136.
 32. Sofi, P. and Rather, A.G. (2007). Studies on genetic variability, correlation and path analysis in maize (*Zea mays* L.). *Maize Genetic Cooperation Newsletter*. 81: 26-27.
 33. Srivas, S. K. and Singh, U. P., (2007). Genetic variability, character association and path analysis of yield and its component traits in forage maize (*Zea mays* L.). *Range Management and Agroforestry*; 25: 2, 149-153. 11 ref.
 34. Umakanth, A.V. and Khan, H.A., (2000). Correlation and path analysis of grain yield and yield components in maize (*Zea mays* L.). *Journal of Research (ANGRAU)* 29(2-3): 87-90
 35. Umakanth, A.V.; Satyanarayana, E. and Nagesh Kumar, M.V., (2000). Correlation and heritability studies in Ashwini maize composite. *Annals of Agricultural Research*, 21(3): 328–330.
 36. Viola, G. Ganesh, M. Reddy, S. S. and Kumar, C. V. S., 2003. Studies on correlation and path coefficient analysis of elite baby corn (*Zea mays* L.) lines. *Progressive Agriculture*; 3: 1/2, 22-24. 9 ref.
 37. Wannows, A. A. Azzam, H. K. and Al-Ahmad, S. A., (2010). Genetic variances, heritability, correlation and path coefficient analysis in yellow maize crosses (*Zea mays* L.). *Agriculture and Biology Journal of North America*; 1: 4, 630-637. 44 ref.
 38. Webber, C.R. and Moorthy, B.R., (1952). Heritable and non-heritable relationship and variability of oil content and agronomic characteristics in the F generation of soybean crosses. *J. Agron.* 44: 202-209.
 39. Wright, S., (1921). System of mating. *Genetics*, 16: 111-178.
 40. Xu, Z.S. and Wen, S.P., (1988). A study on the characters related to grain weight per ear in maize (*Zea mays* L.) *Ningxia Journal of Agril. Forestry Science and Tech.* 2: 9-10
 41. Yagdi, K., Sozen, E. (2009): Heritability, variance components and correlations of yield and quality traits in durum wheat (*Triticum durum* Desf.). *Pak. J. Bot.*, 41(2): 753-759.



Heritability and Genetic Advance Estimates from F¹ lines of Maize (*Zea mays* L.)

Vipin Kumar and Ashvani Panwar*

Dept. of Genetics and Plant Breeding, Gochar Mahavidhalaya, Rampur Maniharan, Saharanpur, (UP) 247451

*Corresponding author & Supervisor

Abstract

A study of heritability and genetic advance was undertaken at Gochar Mahavidhalaya, Rampur Maniharan, Saharanpur (U.P.) in *kharif* season 2011 in randomized block design with three replications. Heritability and genetic advance were studied in 32 F₁ lines of maize. All the lines were collected from the gene Bank of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The data were recorded on fourteen traits viz. days to 50 % anthesis, days to 50 % silking, days to 75 % dry husk, plant height (cm), cob height (cm), cob per plant, cob length (cm), number of kernel row per cob, cob width (cm), number of kernel per row, 100 kernel weight (gm), leaf length (cm), leaf width (cm) and Grain Yield per plant (gm). Higher estimates of heritability and genetic advance were shown by these characters are least influenced by environment and shown only heritable component of the total variation which is important from breeding point of view. It is imperative to partition the overall variability into heritable and non-heritable components. The amount of heritable component is only determined by the help of heritability estimates. Heritability alone does not fulfill the best criteria for better selection in the absence of genetic advance. High heritability estimates were observed for Grain Yield per plant (98.40%), plant height (97.60%), cob height (96.70%), leaf length (94.50%) and moderate estimates of heritability were found for days to 75 % dry husk (31.90%), number of kernel row per cob (19.40%), number of kernel per row (18.90%) and cob length (18.90%), while lowest value was found for cob width (9.20%). Values of genetic advance ranged between 35.52 to 0.23 for grain yield per plant and cob width, respectively (table-1). Greater magnitude of broad sense heritability coupled with higher genetic advance in characters under study provided the evidence that these plant parameters were under the control of additive genetic effects. Indicating that selection should lead to a fast genetic improvement of the material.

Key words : Genetic advance, heritability, F¹ lines, maize,

Introduction

Maize (*Zea mays* L.) is a sturdy, annual plant of North American origin belonging to Poaceae sub-family Maydeae. It is a very versatile crop growing in all sorts of altitudinal and fertility conditions. This makes it to be an important cereal crop having global importance (FAOSTAT, 2012). It is used as a basic staple food crop and produced on nearly 100 million hectares in developing countries (FAOSTAT, 2010 and Thomas, 2012). It is one of the most traded cereals with a total estimated global production of 885.3 million tons (FAOSTAT, 2012). Together with rice and wheat, maize provides at least 30% of the food calories of more than 4.5 billion people in 94 developing countries (Thomas, 2012). Indeed, it is an excellent source of protein and food quality oil. It is more complete in nutrients in comparison to other cereals though all cereals including maize tend to be low in two essential amino acids that are lysine and tryptophan (Olson and Frey, 1987). In India, the production of maize over the years has increased linearly and major breakthrough was experienced at the dawn of 21st century, associated with the development and release of more number of hybrids during this period. Recent

emphasis on development of high yielding hybrids in preference to a continued dependence on composites has yielded rich dividends. This emphasis is likely to ensure still higher growth rates in productivity of this versatile crop in the years to come. Maize is a highly cross pollinated and C₄ type plant which is highly responsive to fertilizers resulting in high per day productivity. It offers tremendous scope for the plant breeders for genetic improvement. Knowledge of heritability and genetic advance of characters indicates scope for improvement of traits through selection. Hence the present study was undertaken to estimate the broad sense heritability and genetic advance in maize.

