



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

Frontiers in Crop Improvement

VOLUME 9 SPECIAL ISSUE-VII DECEMBER 2021

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3. Palmer, J. D. (1992). In : *Cell Organelles* (R. G. Herman, Editor) Springer Verlag, Vienna. 99-133.
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Print ISSN : 2393-8234
Online ISSN : 2454-6011



Frontiers in Crop Improvement

Chief Editor : Dr. S.P. Singh

Volume 9

Special Issue-VII

December 2021

NAAS Rating - 4.67

Peer Reviewed, Refereed and Indexed Journal



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Contents

Research Papers/Articles	Page No.
1. Stability analysis of different sunflower (<i>Helianthus annuus</i> L.) hybrids A.M. Langhi, G.N. Deore and N.D. Sarode	2827-2830
2. Genetic studies for seed yield and its contributing traits in pigeonpea [<i>Cajanus cajan</i> (L.) Millsp.] M. Aarif, S.C. Sharma, M.K. Sharma and Yamini Tak	2831-2836
3. Implication of hybrid vigour in pigeonpea [<i>Cajanus cajan</i> (L.) Millsp.] M. Aarif, S.C. Sharma, M.K. Sharma, and Yamini Tak	2837-2843
4. Effect of optimum levels of organic and inorganic fertilizer on the plant growth and pod's yield of french bean (<i>Phaseolus vulgaris</i> L.) cv. Arka Sharath in Uttarakhand Abhishek Bahuguna, Nirmala Bhatt, G.S. Bisht and Neelam Devrari	2844-2847
5. Impact of varying levels of nitrogen, phosphorous and potassium on soil fertility and interactive effect on indian mustard Adarsh Sharma, Sandeep Kumar Pancholi, B.S. Meena and Surendra Singh Rathore	2848-2850
6. Correlation and association analysis for yield and yield related traits in fine slender rice genotypes (<i>Oryza sativa</i> L.) Anant Kumar Pandey, D.J. Sharma, R. Parihar, A.P. Agrawal, H.P. Agrawal, N.K. Chaure, Ruchismita Mishra and Narad Narayan	2851-2855
7. Efficacy of plant leaves powder as seed treatment to check the initial infection of reniform nematode, <i>Rotylenchulus reniformis</i> on summer mungbean (<i>Vigna radiata</i> L.) Anjali Nagori and B.L. Baheti	2856-2861
8. Knowledge level of tribal women about kitchen gardening of Chhotaudepur District of Gujarat B.L. Dhayal, J.P. Meena and B.M. Mehta	2862-2864
9. Determinants of total factor productivity of milch animals in arid Western Rajasthan Dropati Saran, Madhu Sharma, Balbir Singh Khadda and Hemant Sharma	2865-2870
10. Effect of irrigation levels and genotypes on growth indices of chickpea (<i>Cicer arietinum</i> L.) Ekta Kamboj, Satish Kumar and Anil Kumar Dhaka	2871-2874
11. Assessment of chemical properties and classification of soils of agriculture technical school, manjri farm, Pune Govind Kumar Yadav, A.D. Jagdhani, D.D. Sawale, Pradeep Kumar, G.L. Yadav, S.K. Yadav and K.K. Yadav	2875-2879
12. Evaluation of salt combinations on the basis of soluble cations and anions in the soil Govind Kumar Yadav, A.D. Jagdhani, D.D. Sawale, Pradeep Kumar, G.L. Yadav, S.K. Yadav and K.K. Yadav	2880-2884
13. Delineation of nitrogen fractions of north gujarat and its relationship with different properties of soil J.S. Chaure, R.U. Nimbalkar, Chena Panchal and D.V. Kusalkar	2885-2890
14. Genetic variability, heritability and genetic advance in pigeonpea [<i>Cajanus cajan</i> (L.) Millsp.] Parmar M.J., Monpara B.A., Sharma L.K. and Acharya B.	2891-2893
15. Effect of malting process on nutritional and physical characteristics of quinoa Mahendra Kumar, Alpna Singh, Ankit Bharti and Madhvi Sharma	2894-2899
16. Production of lactic acid from wheat bran using <i>Lactobacillus</i> strains Ramesh Chandra Tripathi, Ramjee Singh and Arpit Srivastava	2900-2902
17. Estimation of combining ability using line $\times$ tester analysis in paddy Ravi Kishan Soni, N.R. Koli and Manoj Kumar	2903-2906
18. Long-term consequences of carbon sequestration in micro aggregate of soils with different clay mineralogy on stabilization Ravi Kumar Meena, Y.K. Sharma, V.P. Yadav, Manisha Gaur, M.A. Khan and M.L. Meena	2907-2913
19. General and specific combining ability analysis for yield and some of its associated characters in late sown condition in bread wheat (<i>Triticum aestivum</i> L. em. Thell) Ritu Choudhary, Hoshiyar Singh, Umesh and Pawan Kumar	2914-2919
20. Inbreeding depression analysis for yield and some of its associated characters in late sown condition in bread wheat (<i>Triticum aestivum</i> L. em. Thell) Ritu Choudhary, Hoshiyar Singh, Umesh and Pawan Kumar	2920-2925
21. Sustainable utilization of bullock power through rotary mode power transmission system in operation of flour mill S.S. Deshvena, S.N. Solanki and P.A. Munde	2926-2930

22. Growth, yield and economics of chickpea (*Cicer arietinum* L.) as influenced by nitrogen levels and different weed control practices 2931-2936
Sandeep Kumar Pancholi, Adarsh Sharma, A.G. Patel, Govardhan Lal Kumhar and Surendra Singh Rathore
23. Efficacy of fungal biocontrol agents as seed dresser for management of root knot nematode, *Meloidogyne incognita* on Okra, *Abelmoschus esculentus* (L.) Moench 2937-2943
Shivangee Bhatnagar, M.K. Sharma and Anjali Nagori
24. Productivity, nutrient uptake of cotton and post harvest fertility status of soil of cotton based intercropping system under organic and rainfed condition 2944-2948
Sunil Kumar, A.B. Turkhede, B.C. Dhayal and Ajit K. Meena
25. Estimation of selection indices in desi chickpea (*Cicer arietinum* L.) 2949-2952
K. Ujjwala, L.K. Sharma, G.U. Kulkarni, S. Jeannie and K.P. Deepthi
26. Effect of plant geometry on growth and qualitative characters of transplanted Indian Mustard (*Brassica juncea* L.) 2953-2956
Uma Shankar Tanwar, R.S. Jat, S.R. Verma, Sawai Singh Nitharwal, Vijay Singh Meena and Kavita Devi Yadav
27. Grouping of kabuli chickpea (*Cicer arietinum* L.) genotypes based on quality seed parameters and chemical tests 2957-2964
V.L. Parmar, L.K. Sharma, R.B. Mori, R.M. Javia and C.S. Divakara
28. Effect of microalgae and organic manure on leaf spot of (*Alternaria* sp.) of quinoa 2967-2970
Jasveer Singh, Sobita Simon, Rakesh and Pawan Kumar
29. Path analysis for bulb yield and its components in garlic (*Allium sativum* L.) genotypes 2971-2974
Kamal Mahala, O.P. Garhwal, Praveen Choyal, Surendra Singh Rathore, Mukesh Chand Bhateshwar and Suman Chahar
30. Stability analysis in wheat (*Triticum aestivum* L.) 2975-2977
Narad Narayan, A.P. Agrawal, D.J. Sharma, R. Parihar and Anant Kumar Pandey
31. Nutrient uptake studies in barley (*Hordeum vulgare* L.) as affected by NP fertilization and zinc nutrition under Southern Rajasthan 2978-2982
Piyush Choudhary, S.L. Mundra, Dilip Singh, D.P. Singh, H.K. Sumeriya, D. Chouhan, Hemraj Jat and M.S. Choudhary
32. Genetic variability studies for yield and its components in Indian Mustard (*Brassica Juncea* L.) 2983-2986
Raju Ram Choudhary, Ram Avtar, Manjeet Singh, Samita and Amit
33. Knowledge and adoption of recommended litchi production technology among the farmers of Jashpur District of Chhattisgarh 2987-2989
Savita Nandan Sai, D.K. Suryawanshi and M.K. Chaturvedi
34. Stenting : A new technique for rapid multiplication of subtropical plum (*Prunus salicina* Lindl.) in respons of different concentration of IBA 2990-2995
Sheetal Rawat, D.C. Dimri, Kishore Kumar Das, Shweta Uniyal, Vandna and Sneha Gupta
35. Effect of growth media and plant growth regulators on seed germination of papaya (*Carica papaya* L.) 2996-3000
Suman Meena, O.P. Garhwal, Atmaram Meena, Komal Bhadala, Pratishtha Diwaker and Surendra Singh Rathore
36. Effect of nitrogen and potassium fertilization on performance of sesame (*Sesamum indicum* L.) under loamy sand soils of Jaipur District of Rajasthan 3001-3003
Anju Bijarnia and O.P. Sharma
37. Effect of solid and liquid forms of organic manure on growth and yield of soybean (*Glycine max* L. merrill) 3004-3006
Gajendra Nagar and Thomas Abraham
38. Yield and quality of mustard (*Brassica juncea*) and lentil (*Lens esculenta*) intercropping system influenced by different fertility levels 3007-3011
Roshan Kumawat, A.C. Shivran, Rajesh Kumar, Anju Bijarnia and Lali Jat
39. Behavioral response of ladybird beetles, *Coccinella septempunctata* linn. and *Coccinella transversalis* fab. to synthetic herbivore-induced plant volatiles (HIPV's) in a y-tube olfactometer 3012-3019
Rakesh Kumar, Suresh M. Nebapure, R.K. Sharma, S.R. Sinha, Rekha Kumawat
40. Correlation and path analysis of yield and its components plant traits in ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] 3020-3024
Sanchit Thakur and Neelam Bhardwaj
41. Effect of STCR based fertilizers and manure application on soil chemical properties and rice (*Oryza sativa* L.) yield in vertisol of central India 3025-3030
Saroj Choudhary, S.S. Baghel, A.K. Upadhyay, Sunita Choudhary and Arjun Singh
42. Effect of weed management practices on weed dynamics, quality parameters vis-a-vis phytotoxicity in urdbean under rainfed condition 3031-3034
Suman Dhayal, S.L. Yadav, Bladev Ram, R.K. Yadav, Akshika Bhawariya, Bhavana Singh Rathore, Pinky Yadav
43. The qualitative and quantitative survey of insect pests of stored pearl millet, *Pennisetum glaucum* (Linn.) R.Br. emend stultz. in agro-climatic zone IIIa of Rajasthan 3035-3040
Anita Sharma and Purushotam Sharma