Materials and Methods

The experimental material used in the study comprised of thirty two F₁ lines of maize were obtained from the gene bank of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The seeds were sown in a randomized block design (RBD) with three replications at the agriculture field of Gochar Mahavidhalaya, Rampur Maniharan, Saharanpur (U.P.). Spacing between row to row and plant to plant was 60 cm and 20 cm, respectively. The crop was raised as per the recommended package of

Table-1 : Heritability and genetic advance for 14 characters of maize F₁ lines.

Characters	Heritability (%)	Genetic advance (K=2.06)	GA as percentage of mean
Days to 50% Anthesis	83.60	3.42	7.22
Days to 50% Silking	82.50	3.40	6.88
Days to 75% dry husk	31.90	2.13	2.52
Plant Height (cm)	97.60	27.46	18.44
Cob Height (cm)	96.70	30.81	44.03
Cob per plant	67.50	0.30	24.30
Cob length (cm)	18.90	1.04	6.94
No. of kernel row per cob	19.40	0.61	4.89
Cob Width (cm)	9.20	0.23	1.82
No. of kernel per row	18.90	2.09	7.74
100 Kernel weight (gm)	72.90	2.94	10.90
Leaf Length (cm)	94.50	16.81	27.61
Leaf Width (cm)	54.50	1.23	15.85
Grain Yield per plant (gm)	98.40	35.52	38.91

practices to obtain proper plant stand in the experiment. The pre and post-harvest observations like days to 50 % anthesis, days to 50 % silking, days to 75 % dry husk, plant height (cm), cob height (cm), cob per plant, cob length (cm), number of kernel row per cob, cob width (cm), number of kernel per row, 100 kernel weight (gm), leaf length (cm), leaf width (cm) and grain yield per plant (gm) were recorded on five plants selected at random from each genotype in each replication. Heritability in broad sense was calculated by the formula given by Hanson *et al.*, (1956). The estimates of genetic advance were obtained by the formula given by Johnson *et al.*, (1955).

Heritability

$$h^2_b(\%) = \frac{{}^2g}{{}^2p} \times 100$$

Where,

${}^2g$ = Genotypic variance

${}^2p$ = Phenotypic variance

${}^2e$ = Error variance

Genetic advance :

It was calculated by following formula as suggested by Johnson *et al.* (1955).

$$GA = K^{SD}ph \times h^2$$

Where,

GA = Genetic advance

H = Heritability estimate

K = Selection differential at 5% selection

Intensity = 2.06

SD ph = Phenotypic standard deviation

Genetic advance in percentage of mean :

It was calculated by the following GA in percentage of mean $\frac{G.A.}{\bar{X}} \times 100$

Where,

G.A. = Genetic advance

$\bar{X}$ = Grand mean of the character

Results and Discussion

In crop improvement programme, only the genetic component of variation is important since only this component is transmitted to the next generation. The extent of contribution of genotypic to the phenotypic variation for a trait in a population is ordinarily expressed as the ratio of genetic variance to the total variance i.e., phenotypic variance for the trait; this ratio is known as heritability. The heritability can be obtained two types depending on the numerous for used for estimation as broad sense and narrow sense. The present values estimated under the study are of broad sense heritability. Low, medium and high estimates of broad sense heritability were found in different plant traits under study (table-1). Highest heritability estimates were found in grain yield per plant (98.40%) followed by plant height (97.60%), cob height (96.70%), leaf length (94.50%), days to 50 % anthesis (83.60%), days to 50 % silking (82.50%), 100 kernel weight (72.90%), cob per plant (67.50%), leaf width (54.50%), days to 75 % dry husk (31.90%), number of kernel row per cob (19.40%), number of kernel per row (18.90%) and cob length (18.90%), while lowest value was found for cob width (9.20%), indicated more influenced by environmental factors. Swamy *et al.* (1971),

Table-2 : Mean performance of thirty two F₁ lines with respect to fourteen characters in maize genotypes.

S. No.	Genotypes	Days to 50% Anthesis	Days to 50% Silking	Days to 75% dry husk	Plant Height (cm)	Cob Height (cm)	Cob par plant	Cob length (cm)	No. of kernel row per cob	Cob. Width (cm)	No. of kernel per row	100 Kernel weight (gm)	Leaf Length (cm)	Leaf Width (cm)	Grain Yield per plant (gm)
1.	M1	46.33	48.33	82.00	139.67	60.00	1.50	15.16	13.33	13.77	27.50	27.20	64.00	9.33	99.70
2.	M2	46.33	48.33	86.33	141.67	53.33	1.03	16.45	12.44	12.64	27.22	29.67	57.33	7.33	100.46
3.	M3	46.00	48.33	83.67	128.67	53.00	1.93	19.43	13.11	12.94	34.83	25.30	49.33	7.67	115.54
4.	M4	47.67	49.67	86.00	149.67	66.00	1.30	17.23	14.66	13.41	30.89	25.33	66.67	8.33	114.74
5.	M5	48.33	50.33	82.00	137.00	66.67	1.53	15.48	12.22	12.85	26.33	28.23	58.33	8.33	90.84
6.	M6	47.67	49.67	80.00	150.33	69.33	1.10	12.53	12.00	11.63	22.17	26.53	64.00	7.00	70.58
7.	M7	47.00	49.00	84.33	153.33	56.00	1.03	16.36	12.67	12.95	29.55	26.40	59.00	7.33	98.83
8.	M8	45.00	46.67	85.67	156.00	67.00	1.27	17.33	13.33	13.00	32.78	27.93	56.33	8.33	122.07
9.	M9	46.33	48.67	85.67	137.00	49.67	1.07	14.20	12.66	12.69	25.89	24.73	55.33	6.67	81.08
10.	M10	49.67	52.00	85.00	134.00	44.67	1.10	13.30	12.11	12.51	22.66	26.30	52.00	7.33	72.18
11.	M11	50.00	51.67	83.33	160.00	79.33	1.10	16.37	12.78	12.81	29.05	27.47	43.00	6.33	101.96
12.	M12	50.00	52.00	82.00	123.67	56.00	1.17	17.58	12.89	13.05	30.44	26.30	47.00	6.33	103.18
13.	M13	48.00	50.00	84.33	192.00	100.00	1.17	15.14	12.33	12.33	26.72	28.53	85.67	10.00	94.01
14.	M14	47.00	50.00	85.00	158.00	82.67	1.30	14.88	12.89	12.58	29.11	29.70	66.00	8.67	111.41
15.	M15	46.33	48.67	82.00	148.00	74.67	1.43	14.82	12.65	12.90	26.55	26.27	68.00	8.67	88.24
16.	M16	46.33	48.33	83.00	138.00	64.00	1.10	15.40	12.78	11.87	27.00	30.00	56.33	8.00	103.49
17.	M17	46.33	48.67	80.67	154.00	78.00	1.00	16.62	12.55	13.44	31.72	24.90	56.00	7.67	99.15
18.	M18	44.67	46.67	87.00	151.00	92.67	1.10	14.89	13.00	12.63	27.39	26.23	62.33	7.33	93.40
19.	M19	50.33	52.33	83.33	154.67	86.00	1.27	14.82	11.89	12.38	25.22	26.37	72.00	8.33	79.04
20.	M20	52.00	54.00	85.00	169.33	100.00	1.27	13.55	11.67	12.17	25.83	29.73	68.00	7.67	89.61
21.	M21	51.00	53.00	81.33	147.33	87.33	1.17	13.69	11.75	12.36	25.78	27.60	66.33	7.33	83.62
22.	M22	48.67	51.00	90.67	155.67	56.00	1.30	13.83	11.53	12.42	26.61	26.90	65.33	8.00	82.56
23.	M23	48.00	50.00	84.67	154.67	87.33	1.27	16.55	13.78	14.49	29.67	24.93	59.67	8.33	101.90
24.	M24	47.67	49.67	86.33	164.00	69.00	1.17	13.23	10.67	11.30	26.50	26.43	67.33	8.00	74.72
25.	M25	46.00	48.00	85.33	141.00	60.33	1.30	12.12	10.00	10.52	19.83	27.70	66.33	8.33	54.94
26.	M26	45.00	47.00	85.33	123.33	50.33	1.07	12.43	10.67	11.38	23.33	29.47	72.00	9.00	73.34
27.	M27	44.67	46.67	87.67	160.00	85.33	1.07	12.28	11.11	12.15	20.05	23.53	59.67	8.00	52.43
28.	M28	46.00	48.00	80.67	153.67	82.00	1.20	15.03	11.67	12.26	27.55	23.50	61.67	8.33	75.54
29.	M29	46.00	48.00	83.33	141.00	77.00	1.53	14.34	14.33	13.38	27.44	26.47	51.33	6.67	104.07
30.	M30	46.00	48.00	83.67	145.67	58.67	1.37	12.64	13.22	12.85	21.94	27.70	64.00	6.33	80.36
31.	M31	48.33	50.33	86.33	149.00	74.67	1.13	14.18	12.78	12.72	22.89	29.50	57.00	7.00	86.26
32.	M32	47.33	49.33	88.33	153.33	52.33	1.17	17.80	13.89	13.60	33.22	26.47	51.00	6.33	122.09
	Mean	47.38	49.45	84.38	148.90	69.98	1.23	14.99	12.48	12.62	26.99	26.98	60.89	7.76	91.29
	min	44.67	46.67	80.00	123.33	44.67	1.00	12.12	10.00	10.52	19.83	23.50	43.00	6.33	52.43
	max	52.00	54.00	90.67	192.00	100.00	1.93	19.43	14.66	14.49	34.83	30.00	85.67	10.00	122.09
	SE	0.66	0.68	2.18	1.73	2.31	0.102	1.97	1.12	0.954	3.95	0.831	1.64	0.602	1.83
	CD 5%	1.31	1.35	4.34	3.44	4.59	0.20	3.92	2.21	1.90	7.86	1.65	3.26	1.20	6.56

Patil *et al.* (1972) and Singh and Chaudhry (1985) also reported similar findings. They computed high heritability estimates for grain yield per plant and plant height. Bhalla *et al.* (1986) also reported high heritability for grain yield per plant and plant height. Results of present studies also got support from the findings of Jha and Ghosh (1998). Values of genetic advance ranged between 35.52 for grain yield per plant to 0.23 for cob width. Highest value of genetic advance was found for grain yield per plant (35.52) followed by cob height (30.81), plant height (27.46), leaf length (16.81), days to 50 % anthesis (3.42), days to 50 % silking (3.40), 100 kernel weight (2.94), days to 75 % dry husk (2.13), number of kernel per row (2.09), leaf width (1.23), cob length (1.04), number of kernel row per cob (0.61), cob per plant (0.30) and cob width (0.23). Since higher estimates of heritability and genetic advance were shown by these characters are least influenced by environment and shown only heritable component of the total variation which is important from breeding point of view. It is imperative to partition the overall variability into heritable and non heritable components. The amount of heritable component is only determined by the help of heritability estimates. Heritability alone does not fulfill the best criteria for better selection in the absence of genetic advance. High heritability estimates were observed for grain yield per plant (98.40%), plant height (97.60%), cob height (96.70%) and leaf length (94.50%). These findings are with accordance of earlier reports of experimental findings. A genetic advancement of 35.52 in grain yield per plant, was estimated from single cycle of selection at K = 2.06. Highest value of genetic advance was found for grain yield per plant (35.52) followed by cob height (30.81), plant height (27.46), leaf length (16.81), days to 50 % anthesis (3.42), days to 50 % silking (3.40), 100 kernel weight (2.94), days to 75 % dry husk (2.13), number of kernel per row (2.09), leaf width (1.23), cob length (1.04), number of kernel row per cob (0.61), cob per plant (0.30) and cob width (0.23). High heritability coupled with high genetic advance was observed for grain yield per plant which indicates the presence of additive gene action for controlling this trait (table-1). High heritability with moderate to low genetic advance is the indication of role of both additive and non additive gene action and vice versa. Similar types of findings were earlier reported by Osuna *et al.* (1995), Satyanarayana and Sai Kumar (1996), Viola *et al.* (2003), Singh *et al.* (1998), Naha Singhal *et al.* (2006), Rafiq *et al.* (2010), Bhusal, T. *et al.* (2017). Results of high heritability and genetic advance of grain yield per plant are also in accordance with those reported by Li and Song (1991), Jha and Ghosh (1998) and Singh and Dash (2000), Kandel, BP. *et al.* (2018),

Bartaula *et al.*, (2019). Hence provides better opportunities for selecting plant material regarding these traits. After studying of heritability it was indicated that highest heritability was existed for grain weight per cob followed by plant height, cob height and leaf length. The highest genetic advance was present for grain weight per cob and cob height.