44. Evaluation of plant products as surface protectant of packaging materials against *Corcyra cephalonica* Staint. in Stored Pearlmillet *Pennisetum glaucum* (Linn.) R. Br. Emend Stunt 3041-3047
Anita Sharma, Purushotam Sharma, Suman Choudhary, Manisha Sharma, K.C. Kumawat and S.K. Khinchi
45. Effect of supplementation of concentrate ration on growth performance of sirohi goats in their native tract 3048-3049
Pankaj Lavania
46. Effect of protein sources on nutrient utilization in lactating gir cows 3050-3054
S.L. Boori, R.P. Jat, and O.P. Choudhary
47. Economics of different protein sources and other feeds for milk production in gir cows 3055-3057
S.L. Boori, R.P. Jat and O.P. Choudhary
48. Heterosis studies for grain yield and quality parameters in rice (*Oryza sativa* L.) 3058-3068
Ravi Kishan Soni, N.R. Koli, Mohamad Aarif, Sandhya, Manoj Kumar, R.K. Mahawar, B.L. Meena, Rajpal Singh, Deepak Meena and Ramesh Kumar
49. Legume intercrops in fruit based agroforestry system of coastal Odisha 3069-3074
Abhisekh Dewangan, Subash Chandra Mohapatra* and Sasmita Behera
50. Characterization of different genotypes of aonla (*Embllica officinalis* Gaertn) developed in JNKVV Jabalpur, M.P. 3075-3081
Jitendra Chandravanshi, Pratibha, Eeshwar Sahu, Rohit Singh and A.K. Singh
51. Studies on some morphological, agronomical components and qualitative characters of teasle gourd (*Momordica subangulata* Blume. Subsp. *Renigera*) 3082-3085
Abhishek Naik, Shirin Akhtar, Arup Chattopadhyay, Umesh Thapa and Pranab Hazra
52. Impact of front line demonstration on yield and profitability of mustard in Ratlam District of Madhya Pradesh 3086-3088
C.R. Kantwa, Sarvesh Tripathy, R.S. Bhadauria and S.R. Jakhar
53. Effect of feeding mineral mixture on blood serum biochemical profile in crossbred cattle 3089-3092
Dheeraj Kumar, V.K. Paswan, Rajendra Kumar, Tushar Rajendra Bhosale, Keshav Kumar and Anjali Nagori
54. Some new species of *Pseudocercospora* associated with foliar spots in forest flora of Nepal Himalayas 3093-3096
H.S.G. Rao
55. Evaluation of constraints of chickpea production in Rajasthan with reference to gangour variety 3097-3099
Keshav Kumar, Vikram Yogi, Shubham Arya and Dheeraj Kumar
56. Impact assessment of micro and macro mineral mixture supplement on milk composition 3100-3103
Rajendra Kumar, Dheeraj Kumar, Asha, R.K. Pandey, Hardeep Singh and Pawan Sarswat
57. Impact of integrated nutrient management on cluster bean soil properties, growth and yield (*Cyamopsis tetragonoloba* L.) Sadabahar cv. pusa pusa sadabahar 3104-3108
Asha, Rajendra Kumar, Manpreet Kaur and Narendra Swaroop
58. Line x tester analysis in sweet corn (*Zea mays* L. sp. *Saccharata*) hybrids for various qualitative and quantitative characters 3109-3111
D. Chouhan, R.B. Dubey, S.K. Bangarwa, P. Choudhary and D. Singh
59. Assessment of diversity using RAPD markers in speciality corn (*Zea mays* L.) genotypes 3112-3115
D. Chouhan, S.R. Maloo and D. Singh
60. Estimation of soil physical properties in Rajasthan's Sri Ganganagar District 3116-3119
Manpreet Kaur, Rajendra Kumar, Asha and Narendra Swaroop



Stability Analysis of Different Sunflower (*Helianthus annuus* L.) Hybrids

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Abstract

In present study was made to test the adaptability of ten hybrids along with two check hybrids for seed yield per plot (g), head diameter (cm) and 100 seed weight over three environments. The Genotype and Genotype x environment interaction were found significant for all the characters suggesting the presence of genetic variability in the hybrid population. The G x E (linear) were non-significant for all the characters under studied when tested against pooled deviation, indicates unpredictable performance of hybrids over the environment. The environment indices revealed that E₂ was the favourable environment for seed yield per plot (g) and head diameter (cm), for 100 seed weight (g) environment E₃ was favourable. For stability parameter, none of the hybrid was ideal with an average stability for all the traits. The hybrid SVSH-488 for seed yield per plot and check hybrid Phule Raviraj indicate high mean, bi value nearer to unity (bi=1) and non-significant S²di indicating average stability and suitable for all environment. Based on mean performance SVSH-514 and check Phule Raviraj for seed yield per plot, hybrid SVSH-479, SVSH-488, SVSH-499, SVSH-512 and SVSH-513, for 100 seed weight hybrid SVSH-479, SVSH-488, SVSH-507 and SVSH-513 showed stable performance.

Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop widely adopted and accepted for its high-quality edible oil. The introduction of this crop to India helped a great deal in increasing total oilseed production. Its seed contain high oil content ranging from 35-50 %. Sunflower is photinsensitive and thus it can be grown around the year. Besides the genetic factors, complex physiological processes determine a specific character and the environment plays an important role in the final phenotypic expression of a character. Therefore, the estimates of combining ability effects based on single season may not reveal the real merits of the parents because of the G x E interaction. Study under different environments is likely to bring out the impact of the genotype x environment interaction on the estimates. Sunflower hybrids are object of breeding attention because of their agronomic and economic advantages over varieties (high productivity, high oil content, uniformity, etc.). Therefore, breeding efforts are directed towards increase the yield levels through the development of high yielding varieties and hybrids for different seasons. Hence, there is a need for the development of season specific hybrids in addition to the identification of stable hybrids over environments. The purpose of this study was to evaluate the performance of promising hybrids of Sunflower for yield and yield related traits. Therefore, here we have performed a stability analysis study of sunflower genotypes in the north Indian plains.

Materials and Methods

In the present study 10 hybrids along with two checks viz; (Phule Raviraj and MDSFH-411) were evaluated

in randomized block design with three replication and tested in three different centers of Mahatma Phule Krushi Vidyapeeth, Rahuri, Maharashtra viz., Savalvihiir (E1), Rahuri (E2) and Karad (E3) in during *kharif* 2018. The performance of different hybrids, along with two checks Phule Raviraj and MDSFH-411 in respect to three characters was studied for estimating the stability and significance of genotype environment interactions. Each hybrid was represented by five rows of 4.5 m length with 60 x 30 cm spacing between and within rows, respectively. Observations were recorded in each entries on per plot basis for seed yield, for 100 seed weight randomly selected 100 seeds and for head diameter on five plant basis. The analysis was carried out in computer using software INDOSTAT as per standard method of Eberhart and Russell (1966) in order to estimate the three parameters of stability viz., mean, regression coefficient (bi), and mean squared deviation (S²di) for each genotype.

Results and Discussion

The results revealed that genotypes x environments interaction were found to be highly significant for all the characters under studied when tested against pooled error as well as pooled deviation indicating significant difference among them. The genotype and environment components were also found highly significant for all the characters as per given in Table No. 1. The G x E (linear) were non-significant for all the characters under studied when tested against pooled deviation, indicates unpredictable performance of hybrids over the environment. Estimates of environmental

Table-1 : Analysis of variance for stability (Eberhart and Russell, 1966) for seed yield per plot, Head diameter and 100 seed weight in sunflower hybrids.

Characters	Genotype	E + (G x E)	Environ- ment	G x E	E (L)	G x E (L)	Pooled deviation	Pooled Error
	11	24	2	22	1	11	12	66
Seed yield per plot (g)	0.07**	0.19	1.41**	0.08**	2.82	0.10	0.06**	0.02
Head diameter (cm)	1.37**	1.40	8.35**	0.77**	16.70	0.65	0.81*	0.34
100 seed weight (g)	0.47**	0.31	0.61*	0.28*	1.22	0.30	0.24	0.13

*, ** Significant at 5 and 1 per cent, respectively.

Table-2 : Environmental indices of sunflower hybrids for three characters.

Characters	Environmental indices		
	E ₁	E ₂	E ₃
Seed yield per plot (g)	-0.063	0.370	-0.307
Head diameter (cm)	-0.954	0.594	0.360
100 seed weight (g)	-0.252	0.070	0.181

indices (Ij), given in the Table No. 2 suggested that E₂ was the most favourable environment for seed yield per plot and head diameter and for 100 seed weight E₃ is found favourable environment. The significance of G x E interactions has also been reported by Nel *et al.* (2000), Kumar *et al.* (2002), Pawankumar *et al.* (2003), Murali *et al.* (2004), Tabrizi (2012) and Bhoite *et al.* (2018).

The presented in Table No. 3 indicate that, for seed yield per plot (g) out of twelve hybrids, nine hybrids observed to have non linear portion of G x E interaction as only S²di values non significant for seed yield per plot (g). Among the hybrids, hybrid SVSH-488 was found higher mean than hybrid mean (1.51 g) along with mean squared deviation (S²di) non significant and regression coefficient (bi) was nearer to unity (bi=1.06) hence it was high stability and average responsive to all environments. Hybrid SVSH-514 and check Phule Raviraj were with significantly higher mean than hybrid mean, mean squared deviation (S²di) non significant and regression coefficient (bi) more than unity indicated that below average response, high stability in favourable environment (bi>1). Similar results for above and below average stability were also reported by Halaswamy *et al.* (2000), Rao *et al.* (2004), Balu *et al.* (2007), Mijic *et al.* (2007), Ahmed and Abdella (2009), Reddy *et al.* (2009), Tyagi (2012), Bhoite *et al.* (2015), Bhoite *et al.* (2018) and Ghaffari *et al.* (2020).

Considering head diameter six hybrids found higher mean values than hybrid mean (15.07 cm) and mean squared deviation (S²di) non significant in Table No. 3. Hybrids SVSH-479, SVSH-499 and SVSH-512 exhibited higher mean value coupled with regression coefficient lower than unity and non significant S²di indicating its stability for poor

environment i.e. above average stability (bi>1), while hybrid SVSH-488 and SVSH-513 showed higher mean value coupled with regression coefficient significantly higher than unity and non significant S²di indicating its stability for good environment i.e. below average stability (bi<1). The check hybrid Phule Raviraj found higher mean than hybrid mean, regression coefficient value bi value nearer to unity (bi=1) and mean squared deviation (S²di) non significant and higher mean than hybrid mean indicating responsive to average stability and suitable for all environment. These findings are in conformity with Panduranga *et al.* (2000), Rao *et al.* (2004), Balu *et al.* (2007), Waghmare *et al.* (2011), Taran *et al.* (2014), Bhoite *et al.* (2015) and Tyagi *et al.* (2018).

The hybrids namely SVSH-479 and SVSH-488 recorded significantly higher for 100 seed weight than hybrid mean (5.22 g) with regression coefficient less than unity (bi<1) and non significant least deviation from regression (S²di), thus found stable above average stability and specific adaptable to a poor environment, while below average stability (bi>1) and non significant S²di were exhibited in SVSH-499, SVSH-507 and SVSH-513 hence were responsive to specific adaptation to the favorable or rich environment. Similar finding also reported by Narendra and Rao (2006), Rukmini *et al.* (2006), Ahmed *et al.* (2009), Neelima and Parmeshwarappa (2017), Chandra *et al.* (2018),

From the above findings, it could be summarized that non of the hybrids were stable for all characters under study. Similar results were also reported by Bhoite *et al.* (2018). Based on mean performance for high yield the hybrid SVSH-488 had bi value nearer to unity (Bi=1), non-significant value of S²di and higher mean than hybrid mean indicating average stability and suitable for all environment. For head diameter check hybrid Phule

Table-3 : Stability parameters of sunflower hybrids for Seed yield per plot (g) and Head diameter (cm).

Sr. No.	Genotype	Seed yield per plot (g)			Head diameter (cm)		
		Mean (μ)	S-2di	bi	Mean (μ)	S-2di	bi
1.	SVSH-479	1.51	0.00	0.57	15.07	0.18	0.05
2.	SVSH-488	1.88	-0.01	1.06**	16.30	-0.05	2.10**
3.	SVSH-491	1.51	-0.02	1.86**	13.60	-0.06	0.83
4.	SVSH-493	1.46	0.15**	0.87	15.39	4.14**	1.13
5.	SVSH-495	1.46	0.04	1.40*	14.97	-0.33	1.41**
6.	SVSH-499	1.42	0.00	0.14	15.76	0.65	0.25
7.	SVSH-507	1.46	0.12*	0.78	14.97	-0.26	1.33**
8.	SVSH-512	1.33	0.02	0.58	15.31	0.75	0.31
9.	SVSH-513	1.32	0.04	-0.13	15.16	-0.34	1.32**
10.	SVSH-514	1.72	0.02	1.59**	14.26	0.39	2.01*
11.	Phule Raviraj (c)	1.57	0.02	1.53**	15.17	0.66	0.99
12.	MDSFH-411 (c)	1.45	0.10*	1.77**	14.91	-0.06	0.25
	Mean	1.51			15.07		
	SEm $\pm$ mean	0.17			0.64		
	SE (bi)	0.49			0.76		

*, ** Significant at 5 and 1 per cent, respectively

Table-4 : Stability parameters of sunflower hybrids for 100 grain weight.