References

1. Bartaula, *et al.*, (2019), S. Bartaula, U. Panthi, K. Timilsena, S. Acharya, J. Shrestha, Variability, heritability, and genetic advance of maize (*Zea mays* L.) genotypes *Res. Agri. Live. Fish.*, 6 (2), pp. 163-169.
2. Bhalla, S.K., S. Bali, S. Sharma and B.K. Sharma.(1986). Assessment of genetic variability and correlation in indigenous maize germplasm of Himachal Pradesh. *Himachal J. Agric. Res.*, 12: 75-81
3. Bhusal T, GM Lal, S Marker and GJ Synrem,(2017). Genetic variability and traits association in maize (*Zea mays* L.) genotypes. *Annals of Plants and Soil Research*, 19(1): 59-65
4. FAOSTAT (2012). Agriculture database; agricultural production, *Food and Agriculture Organization*.
5. FAOSTAT (2010). Statistical databases and data-sets of the *Food and Agriculture Organization of the United Nations*.
6. Hanson, G.H., Robinson, H.F. and Comstock, R.E., (1956). Biometrical studies of yield in segregating populations of Korean hespedeza. *Agron. J.*, 48: 267-282.
7. Jha, P.B. and J. Ghosh, (1998). Genetic variability in fodder maize. *J. Res.Birsa Agri. Univ.* 10: 139-43
8. Johnson, H.W., Robinson, H.F. and Comstock, R.E., (1955). Genotypic and phenotypic correlations and their implications in selection of soybean. *Agron. J.*, 47: 477-483.
9. Kandel, B.P., B.K. Sharma, S. Sharma and J. Shrestha, (2018). Genetic variability, heritability, and genetic advance estimates in early maize (*Zea mays* L.) genotypes in Nepal. *Agricultura*, **107**(3-4): 29-35.
10. Li, W. and T.M. Song, (1991). Estimates of genetic parameters for 13 quantitative traits in a recombined high oil maize population of IHO[(80) x Alexo(C23)]. *Acta Agronomica Sinica.*, 17: 470-5
11. Neha Singhal Verma, S. S. Baskheti, D. C. and Anil Kumar., (2006). Heritability, genetic advance, correlation and path-coefficient estimation in high quality protein maize (*Zea mays* L.). *Asian Journal of Bio Science*; **1**: 2, 54-56. 11 ref
12. Olson, R. and Frey, K.(1987.) Nutritional quality of cereal grains. *Crop science society of America, Agronomy*, 28 (511).
13. Osuna, A.J.; Churata, B.G.; Avila, L.G. and Cespedes, P.L.M., (1995). Estimates of genetic parameters in the maize composite (*Zea mays* L.). *Memorias de la III Reunion Latinoamericana Maize.*, Cochabamba, Santa Cruz, Bolivia, pp. 769-779.
14. Patil, S.J., R.T. Swamy and S. Ramamurty, (1972). Genetic variation, heritability and genetic advance of quantitative characters in maize. *Genetic Polonica.*, 13: 181-2.

15. Rafiq, C.M. Muhammad Rafiq, Amer Hussain and Muhammad Altaf., (2010). Studies on heritability, correlation and path analysis in maize (*Zea mays* L.) *Journal of Agricultural Research (Lahore)*; 48: 1, 35-38. .
16. Satyanarayan, E. and Sai Kumar, R., (1996). Genetic variability of yield and maturity components in maize hybrids. *Curr. Res. Univ. Agric. Sci.* Bangalore, 25(1): 10-11.
17. Singh, A. K. Shahi, J. P. Singh, J. K. and Singh, R. N., (1998). Heritability and genetic advance for maturity and yield attributes in maize. *Journal of Applied Biology*; 8: 1, 42-45.
18. Singh, J.M. and B. Dash, (2000). Analysis of genetic variability and character association in maize. *African Crop Sci.*, 5: 1-8.
19. Singh, R.K. and B.D. Chaudhry, (1985). Biometrical Methods in Quantitative Genetic Analysis. pp: 38-54. *Kalyani Pub.*, New Delhi, India
20. Sumathi P, Nirmalakumari A and Mohanraj K (2005). Genetic variability and traits interrelationship studies in industrially utilized oil rich CIMMYT lines of maize (*Zea mays* L). *Madras Agric. J.* 92 (10-12): 612-617.
21. Swamy, R., T.A. Ramamurty, S.J. Patil and R.S. Aradhya, (1971). Genetic variability and heterosis in maize. *Madras Agric. J.*, 58: 620-3
22. Thomas, A.(2012) Help for Developing Countries in a World of Rising Grain Prices, *CIMMYT*,.
23. Viola, G. Ganesh, M. Reddy, S. S. and Kumar, C. V. S., (2003). Studies on correlation and path coefficient analysis of elite babycom (*Zea mays* L.) lines. *Progressive Agriculture*; 3: 1/2, 22-24.