Sr. No.	Genotype	100 seed weight (g)		
		Mean (μ)	S-2di	bi
1.	SVSH-479	5.46	-0.03	0.22
2.	SVSH-488	5.98	0.25	0.47
3.	SVSH-491	4.73	0.13	1.31
4.	SVSH-493	5.20	0.13	1.47
5.	SVSH-495	5.02	0.04	2.53
6.	SVSH-499	5.27	0.08	2.41
7.	SVSH-507	5.29	-0.12	4.43**
8.	SVSH-512	5.37	1.15**	-1.08
9.	SVSH-513	5.79	-0.13	-1.69
10.	SVSH-514	4.66	-0.10	1.69*
11.	Phule Raviraj (c)	4.90	-0.14	-0.68
12.	MDSFH-411 (c)	5.00	-0.02	0.93
	Mean	5.22		
	SEm $\pm$ mean	0.35		
	SE (bi)	1.54		

*, ** Significant at 5 and 1 per cent, respectively.

Raviraj found bi value nearer to unity ($bi=1$), S^2di non-significant and higher mean than hybrid mean indicating responsive to average stability and suitable for all environment. For 100 seed weight SVSH-479 and SVSH-488 showed its stable performance under unfavourable environment and SVSH-499, SVSH-507 and SVSH-513 showed stable performance under favourable environment.

References

- Ahmed, S.B.M. and Abdella, A.W.H. (2009). Genetic yield stability in some sunflower (*Helianthus annuus* L.) hybrids under different environmental conditions of Sudan. *J. Plant Breed. Crop Sci.*, 1 (1): 16-21.
- Balu, A.; Sumathi, P.; Ibrahim, S.M. and Kalaimagal, T. (2007). G X E interaction and stability analysis in sunflower (*Helianthus annuus* L.). *Indian J. Genet. and Plant Breed.*, 67 (4): 388-391.
- Bharati (2000). Stability analysis of few promising sunflower hybrids over seasons. *Thesis M.Sc. (Agri.)* University of Agricultural Sciences, Bangalore (India).
- Bhoite, K.D.; Mane, L.L. and Langhi, A. M. (2015). Stability analysis for traits related to seed yield in sunflower (*Helianthus annuus* L.). *J. Oilseeds Res.*, 32 (1): 91-93.
- Bhoite, K.D.; Dubey, R.B.; Vyas, M.; Mundra, S.L. and Ameta, K.D. (2018). Studies on Genotype x Environment interaction of F_1 hybrids of sunflower. *J. of Pharm. And Phytochem.*, 7(5): 1465-1471.
- Chandra, B.S.; Kumar, S.S. and Ranganatha, A.R.G. (2018). Genotype x Environment interaction and stability analysis for seed yield and its component traits in sunflower (*Helianthus annuus* L.). *Int. J. Curr. Microbiol. App. Sci.* 7 (11): 170-182.

7. *Comstock, R.E. and Moll, R.E. (1963). Genotype-environment interactions. In: "Statistical Genetics and Plant Breeding, NAS-NRC Pub., 982: 164-196.
8. Eberhart S.A. and Russell W.A. (1966). Stability parameters for comparing varieties. *Crop Sci.*, 16: 36-40.
9. Ghaffari, M.; Andarkhor, S.A.; Ahmadi, S.A.K.; Shariyati, F.; Jamali, H. and Rahmanpour, S. (2020). Agronomic attributes and stability of exotic sunflower hybrid in Iran. *Helia*, 43 (72): 67-81.
10. Halaswamy, B.H.; Bhushana, H.O.; Kulkarni, R.S. and Seetharam, A. (2000). Stability analysis for yield and yield components of three-way and single crosses in sunflower. *Karnataka J. Agric. Sci.*, 13 (4): 824-829.
11. Kumar, M.H.; Murali, M.R.; Devi, K.R.; Narendra, B. and Sreedhar, V. (2002). Analysis of stability parameters for yield in sunflower. *Punab Rao Deshmukh Krishi Vidyapeeth, Res. J.*, 26 (1): 99-100.
12. Mijic, A.; Krizmanic, M.; Pepó, P.; Kovačević, V.; Markulj, A.; Duvnjak, T. and Krizmanic, G. (2007). Influence of cytoplasmic male sterile and restorer lines on the grain yield stability of sunflower under different environmental conditions. *Acta Agronomica Hungarica*, 60 (3): 247-255.
13. Murali, M.R.; Ranganath, A.R.G.; Kumar, M.H.; Devi, K.R. and Narendra, B. (2004). Adoptability of sunflower hybrids to crop growing seasons of scarce rainfall zone. *J. Maharashtra Agric. Univ.*, 29 (20): 138-140.
14. Narendra, B. and Rao, A. (2006). Performance of single cross hybrid in sunflower (*Helianthus annuus* L.). *J. Oilseeds Res.*, 23: 80-85.
15. Neelima, S. and Parameshwarappa, K.G. (2017). Stability of single and three-way cross hybrids for seed yield and other important agronomical traits in sunflower (*Helianthus annuus* L.). *Helia*, 40 (67): 197-210.
16. Nel, A.A.; Loubse, H.L. and Hannes, P.S. (2000). The effect of environment and cultivar on sunflower seed yield, hull ability and physical seed characteristics. *South African J. plant and Soil*, 17 (3): 133-137.
17. Panduranga, Y.K. (2000). Stability studies in new sunflower (*Helianthus annuus* L.) hybrids under different agro-climatic conditions. *Thesis M.Sc. (Agri.)*, University of Agricultural Sciences. Bangalore. (India).
18. Panse, V.G. and Sukhatme, P.V. (1985). Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.
19. Pawankumar,; Prasad, M.K. and Jyotirmoy G. (2003). Phenotypic stability of sunflower (*Helianthus annuus* L.) genotypes. *J. Appl. Biol.*, 13 (1-2): 20-23.
20. Rao M.; Reddy, G.L.; Kulkarni, R.S.; Reddy, S.L. and Ramesh, S. (2004). Stability analysis of sunflower hybrids through non-parametric model. *Helia*, 27 (41): 59-66.
21. Reddy, C.V.C.M.; Sinha, B.; Reddy, A.V.V. and Reddy, Y.R. (2009). Studies on stability parameters of parents and F1 hybrids of sunflower (*Helianthus annuus* L.) in different environments. *Plant Archives*, 9 (1): 183-188.
22. Rukminidevi, K.; Ranganatha, A.R.G. and Ganesh, M. (2006). Analysis of diverse hybrids for stability to seed yield and yield components in sunflower. *Annals of Agric. Res. News Series*, 27 (2): 167-178.
23. Singh, R.K. and Choudhary, B.D. (1972). Biometrical methods in quantitative genetic analysis, *Kalyani Publishers, New Delhi*.
24. Tabrizi, H.Z. (2012). Genotype by environment interaction and oil yield stability analysis of six sunflower cultivars. *Advances in Environ. Biol.*, 6 (1): 227-231.
25. Taran, S.A.; Khan, N.U.; Kakar, M.A.; Khan, M.M.; Saeed, M.; Iqbal, M.; Agha, S. and Fazal Ahmed. (2014). Stability of sunflower hybrids for earliness and achene yield over environments. *J. Food Agric. and Env.*, 12 (1): 317-322.
26. Tyagi, V.; Dhillon, S.K. and Kaushik, P. (2018). Stability analysis of novel cytoplasmic sterile sources of sunflower and their hybrids. *Helia*, 41 (69): 153-200.
27. Waghmare, K.D.; Wadikar, P.B.; Ghodke, M.K. and Jagtap, P.K. (2011). Stability analysis for pollen production and yield components in restorer lines of sunflower (*Helianthus annuus* L.). *Advances Plant Sci.*, 24 (2): 649-653.



Genetic Studies for Seed Yield and it's Contributing Traits in Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract

The present experiment was undertaken to study the combining ability for seed yield and it's contributing traits in pigeonpea. The experimental material consisted of thirteen parents and their thirty F₁'s produced in line × tester mating design. The estimates of general combining ability revealed that lines RKPV 916-1, RKPV 918-1, RKPV 0527 and tester ICPL 88039 were identified as good general combiner for seed yield and it's contributing traits. Therefore, these parents were noted as good source of favourable genes for increasing seed yield through various yield contributing characters. The estimates of SCA effects revealed that out of thirty hybrids, six hybrids registered significant positive SCA effects for seed yield per plant. The cross combinations RKPV 1015-1 × UPAS 120, RKPV 0527 × PA 291, RKPV 912-1 × ICPL 88039 RKPV 1013 × ICPL 88039 and RKPV 918-1 × ICPL 88039 were observed as promising hybrids with significant *sca* effects as well as high *per se* performance in desired direction for seed yield and most of the yield contributing traits in pigeonpea.

Key words : Combining ability, *gca* effects, *sca* effects, line × tester analysis, pigeonpea.

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the prominent legume crops of tropics and sub-tropics of Asia and Africa. It is a short-lived perennial shrub cultivated annually for grain purpose. Pigeonpea is an often cross-pollinated crop with 25-70 % natural out-crossing reported from different locations (Saxena *et al.* 1990). This considerable amount of natural out crossing has been used efficiently in hybrid breeding technology. Based on the genetic diversity of the crop, Van der Maesen (1980) concluded that India was the primary center of origin and Africa was the secondary center of origin of pigeonpea. It is drought tolerant crop and possess the ability to use residual moisture at the time of dry season (Srivarsha *et al.* 2018). The crop is primarily cultivated for de-hulled split peas, however immature green seeds and pods are also consumed fresh as a green vegetable. It is an economical source of protein, carbohydrate, minerals and vitamins such as B-complex particularly in the vegetarian diet. Pigeonpea ranks sixth in global grain legume production and worldwide it is cultivated in about 6.99 million hectares area with an annual production of 5.96 million tons and a mean productivity of 852 kg/ha. In India, total area coverage and production of pigeonpea were 4.23 million hectares and 3.89 million tons, respectively with 919 kg/ha productivity (AICRP on Pigeonpea, Project Coordinator's Report, 2020-2021).

Information on combining ability provide guidelines

to plant breeders in selecting the elite parents and desirable cross combinations to be used in formulation of efficient breeding programme and at the same time reveals the nature and magnitude of gene action involved in the inheritance of various traits. It also provides the vital and necessary information on the nature of gene action governing the expression of the character. The ability of parent to combine will depend on complex interaction among genes, which cannot be predicted from yield adaptability of parents. The success of breeding procedure is determined by the useful gene combinations organized in the form of good combining lines and isolation of valuable germplasm (Patel *et al.* 2020).

Materials and Methods

The present experiment was carried out at Field of AICRP on Pigeonpea, Agricultural Research Station, Ummедganj, Kota (Rajasthan), which is situated in south-eastern part of Rajasthan at 25°13'N latitude and 75°54'E longitude with an elevation of 257 m above mean sea level. The experimental material comprised of ten lines (RKPV 0527, RKPV 901-2, RKPV 904-1, RKPV 912-1, RKPV 916-1, RKPV 917-1, RKPV 918-1, RKPV 1011-1, RKPV 1013 and RKPV 1015-1) were crossed with three testers (UPAS 120, ICPL 88039 and PA 291) in line × tester fashion. The resultant thirty hybrids along with their thirteen parents were evaluated in a randomized block design with three replications during *Kharif* -2020-21. Ten competitive plants of each genotypes were selected randomly in each replication for recording the observations of characters *viz.*, plant height (cm), number

of primary branches per plant, number of pods per plant, number of seeds per pod, pod length (cm), 100 seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index (%). The observation on days to 50% flowering and days to maturity was recorded on whole plot basis. The general combining ability (GCA) and specific combining ability (SCA) variances were worked out as per the method given by Kempthorne (1957).

Results and Discussion

The concept of general and specific combining ability as a measure of gene action was proposed by Sprague and Tatum (1942). The total genetic variance is partitioned into the variance due to gca and sca. This helps in ascertaining the relative proportion of additive and non-additive variances in the inheritance of individual traits that is the decisive basis for choosing the appropriate breeding methods for effective exploitation of the available genetic variation (Patel *et al.* 2020).

The analysis of variance for combining ability was carried out for seed yield and its contributing characters and mean sum of squares are presented in Table-1. The genotypes registered highly significant differences for all the characters. The parents exhibited significant differences for all the characters, except plant height whereas, crosses registered significant differences for all the characters under study. The parents vs. crosses also showed significant differences for all the characters except days to maturity, 100-seed weight and harvest index. The effects of hybrids were partitioned into lines, testers and their interactions. The lines were found to be significant for all the characters whereas, among testers, the differences were significant for all the characters except plant height. The interaction effects (lines x testers) were found to be significant for all the characters, suggesting that line x tester interaction variance contributed largely for total genetic variance and both lines and testers interacted differently in cross combinations.

A comparison of relative magnitude of general and specific combining ability indicated that additive genetic effects were predominant for control of most of the seed yield and its attributing characters except seeds per pod, pod length, 100-seed weight and harvest index for which the same was non additive. Under the circumstances, where both additive and non-additive gene actions are in operation, the most appropriate and effective breeding approach would be to mop up the additive genes and simultaneously maintaining degree of heterozygosity for exploiting dominance component *i.e.*, biparental mating and *inter se* crossing between suitable lines followed by recurrent selection.

Table-1 : Analysis of variance for combining ability in Line x Tester analysis for seed yield and its contributing traits in pigeonpea.

Source of variation	df	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of pods per plant	Number of Seeds per pod	Pod length (cm)	100-seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index (%)
Replication	2	1.51	1.64	280.80	0.21	367.26	0.04	0.01	0.00	10.90	172.27	2.59
Genotypes	43	129.66**	188.72**	490.24**	10.66**	3772.89**	1.05**	0.85**	2.69**	170.42**	2376.74**	9.24**
Parents	12	163.14**	302.70**	221.95	5.58**	1932.25**	0.78**	0.93**	2.77**	95.86**	761.79**	15.16**
Parents vs Crosses	1	204.17**	4.08	2815.77**	17.63**	7609.23**	1.14**	0.45**	0.20	178.73**	4658.52**	2.97
Crosses	29	103.43**	138.51**	516.44**	12.89**	4526.82**	1.19**	0.82**	2.84**	205.15**	3037.42**	7.31**
Lines effect	9	174.75**	210.13**	472.58**	9.68**	4420.49**	0.66**	0.85**	2.56**	203.70**	2885.71**	6.26**
Testers effect	2	106.08**	202.23**	181.46	73.59**	22377.51**	5.84**	3.99**	12.01**	1042.46**	15269.30**	7.64*
Lines x Testers	18	67.47**	95.62**	575.60**	7.77**	2596.79**	0.95**	0.45**	1.96**	114.46**	1754.19**	7.80**
Error	86	2.96	4.13	216.61	0.82	253.41	0.04	0.06	0.07	7.53	209.81	2.36

*, **Significant at 5% and 1% level of significance, respectively.

Table-2 : Proportional contribution of lines, testers and line x tester to total variance for seed yield and its contributing traits in pigeonpea.

S. No.	Characters	Lines	Tester	L x T
1.	Day to 50% flowering	52.43	7.07	40.49
2.	Days to maturity	47.08	10.07	42.85
3.	Plant height (cm)	28.40	2.42	69.18
4.	Primary branches per plant	23.20	39.38	37.42
5.	Pods per plant	30.30	34.09	35.61
6.	Seeds per pod	17.06	33.74	49.20
7.	Pod length (cm)	32.22	33.53	34.25
8.	100-Seed weight (g)	27.99	29.18	42.83
9.	Seed yield per plant (g)	30.66	34.87	34.46
10.	Biological yield per plant (g)	29.48	34.67	35.85
11.	Harvest index (%)	26.59	7.21	66.20

The proportional contribution of lines, testers, and line x testers for various characters to total variance are presented in Table 2. The data revealed that contribution of line x tester was higher than both lines and testers for characters, plant height, pods per plant, seeds per pod, pod length, 100-seed weight, biological yield per plant and harvest index. The contribution of tester was highest for primary branches per plant and seed yield per plant than line and line x tester. The contribution of lines was more than testers and line x tester for the characters, days to 50% flowering and days to maturity.

General combining ability effect : An average performance of a line in a series of cross combinations termed as general combining ability. The parents having significant GCA effect in desired direction, non-significant GCA effect in desired direction and significant GCA effect in undesired direction were classified as good, average and poor general combiner, respectively; similarly, crosses were also classified as good, average and poor specific combiner for seed yield and its contributing traits.