Nitrogen Management in Late Sown Wheat (*Triticum aestivum* L.) Varieties

Komal Sharma and Udham Singh Tiwana

School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

A field experiment was conducted during the *rabi* season of 2019-20 at Agriculture Research Farm of School of Agricultural Sciences and technology, RIMT University, Mandi Gobindgarh, Punjab to study the nitrogen management in late sown wheat varieties. The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments comprised of two varieties viz; PBW-343, PBW-550 and four nitrogen levels viz; 100, 125, 150 kg N ha⁻¹ and leaf color chart (LCC). The plant population was not influenced significantly by varieties and nitrogen levels. The variety PBW-343 recorded significantly higher plant height (92.1 cm) over PBW-550 (87.4 cm). The grain yield was recorded significantly higher in variety PBW 550 (49.1 q ha⁻¹) over PBW 343 (46.9 q ha⁻¹). Straw yield and harvest index also followed the same trend in varieties. The application of 125 kg N ha⁻¹ produced significantly taller plants (85.5 cm) over 100 kg N ha⁻¹ (78.3 cm) but was at par with LCC (82.60 cm) and 150 kg N ha⁻¹ (83.6 cm). The application of 125 kg N ha⁻¹ recorded significantly higher yield attributes over the 100 kg N ha⁻¹ but was at par with LCC. The application of 125 kg N ha⁻¹ (49.1 q ha⁻¹) recorded significantly higher grain yield over 100 kg N ha⁻¹ (45.0 q ha⁻¹) and but was at par with 150 kg N ha⁻¹ (47.9 q ha⁻¹) LCC (46.2 q ha⁻¹). The Straw yield and harvest index also followed the same trend. The interaction effect between varieties and nitrogen levels was found to be non-significant in all the parameters.

Key words : *Wheat varieties, nitrogen levels and LCC.*

Introduction

Wheat is the most extensively grown cereal crop in the world. It is grown all over the world for its highly nutritious and useful grain. It is used in production of bread, biscuits, feeds, confectionary, amongst many, utilization (Oyewole, 2016). In the world, wheat is cultivated in an area of about 239 million hectares with a total production of 425.5 million tonnes of grains. In the marketing year of 2019-20, the global production volume of wheat amounted to over 765 million metric tons. This was an increase of over 30 million tons compared to the previous marketing year (Shahbandeh, 2021). Presently in India, wheat is grown over an area of 23.61 million hectares with total production of 44.25 million tonnes of grains annually. In Punjab, wheat was grown on an area of 35.20 lakh hectares during 2019-2020 with production 176.2 lakh tonnes and average yield of 50.04 quintals per hectare (Anonymous, 2021). Nitrogen is an essential constituent of chlorophyll and plays a vital role in metabolic process (Ali et al., 2012). The important role of nitrogen in the plant is its presence in the structure of protein, the most important building substances from which the living material of protoplasm of every cell is made. Excessive nitrogen causes lush succulent growth, resulting in greatly increased danger of lodging, delayed maturity and greater susceptibility to diseases (Abedi et al., 2011). LCC is a visual and subjective indicator of deficiency of nitrogen in plant and it is inexpensive and easy to use. It measures leaf color

intensity which is related to nitrogen status of the leaf. The different shades of green color are present on the LCC and by matching the color of the plant leaf to the color on LCC, the right quantity of nitrogen fertilizer and right time to apply the fertilizer can be decided easily (Adhikary, 2015).

Materials and Methods

The experiment was carried out during the *rabi* season of 2019 at the Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experiment is located at 30.6642°N latitude and 76.2914°E longitude at an altitude of 268 meters above mean sea level. The maximum temperature often exceeds 40°C during summer. Minimum temperature falls below 6°C with some frosty spells of 8-10 days during winter months of December and January. The average rainfall of Mandi Gobindgarh is 730.2 mm. The experiment field tested was in organic carbon (0.48%) and available nitrogen (144.6 kg N ha⁻¹), medium in available phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of i.e. two varieties PBW-343 and PBW-550 and four nitrogen levels viz. 100, 125, 150 kg N ha⁻¹ and LCC. The seed at the rate of 112.5 kg per hectare was used for sowing the experiment. The gross plot size was 4.3 m × 3.5 m and net plot size was 4.0 m × 3.0 m. The crop was sown 28th

Table-1 : Effect of different nitrogen levels on late sown wheat varieties under different nitrogen levels.

Treatment	Plant population	Plant Height (cm)	Ear length (cm)	Grain wt./ear (g)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Varieties								
PBW-343	125.2	92.1	11.0	2.80	36.1	46.9	65.5	41.3
PBW-550	126.4	87.4	13.0	3.24	38.2	49.1	69.7	41.7
6CD at 5%	NS	4.94	1.36	0.40	2.06	2.21	3.70	NS
Nitrogen levels (kg/ha)								
100	124.1	78.3	10.2	2.5	35.7	45.0	63.1	41.62
125	127.6	85.5	13.9	3.5	38.9	49.1	67.7	42.8
150	123.9	83.6	13.1	3.4	37.7	47.9	65.5	41.4
LCC	127.7	82.6	12.9	3.3	38.6	44.2	62.3	41.5
CD at 5%	NS	3.49	0.96	0.28	1.46	1.87	2.37	1.22
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV %	8.92	7.09	9.08	10.0	5.28	7.19	8.14	2.60

December, 2019 and harvest 6th May, 2020. All the other culture practices were uniformly followed.

Results and Discussion

Growth Parameters

Plant population : The plant population of wheat varieties was not influenced significantly by different levels of nitrogen (Table-1).

Plant height : Significantly higher plant height was recorded in variety PBW-343 (92.1 cm) over PBW-550 (87.4 cm). The application of 125 kg N ha⁻¹ (85.5 cm) recorded significantly higher plant height over 100 kg N ha⁻¹ (78.3 cm) but was at par with 150 kg N ha⁻¹ (83.6 cm) and LCC (82.6 cm). The interaction effect between varieties and nitrogen levels was found to be non-significant. Variation in plant height among varieties might also be probably due to their genetic characters. Similarly finding in respect to varieties were reported by Brijkishor (1998). Higher nitrogen level resulted higher nitrogen uptake, which ultimate results into increased protein synthesis, cell division and cell enlargement which express morphologically an increase in height of plant. Similar finding was reported by Mankotia et. al. (2017).