The estimates of general combining ability (Table 3) revealed that lines RKPV 916-1, RKPV 918-1, RKPV 0527 and tester ICPL 88039 were observed as good general combiner with high *per se* performance for seed yield and most of the its contributing characters. For days to flowering and days to maturity, the lines RKPV 1015-1, RKPV 917-1 and tester UPAS 120 were found good general combiner. The gca effect is confined to additive gene action which is fixable in nature therefore direct selection of these parents might be useful for recombination breeding programme as parents for yield improvement in pigeonpea. The results are in accordance with the findings of Mesharam *et al.* (2013), Pandey *et al.* (2014), Mhasal *et al.* (2015), Soni and Patel (2016), Maida *et al.* (2017), Moses *et al.* (2020) and Patel *et al.* (2020).

Specific combining ability effect : Specific combining ability effects are the index to determine usefulness of a

particular combination in the exploitation of heterosis. It is defined as the deviation from the expected performance of specific hybrid combination on the basis of average performance of parents involved in the crosses and it can be regarded as a measure of non additive gene action resulted from both intra allelic and inter allelic gene action (Patel *et al.* 2020).

The estimate of SCA effects of the hybrids are presented in Table 4. For the traits seed yield per plant, the cross combinations viz., RKPV 1015-1 × UPAS 120 (average × poor), RKPV 0527 × PA 291 (good × poor), RKPV 912-1 × ICPL 88039 (average × good), RKPV 1013 × ICPL-88039 (poor × good) and RKPV 918-1 × ICPL 88039 (good × good) recorded positive and significant SCA effect in desired direction however, the cross combinations, RKPV 904-1 × ICPL 88039 and RKPV 916-1 × ICPL 88039 having high *per se* performance for seed yield and its contributing traits, also showed non-significant SCA effect but in desired direction in pigeonpea.

The hybrids, RKPV 904-1 × PA 291 (good × average), RKPV 1013 × UPAS 120 (good × good) and RKPV 1015-1 × UPAS 120 (good × good) were identified as best hybrids for days to 50 per cent flowering and days to maturity, as these hybrids showed high *sca* effects as well as *per se* performance in desired direction. These hybrids involved high × high or high × moderate combination indicating the major role of additive × additive gene action for expression of traits. Therefore, these crosses may be utilized for heterosis breeding as well as for isolating the promising segregates for earliness in advanced generation as these crosses are under the control of additive gene action which are fixable (Singh and Singh, 2009 and Rama devi *et al.*, 2011).

Among the 30 hybrids evaluated, one cross combination RKPV-918-1 × PA-291 was exhibited significant SCA effect in negative direction for the traits plant height.

Table-3: Estimation of General combining ability (gca) effects for seed yield and its contributing traits in pigeonpea.

S. No.	Parents	Days to 50% Flowering	Days to Maturity	Plant height (cm)	Number of primary branches per plant	Number of pods per plant	Number of seeds per pod	Pod length (cm)	100-Seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index (%)
Lines												
1.	RKPV-0527	3.06**	0.34	15.49**	0.71*	17.96**	0.12	0.21*	0.62**	4.42**	18.79**	0.42
2.	RKPV-901-2	6.39**	3.79**	-5.37	-1.05**	-19.26**	-0.39**	-0.18*	-0.22*	-4.93**	-14.23**	-1.69**
3.	RKPV-904-1	-4.83**	-7.32**	-5.00	-0.04	-2.29	0.05	-0.12	0.10	-0.56	-2.38	-0.03
4.	RKPV-912-1	-2.17**	-3.43**	-2.43	-0.10	-11.77*	0.13	-0.06	0.26**	-0.81	-7.16	0.73
5.	RKPV-916-1	7.06**	9.01**	1.52	1.51**	32.56**	0.46**	0.44**	0.27**	7.21**	30.04**	0.36
6.	RKPV-917-1	-2.72**	-1.54*	-6.85	-0.56	-9.85	-0.23**	-0.01	-0.32**	-2.32*	-9.59	-0.03
7.	RKPV-918-1	0.72	3.34**	9.61	1.60**	35.10**	0.30**	0.48**	0.84**	6.88**	22.57**	1.28*
8.	RKPV-1011-1	0.61	2.23**	-5.38	-1.65**	-32.56**	-0.32**	-0.52**	-0.78**	-6.74**	-25.33**	-0.87
9.	RKPV-1013	-2.39**	-0.99	0.00	-0.42	-11.45*	0.00	-0.25**	-0.75**	-2.95**	-11.22*	-0.38
10.	RKPV-1015-1	-5.72**	-5.43**	-1.59	0.01	1.56	-0.12	0.02	-0.03	-0.19	-1.48	0.21
	SE	0.60	0.71	5.15	0.32	5.57	0.07	0.09	0.09	0.96	5.06	0.54
	gi-gj	0.81	0.96	6.94	0.43	7.50	0.09	0.12	0.13	1.29	6.83	0.72
Testers												
11.	UPAS-120	-1.66**	-2.43**	2.03	-0.73**	-8.89**	-0.23**	-0.09	-0.27**	-2.38**	-8.53**	-0.32
12.	ICPL-88039	2.04**	2.73**	0.70	1.80**	30.65**	0.51**	0.40**	0.72**	6.71**	25.58**	0.58
13.	PA-291	-0.39	-0.30	-2.73	-1.07**	-21.76**	-0.28**	-0.31**	-0.45**	-4.33**	-17.05**	-0.26
	SE	0.36	0.43	3.10	0.19	3.36	0.04	0.05	0.06	0.58	3.05	0.32
	gi-gj	0.44	0.52	3.80	0.23	4.11	0.05	0.07	0.07	0.71	3.74	0.40

*, **Significant at 5% and 1% level of significance, respectively.

The estimates of SCA effect revealed that total six hybrids exhibited significant SCA effect in positive direction for primary branches per plant. The crosses combinations, RKPV 1015-1 × UPAS 120 (average × poor) followed by RKPV 0527 × PA-291 (good × poor), RKPV 912-1 × ICPL 88039 (average × good), RKPV-904-1 × ICPL 88039 (average × good) and RKPV-1013 × ICPL-88039 (average × good) were identified as best hybrids for number of primary branches per plant, based on highest *sca* effects and *per se* performance in pigeonpea.

For the traits pods per plant, seven crosses recorded positive significant SCA effects. The cross combinations viz., RKPV 1015-1 × UPAS 120 (average × poor), RKPV 0527 × PA 291 (good × poor), RKPV 912-1 × ICPL 88039 (poor × good) and RKPV 1013 × ICPL 88039 (poor × good) showed high *sca* effects as well as *per se* performance and identified as good specific combiner for number of pods per plant in pigeonpea.

Out of thirty hybrids, total seven crosses registered positive significant SCA effects for the trait seeds per pod. The crosses viz., RKPV 0527 × PA 291, RKPV 1015-1 × UPAS 120, RKPV 1013 × ICPL 88039 and RKPV 918-1 × ICPL 88039 were identified as promising hybrids based on high *sca* effects as well as *per se* performance in pigeonpea.

For the trait pod length, total six hybrids registered significant positive SCA effects. The crosses, RKPV 901-2 × UPAS 120 (poor × average), RKPV 1015-1 × UPAS 120 (average × poor), RKPV 0527 × PA-291 (good × poor), RKPV 912-1 × ICPL 88039 (average × good) and RKPV 1013 × ICPL 88039 (poor × good) was identified as good specific combiner with significant positive SCA effects as well as high *per se* for pod length in pigeonpea.

The estimates of SCA effects for the traits 100-seed weight revealed that total eight crosses showed significant positive SCA effect. The promising hybrids based on highly significant SCA effects as well as *per se* performance in desired direction was identified as RKPV 1013 × ICPL 88039 (poor × good), RKPV 901-2 × UPAS 120 (poor × poor), RKPV 912-1 × ICPL 88039 (good ×

Table-4 : Estimation of specific combining ability effects (sca) for seed yield and its contributing traits in pigeonpea.