Yield Attributes

Ear length (cm) : The yield attribute of ear length was significantly influenced by late sown varieties and nitrogen levels (Table-1). The maximum length of ear was observed with variety PBW- 550 (13.0 cm) which was significantly over variety PBW-343 (11.0 cm). The significantly higher ear length was found in 125 kg N ha⁻¹ (13.9 cm) over 100 kg N ha⁻¹ (10.2 cm) but was at par with 150 kg N ha⁻¹ (13.1 cm) and LCC (12.9 cm). Non-significant interaction effect between variety and nitrogen levels was recorded.

Grain weight/ear : Grain weight ear-1 of late sown wheat was influenced significantly by varieties and nitrogen levels (Table-1). The maximum grain weight /ear was found with variety PBW-550 (3.24 g) significantly over variety PBW-343 (2.80 g). Application of 125 kg N ha⁻¹ (3.5 g) produced significantly higher grain weight ear⁻¹ over 100 kg N ha⁻¹ (2.5 g) but was at par with LCC (3.3 g) and 150 kg N ha⁻¹ (3.4 g). The interaction effect between of varieties and nitrogen levels was found non-significant.

1000 grain weight (g) : Test weight of late sown wheat was influenced significantly by varieties and nitrogen levels (Table-1). The significantly higher grain weight was recorded in variety PBW-550 (38.2 g) over PBW-550 (36.1 g). The application of nitrogen 125 kg N ha⁻¹ (38.9 g) recorded significantly higher test weight over 100 kg N ha⁻¹ (35.7 g) but was at par with LCC (38.6 g) and 150 kg N ha⁻¹ (37.7 g). Non-significant interaction effect between varieties and nitrogen levels was recorded. Singh and Singh (1989) also found that variety gave higher number of grain ear-1, ear length, 1000 grain weight, than variety might be due to the genetic character of the variety.

Grain yield (q ha⁻¹) : Grain yield of late sown wheat was influenced significantly by varieties and nitrogen levels (Table-1). Among the varieties, maximum grain yield was recorded with variety PBW-550 (49.1 q ha⁻¹), which was significantly higher over variety PBW-343 (46.9 q ha⁻¹). The grain yield increases with increase nitrogen level into 125 kg N ha⁻¹ (49.1 q ha⁻¹). Application of 150 kg N ha⁻¹ (47.9 q ha⁻¹) was significantly superior over 100 kg N ha⁻¹ (45.0 q ha⁻¹) but was at par with 125 kg N ha⁻¹ (49.1 q ha⁻¹) and LCC (44.2). The higher grain yield was might be due to more ear length, number of grains ear-1, grain weight ear-1 and 1000 grain weight. Similar findings were

reported by Singh et. al, (2002). Interaction effect between varieties and nitrogen levels was non-significant.

Straw yield (q ha^{-1}) and Harvest index (%) : The data in (Table-1) reveal that the straw yield was affected significantly due to varieties and nitrogen levels. Maximum straw yield was recorded with variety PBW-550 (69.7 q ha^{-1}) which was significantly higher over variety PBW-343 (65.5 q ha^{-1}). Straw yield increased significantly with increasing nitrogen levels up to 150 kg N ha^{-1} (65.5 q ha^{-1}). Application of 125 kg N ha^{-1} (67.7 q ha^{-1}) recorded significantly higher over 100 kg N ha^{-1} (63.1 q ha^{-1}) but was at with 150 kg N ha^{-1} (65.5 q ha^{-1}) and LCC (62.3). Interaction effect between varieties and nitrogen levels was non-significant. This may be probably due to higher shoots and increased rate of dry matter accumulation. Similar results were given by Singh (2002). However, nitrogen management and late sown wheat varieties were failed to affect the harvest index.

Conclusion

It may be concluded from the current experiment that grain yield (49.1 q/ha) with the application of 125 kg N/ha .

References

1. Anonymous (2021) *Pack of practices for crops of Punjab, Rabi 2020-21*. Punjab Agricultural University, Ludhiana, India, Pp: 1-7.
2. Abedi, T., Alemzadeh, A and Kazemeini, S.A. (2011) Wheat yield and grain protein response to nitrogen amount and timing. *Australian journal of crop science*, 5: 330-36.
3. Adhikary, P., (2015) Leaf color chart a tool for nitrogen management. *Rashtriya Krishi*, 10(1): 110-11.
4. Ali, A., Ahmad, A., Syed, W.H., Khaliq, T., Asif, M. and Aziz, M. (2012). Effects of nitrogen on growth and yield components of wheat. *Science International Lahore*, 24: 331-32.
5. Brijkishor (1998). To assess the performance of newly developed strains of wheat under zero tillage condition with varying nitrogen levels. *M.Sc. (Ag) Thesis submitted to N.D.U.A and T., Kumarganj, Faizabad*.
6. Mankotia, K., Savic, N., Jelic, J. and Nikoic, K. (2007). The influence of mineral nitrogen on plant height and spike length at various cultivar of wheat. Faculty of agriculture, University of Prishtin, Leseak, Serbia. 58(2): 37-42.
7. Oyewole, C. (2016). The wheat crop. *Research gate*, 10: 13776-92164.
8. Shahbandeh, M., (2021). Wheat -production volume worldwide 2011/2012-2020/21.
9. Singh, A.N., (2002). Response of wheat varieties to various nitrogen levels. *M.Sc. (Ag) Thesis submitted to N.D.U.A and T., Kumarganj, Faizabad, India*.
10. Singh, B., Singh, Y., Ladha, J.K., Bronson, K.F., Balasubramanian, V., Singh, J., Khind, C.S. (2002). Nitrogen management for rice and wheat in north eastern India, *Journal of Agronomy*, 94: 821-29.
11. Singh, B. (1998). To assess the performance of new wheat varieties under late-sown condition with different nitrogen levels. *M.Sc. (Ag) Thesis submitted to N.D.U.A. and T., Kumarganj, Faizabad*.