S. No.	Crosses	Days to 50% Flowering	Days to Maturity	Plant height (cm)	Primary branches per plant	Number of pods per plant	Number of seeds per pod	Pod length (cm)	100-Seed weight (g)	Seed yield per plant (g)	Biological yield per plant (g)	Harvest index (%)
1.	RKPV-0527 × UPAS-120	3.54**	3.32*	-12.48	-0.89	-14.13	-0.35*	-0.22	0.23	-3.02	-19.02	1.25
2.	RKPV-901-2 × UPAS-120	-4.12**	-2.46	3.69	2.23**	47.60**	0.46**	0.57**	0.93**	9.52**	39.98**	0.70
3.	RKPV-904-1 × UPAS-120	5.10**	5.66**	0.29	-0.18	10.93	0.13	0.08	-0.55**	2.43	12.23	-0.36
4.	RKPV-912-1 × UPAS-120	0.10	2.10	21.03*	-0.72	-14.06	-0.46**	-0.09	-0.85**	-4.84*	-15.86	-1.71
5.	RKPV-916-1x UPAS-120	-0.46	-3.01*	6.60	-1.19	-20.43	-0.51**	-0.19	-0.43*	-4.00*	-18.95	0.26
6.	RKPV-917-1x UPAS-120	-2.01	0.54	-12.31	-0.16	-9.25	0.01	0.07	-0.60**	-1.76	-8.49	0.25
7.	RKPV-918-1x UPAS-120	3.88**	1.66	23.83*	-0.75	-11.26	-0.26	-0.22	-0.16	-2.72	-2.25	-1.62
8.	RKPV-1011-1x UPAS-120	3.32**	8.10**	-11.93	0.30	-9.24	0.43**	-0.22	1.40**	-1.23	-7.55	0.02
9.	RKPV-1013 × UPAS-120	-6.34**	-11.01**	-6.64	-1.07	-23.11*	-0.36*	-0.33	-0.67**	-4.29*	-20.30*	0.58
10.	RKPV-1015-1x UPAS-120	-3.01*	-4.90**	-12.08	2.44**	42.94**	0.90**	0.57**	0.71**	9.90**	40.23**	0.61
11.	RKPV-0527 × ICPL-88039	1.51	1.16	6.57	-1.39*	-24.43*	-0.62**	-0.35	-0.73**	-5.81**	-13.12	-2.16*
12.	RKPV-901-2 × ICPL-88039	-0.82	1.38	-1.50	-2.06**	-39.80**	-0.58**	-0.42*	-1.17**	-8.67**	-28.00**	-2.37*
13.	RKPV-904-1 × ICPL-88039	2.40*	1.82	7.28	1.56*	18.13	0.19	0.25	0.32	3.18	11.85	0.64
14.	RKPV-912-1x ICPL-88039	-4.27**	-4.07**	-13.79	2.02**	35.41**	0.44**	0.45*	0.85**	7.02**	24.30*	1.07
15.	RKPV-916-1x ICPL-88039	-1.49	-0.51	-15.62	0.38	-1.76	0.45**	-0.08	0.38*	1.21	-3.14	1.35
16.	RKPV-917-1x ICPL-88039	-2.71*	-2.96*	1.95	0.28	11.42	0.07	-0.02	0.03	2.77	13.22	-0.01
17.	RKPV-918-1x ICPL-88039	-3.49**	-5.18**	-1.02	0.79	10.47	0.54**	0.19	0.11	3.97*	-3.07	2.79*
18.	RKPV-1011-1x ICPL-88039	-2.04	-4.07**	-1.55	-1.43*	-13.74	-0.44**	-0.15	-0.57**	-2.74	-2.85	-1.74
19.	RKPV-1013 × ICPL-88039	6.96**	7.16**	6.63	1.27*	26.52*	0.60**	0.41*	1.13**	5.28**	21.55*	0.77
20.	RKPV-1015-1x ICPL-88039	3.96**	5.27**	11.06	-1.42*	-22.23*	-0.64**	-0.29	-0.36	-5.42**	-20.72*	-0.35
21.	RKPV-0527 × PA-291	-5.06**	-4.48**	5.92	2.28**	38.55**	0.97**	0.57**	0.51**	8.83**	32.14**	0.91
22.	RKPV-901-2 × PA-291	4.94**	1.08	-2.19	-0.16	-7.79	0.11	-0.14	0.24	-0.85	-11.97	1.67
23.	RKPV-904-1 × PA-291	-7.50**	-7.48**	-7.56	-1.38*	-29.06*	-0.32*	-0.33	0.23	-5.61**	-24.08*	-0.29
24.	RKPV-912-1 × PA-291	4.17**	1.97	-7.24	-1.31*	-21.35	0.02	-0.37*	-0.01	-2.18	-8.44	0.63
25.	RKPV-916-1x PA-291	1.94	3.52*	9.02	0.81	22.18*	0.07	0.27	0.05	2.80	22.09*	-1.62
26.	RKPV-917-1x PA-291	4.72**	2.41	10.35	-0.12	-2.17	-0.08	-0.04	0.57**	-1.00	-4.72	-0.24
27.	RKPV-918-1x PA-291	-0.39	3.52*	-22.80*	-0.04	0.78	-0.28*	0.03	0.05	-0.48	5.33	-1.18
28.	RKPV-1011-1x PA-291	-1.28	-4.03**	13.48	1.14	22.97*	0.01	0.37*	-0.83**	3.20	10.41	1.72
29.	RKPV-1013 × PA-291	-0.61	3.86**	0.00	-0.20	-3.40	-0.24	-0.08	-0.46*	-0.99	-1.25	-1.35
30.	RKPV-1015-1x PA-291	-0.94	-0.37	1.03	-1.02	-20.72	-0.26	-0.28	-0.35	-4.48*	-19.50	-0.26
SE		1.20	1.42	10.29	0.63	11.13	0.14	0.18	0.19	1.92	10.13	1.07
Sij-Sjk		1.68	1.99	14.39	0.88	15.56	0.19	0.25	0.26	2.68	14.16	1.50

*, ** Significant at 5% and 1% level of significance, respectively.

good), RKPV 0527 × PA 291 (good × poor) and RKPV 916-1 × ICPL 88039 (good × good).

For the trait biological yield per plant, six hybrids were reported significant SCA effect in desired direction. The cross combinations viz., RKPV 1015-1 × UPAS 120, RKPV 901-2 × UPAS 120, RKPV 0527 × PA 291, RKPV 912-1 × ICPL 88039 and RKPV 916-1 × PA 291 were identified as promising hybrids with highly significant SCA effect in desired direction. For the trait harvest index, cross RKPV 918-1 × ICPL 88039 (good × average) was identified as promising hybrid with highest SCA effect as well as *per se* performance in desired direction in pigeonpea. These results are in agreement with the earlier reported by Meshram *et al.* (2013), Yamamura *et al.* (2014), Soni and Patel (2016), Tikle *et al.* (2016), Sriversha *et al.* (2018), Moses *et al.* (2020) and Patel *et al.* (2020).

In conclusion to the present investigation, overall results revealed that the lines RKPV 916-1, RKPV 918-1, RKPV 0527 and tester ICPL 88039 was proved to be good general combiners for seed yield and its contributing traits in pigeonpea. The line RKPV 1015-1 and tester UPAS 120 also appeared good general combiner for days to flowering and days to maturity. Based on mean performance and significant SCA effect for seed yield and its contributing traits, the hybrids RKPV 1015-1 × UPAS 120, RKPV 0527 × PA 291, RKPV 912-1 × ICPL 88039, RKPV 1013 × ICPL 88039 and RKPV 918-1 × ICPL 88039 was found most promising. Therefore, it needs to be exploited in future breeding programme of pigeonpea.