Response of Wheat (*Triticum aestivum* L.) Varieties to Phosphorous Levels Under Late Sown Conditions

Pritpal Singh and Udham Singh Tiwana

School of Agriculture Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India

Abstract

The field experiment was carried out at Agricultural Research Farm of School of Agriculture Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during the *rabi* season of 2019-20 to study the response of wheat (*Triticum aestivum* L.) varieties to phosphorus levels. The treatments consisted of two varieties viz. PBW 550 and PBW 725 and four phosphorus levels viz. 0, 30, 60, 90 kg P₂O₅ ha⁻¹. The experiment was laid out in randomized complete block design (RCBD) with three replications. The variety PBW 550 recorded significantly higher grain yield 51.1 (q ha⁻¹) of late sown wheat over variety PBW 725 (48.0 q/ha⁻¹) by a margin of 6%. The higher grain yield 51.1 q/ha⁻¹ in PBW 550 was might be due to highest number of tillers, long spike, more grains spike⁻¹ and more 1000-grains weight. Similarly, in case of phosphorus the highest grain yield was observed with 90 kg P₂O₅ ha⁻¹ which was significantly higher than control and 30 kg P₂O₅ ha⁻¹ but was a par with 60 kg P₂O₅ ha⁻¹. The magnitude of increase was 42.2 %, 8 %, 4.1 % over control, 30 and 60 kg P₂O₅ ha⁻¹ respectively. The higher grain yield with the application of 90 kg P₂O₅ ha⁻¹ was might be due to adequate nutrient availability which might have increased the dry matter accumulation, higher yield attributes and thus led to higher yield. The interaction between varieties and phosphorus levels was non-significant in all growth parameters, yield attributes and yield.

Key words : Wheat varieties, phosphorus levels, growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important winter cereal crop in India after rice. It contributes substantially to the national food security by providing more than 50 percent calories to the people who mainly depend it (Kaur *et al.* 2015). Wheat is grown in India over an area of about 30.55 million hectare with production 107 MT. (Anonymous, 2020). In Punjab, it is grown on an area of 35.20 lakh tonnes with production of 176.2 lakh tonnes and average yield of 50.04 quintals per hectare (Anonymous, 2021). Wheat is a major cereal crop of Punjab but the grain of wheat is much low than other developed countries. Sowing time, Seed rate, Nitrogen application particularly, Phosphorus application and varieties are major factor which influence the grain yield of wheat. Phosphorus is the most essential plant nutrient next to nitrogen which plays a major role for achieving the maximum crop production. It plays a vital role in several physiological processes viz. photosynthesis, respiration energy storage and cell division. It is also important structural components of many biochemicals viz. nucleic acid (DNA and RNA enzymes and co-enzymes) and also stimulates root growth and associated with early maturity of crops (Bairwa *et al.* 2018).

Materials and Methods

The experiment was carried out during *rabi* season 2019-21 at the Agriculture Research Farm, RIMT

University, Mandi Gobindgarh, Punjab. The experimental located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium in phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of two varieties sowing viz. PBW 550 and PBW 725 and four phosphorus levels viz. 0, 30, 60, 90. The 120 kg seed ha⁻¹ was used for sowing and crop was sowing on December 27, 2019 at a spacing of 20 x 15 cm. The phosphorus in the form of single superphosphate (16-22% P₂O₅) was applied as per the treatments. The gross plot size 4.5 m x 3.5 m and net plot size was 4.0 m x 3.0 m. The crop was harvested on May 7, 2020. All the other practices were applied uniformly to the treatments.

Results and Discussion

Growth Parameters

Plant height : The plant height of late sown wheat was influenced significantly by varieties and phosphorus levels (Table-1). Among different varieties, the significantly higher plant height was observed in PBW 725 (91.1 cm) than PBW 550 (76.8 cm). The magnitude of increase in plant height was 15.6 percent. Variation in plant height among varieties was might also be probably due to their genetic characters. Phosphorus levels, recorded plant

Table-1 : Effect of varieties and phosphorus levels on the growth parameters, yield attributes and yield of late sown wheat.

Treatments	Plant height (cm)	Number of tillers (m/row length)	Ear length (cm)	Numbers of grains/ear	1000-grains weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Varieties								
PBW 550	76.8	81.8	9.8	32.3	35.5	51.1	70.6	41.8
PBW 725	91.1	77.0	8.2	30.4	32.3	48.0	73.7	39.4
CD at 5%	4.6	4.3	0.54	1.7	1.9	2.6	NS	2.2
Phosphorus levels (kg P₂O₅ ha⁻¹)								
P ₁ Control	73.8	71.6	7.2	27.1	29.3	38.8	65.1	37.6
P ₂ 30	80.5	77.8	8.3	30.0	32.4	51.1	73.6	40.7
P ₃ 60	87.3	84.0	9.7	32.9	35.4	53.0	72.0	42.0
P ₄ 90	94.1	84.3	10.9	35.5	38.3	55.2	75.9	42.3
CD at 5%	6.5	6.1	0.77	2.4	2.7	3.8	NS	3.1
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.2	6.1	6.8	6.3	6.5	6.2	10.3	6.1

height with the application of 90 kg P₂O₅ ha⁻¹ significant with rest levels at all stages of growth. Interaction effect due to varieties and phosphorus levels was non-significant. Tallest plants with 90 kg P₂O₅ ha⁻¹ higher phosphorus levels were due to rapid by maintenance of adequate and continuous phosphorus supply to the crops which maintained good establishment of the roots and various metabolic process which performed higher nutrient mobilization and uptake resulting in rapid cell division, cell elongation and thus resulted in higher plant height. The smallest plants were measured under control at all the growth stages due to poor root growth caused by nutrient deficit condition. Singh *et al.* (2018) also reported similar results.

Tillers/m row length : Number of tillers of late sown wheat was recorded significantly by varieties and phosphorus levels (Table-1). Among different varieties, the variety PBW 550 (82.1) recorded significant higher tillers per m/row length of late sown wheat over variety PBW 725 (78.1). The magnitude of increase was 4.8 percent. Interaction effect due to varieties and phosphorus levels was non-significant. The phosphorus result indicated that highest number of tillers m/row length (84.3) were observed with 90 kg P₂O₅ which was significantly higher than control and 30 kg P₂O₅ ha⁻¹ but was at par with 60 kg P₂O₅ ha⁻¹. The increased number of tillers m/row length with phosphorus doses might be due to effective root system and better nutrient absorption from soil. Rahim *et al.* (2010) observed higher number of tillers, grain spike⁻¹, test weight and wheat grain yield was increased significantly up to 81 kg P₂O₅ ha⁻¹.

Yield Attributes

Ear length : The ear length of late sown wheat was influenced significantly by varieties and phosphorus levels

(Table-1). The variety PBW 550 recorded significantly higher ear length (9.8 cm) over variety PBW 725. In case of phosphorus levels, maximum ear length (10.9 cm) was recorded with 90 kg P₂O₅ ha⁻¹. This could be attributed to the fact that, phosphorus plays a key role in root development, energy transformation and metabolic processes in plant. These results are in conformity with those of Mumtaz *et al.* (2014) and Noonari *et al.* (2016).

Grains/ear : The grains/ear of late sown wheat were also influenced significantly by varieties and phosphorus levels (Table-1). Among different varieties, grains ear⁻¹ increased significantly in variety PBW 550 (32.3) over the variety PBW 725 (30.4) by a margin 5.8 percent higher respectively. The more grains/ear in PBW 550 were might be due to genetic variability. The highest number of grains per spike (35.5) were recorded for 90 kg P₂O₅. It could may be due to higher rate of phosphorus. Dugassa *et al.* (2019) also reported the similar result.

Test weight : Test weight of late sown wheat was influenced significantly by varieties and phosphorus levels (Table-1). Among different varieties, the significantly higher test weight was observed in variety PBW 550 (35.5 g) over variety PBW 725 (32.3 g). The test weight observed (38.3 g) which 90 kg P₂O₅ which was significantly higher than control, 30 and 60 kg P₂O₅ ha⁻¹. Higher phosphorus application rate which causes increased in grain size which ultimate increased the number of grains per ear and grain weight. The interaction between varieties and phosphorus levels were non-significant.

Yield Parameters

Grain yield : Grain yield of late sown wheat was influenced significantly by varieties and phosphorus levels (Table-1). The variety PBW 550 recorded significantly

higher grain yield (51.1 q ha^{-1}) over variety PBW 725 (48.0 q ha^{-1}). The higher yield in varieties might was due to highest number of tillers, long spike and more grains spike $^{-1}$ with more test weight. In case of phosphorus levels, significantly higher grain yield of 55.2 q ha^{-1} with $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ which was significantly superior to $0 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ and $30 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ but was at par with $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. The magnitude of increase was 42.2%, 8% and 4.1 % over control, 30 and $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ respectively. The higher grain yield was might be due to adequate nutrient availability which contributed to increase dry matter accumulation, higher yield attributes and thus led to higher yield with the $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. Reduced phosphorus dose control produced lowest yield due to poor growth, metabolic process and yield attributes. Singh *et al.* (2018) also reported similar results.

The straw yield of late sown wheat was not affected significantly with the wheat varieties (Table-1). Similarly, application of phosphorus levels also did not influence the straw yield of late sown wheat significantly.

Conclusion

It may be concluded from the present study that higher grain yield of wheat variety PBW 550 can be obtained with $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$.

References

1. Anonymous (2021). *Packages of practices for crops of Punjab, rabi*, Punjab Agriculture University, Ludhiana, 38(2): 1-7.
2. Anonymous (2020). *Progress report of all India coordinated Research Project on wheat and barley 2019-20*, Social Sciences.
3. Bairwa, D.D., Modhvia, J.M. and Bhadu, V. (2018). Response of wheat (*Triticum aestivum* L.) to phosphorus and sulphur fertilization. *International Journal of Pure & Applied Bioscience*, 6(6): 354-57.
4. Dugassa, A., Belete K. and Shimbir T.F. (2019). Response of wheat to different rates of nitrogen and phosphorus at Fiche-Salale, highlands of Ethiopia. *International Journal of Plant Breeding and crop Sciences*, 6(1): 474-80.
5. Kaur, S.J. and Dhaliwal L.K. (2015). Yield and yield contributing characteristics of wheat under bed planting method. *International Journal of Farm Sciences*, 5(3): 1-10.
6. Jat, R.C., Sharma Y., Jakhar R.K. and Sharma R.K. (2018). Effect of phosphorus, Zinc and Iron Physico- chemical properties of soils and yield of wheat in loamy sand soils. *International Journal of current Microbiology and Applied Sciences*, 7(3): 2055-62.
7. Mumtaz, M.Z., Aslam, M., Jamil, M. and Ahmad, M. (2014). Effect of different Phosphorus levels on Growth and Yield of wheat under water stress conditions. *Journal of Environment and Earth Science*, 4(19): 2224-3216.
8. Noonari, S., Kalhoro, S.A., Ali, A., Mahar, A., Raza, A., Ahmed, M., Shah, S.F.A. and Baloch, S.U. (2016). Effect of different levels of phosphorus and methods of application on the growth and yield of wheat. *Natural Science*, 8: 305-14.
9. Rahim, A., Ranjha, A.M., and Waraich, E.A. (2010). Effect of phosphorus application and irrigation scheduling on wheat yield and phosphorus use efficiency. *Soil and Environment*, 29, 15-22.
10. Singh, V., Singh, R.S., Singh, G., Singh, B.N. and Singh, R. (2018). Effect of phosphorus levels on the growth characters and yield of wheat varieties grown under late sown condition. *International Journal of Chemical Studies* 6(5): 2468-71.