References

1. ICAR-AICRP on Pigeonpea, Project Coordinator's Report, 2020-21. *Online Annual Kharif Pulses Group Meet*, pp-33.
2. Kempthorne, O. 1957. An introduction to genetic statistics. *John Wiley and Sona Inc.*, New York.
3. Maida, R.K., Patel, M.P., Ahiwar, C. and Patel, A.M. 2017. Estimation of combining ability and gene action for yield and its components in pigeonpea [*Cajanus cajan* (L.) Millspaugh]. *Indian J. Agric. Res.*, 51(6): 550-555.
4. Meshram, M.P., Patil, A.N. and Abhilasha, K. 2013. Combining ability analysis in medium duration cgms based hybrid pigeonpea (*Cajanus cajan* (L.) Millsp.). *J. Food Legumes*, 26 (3&4): 29-33.
5. Mhasal, G.S., Marawar, M.W., Solanke, A.C. and Tayade, S.D. 2015. Heterosis and combining ability studies in medium duration pigeonpea F₁ hybrids. *J. Agric. Res.*, 53(1): 11-22.
6. Moses, N., Sharma, M.B., Seyie, K. Shah, P and Ozukum, C. 2020. Combining ability study in vegetable-type pigeon pea [*Cajanus cajan* (L.) Millsp.]. *International Journal of Recent Scientific Research*. 11(2): 37318-37321.
7. Pandey, P., Tiwari, D., Pandey, V.R. and Yadav, S. (2014). Studies on gene action and combining ability of cytoplasmic-genic male sterile hybrids in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Aus. J. Crop Sci.*, 8 (5): 814-821.
8. Patel, H.S., Patel, A.M., Chaudhary, N.B., Patel, P.C. and Viradiya, Y.A. 2020. Investigation of combining ability and gene action for seed yield and its component traits in pigeonpea [*Cajanus cajan* (L.) Millspaugh]. *Int. J. Curr. Microbiol. App. Sci.*, 9(8): 1095-1103.
9. Rama Devi, S., Prasanthi, L., Reddy, K.H.P. and Reddy, B.V.B. 2011. Gene action for yield and yield contributing characters in pigeonpea (*Cajanus cajan* (L.) Millsp.). *Curr. Biotica*, 5(2): 137-143.
10. Saxena, K. B., Singh, L. and Gupta, M. D. (1990). Variation for natural out-crossing in pigeonpea. *Euphytica*, 46: 143-148.
11. Singh, O. and Singh, M.N. 2009. Combining ability analysis in pigeonpea. *J. Food Legumes*, 22 (1): 30-33.
12. Soni, N and Patel. 2016. Studies on gene action and combining ability of cytoplasmic-genic male sterility system based hybrids in pigeonpea [*Cajanus Cajan* (L.) Millsp.]. *International Journal of Horticulture*. 6(24): 1-7.
13. Sprague, G.F. and Tatum, L.A. 1942. General v/s specific combining ability in single cross on corn. *Journal of American Society of Agronomy*, 34: 923-932.
14. Srivashra, J., Jahagirdar, J.E., Kumar Sameer, C.V., Patil, D.K. and Hingane, A.J. 2018. Combining ability studies for grain yield and yield contributing characters in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *IJABR*, 8 (4): 445-450.
15. Tikle, A.N., Kumar, S., Kumar, R. V. and Saxena, K.B. 2016. Gene action and combining ability estimates using cytoplasmic-genic male sterile lines to develop pigeonpea hybrids for rainfed condition. *International Journal of Scientific and Research Publications*, 6(1): 502-506.
16. Van der Maesen L.J.G. (1980) India is the native home of pigeonpea. In: Arends JC, Boelema G, de Groot CT, Leeuwenberg AJM (eds) *Libergratulatorius in honorem H. C.D. de Wit landbouwhogeschool Miscellaneous paper no19*. Veenman H, Zonen BV, Wageningen, Netherlands, pp: 257-262.
17. Yamanura, Lokesh, R., Dharmaraj, P.S., Muniswamy, S. and Diwan, J.R. 2014. Estimation of Heterosis, Combining ability and Gene action in Pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Electron. J. Plant Breed.*, 5 (2): 173-178.



Implication of Hybrid Vigour in Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract

The present investigation was conducted to study the magnitude of hybrid vigour for seed yield and its contributing traits in pigeonpea. The experimental material comprised of ten diverse lines, three testers and their thirty hybrids produced in line × tester mating design along with standard check PAU-881. The results of heterosis revealed that the cross combinations, RKPV-918-1 × ICPL-88039, RKPV-916-1 × ICPL-88039, RKPV-904-1 × ICPL-88039, RKPV-1013 × ICPL-88039, RKPV-0527 × PA-291 and RKPV-912-1 × ICPL-88039 were identified as promising hybrids having significant heterosis with high *per se* performance in desired direction for seed yield and most of the yield contributing characters.

Key words : Hybrid vigour, line × tester, pigeonpea.

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the major grain legume crops in the tropical and sub-tropical regions of the world. India is the primary center of origin and diversification for pigeonpea (Van der Maesen, 1990). It is an often cross pollinated crop (20–70%) with diploid chromosome number ($2n=2x=22$) and genome size of 858 Mbp (Varshney *et al.* 2013). In India, pigeonpea is the second most important pulse crop after chickpea and is being widely grown in the country. Limited man made selections and several physiological and management limitation leading to low harvest index are the main reasons for low productivity of pigeonpea (Ashutosh *et al.* 2017). Besides this, several abiotic and biotic stresses are also major constraints to productivity in pigeonpea. Pigeonpea ranks sixth in global grain legume production and worldwide it is cultivated in about 6.99 million hectares area with an annual production of 5.96 million tons and a mean productivity of 852 kg/ha. In India, total area coverage and production of pigeonpea were 4.23 million hectares and 3.89 million tons, respectively with 919 kg/ha productivity (ICAR-AICRP on Pigeonpea, Project Coordinator's Report, 2020-2021).

An alternative breeding approach such as hybrid technology is pivotal to augment the yield of pigeonpea for assuring food and nutritional security. The magnitude of heterosis serves as guide for the choice of desirable parents and is also a basis for determining the genetic diversity (Swindell and Poehlman, 1976). Yield improvement can be achieved by exploitation of heterosis and hybrid vigor in pigeonpea by considerable additive and non-additive gene action in heterosis breeding (Saxena and Sharma, 1990). Non-additive genetic

variation can be subjugated through the production of heterotic hybrids as considerable degree of natural out crossing (20-70%) is present in pigeonpea (Saxena *et al.* 1990).

Considering the importance of pigeonpea in fulfilling nutritional requirements of ever increasing population with reducing availability of land resources and low productivity level, there is urgent need to develop high yielding conventional and hybrid varieties of pigeonpea adapted to different agro-climatic conditions. Therefore, the present investigation was undertaken to estimate the magnitude of heterosis, heterobeltiosis and standard heterosis for yield and its contributing traits in pigeonpea.

Materials and Methods

The present experiment was carried out at Field of AICRP on Pigeonpea, Agricultural Research Station, Ummedganj, Kota (Rajasthan), which is situated in south-eastern part of Rajasthan at 25° 13'N latitude and 75° 54'E longitude with an elevation of 257 m above mean sea level. The experimental material comprised of ten lines *viz.*, RKPV 0527, RKPV 901-2, RKPV 904-1, RKPV 912-1, RKPV 916-1, RKPV 917-1, RKPV 918-1, RKPV 1011-1, RKPV 1013 and RKPV 1015-1, three testers UPAS 120, ICPL 88039 and PA 291 and 30 F₁'s obtained by line × tester mating design. Hand pollination was carried out to obtain the crossed seeds during *Kharif* 2019-20. The resultant thirty hybrids along with their thirteen parents and check PAU-881 were evaluated in a randomized block design with three replications during *Kharif* 2020-21. Ten competitive plants of each genotypes were selected randomly in each replication for recording the observations of characters *viz.*, plant height (cm), number of primary branches per plant, number of pods per

Table-1 : Extent of heterosis over mid parent (MP), better parent (BP) and standard check (SC) for days to flowering, days to maturity and plant height in pigeonpea.

Crosses	Days to 50% flowering			Days to maturity			Plant height (cm)		
	MP	BP	SC	MP	BP	SC	MP	BP	SC
RKPV-0527 × UPAS-120	1.96	17.70**	20.17**	-3.21**	4.55**	8.42**	-9.18	-6.30	11.44
RKPV-901-2 × UPAS-120	3.41*	12.35**	14.71**	2.16*	3.17**	6.98**	-9.35	-9.02	8.20
RKPV-904-1 × UPAS-120	-3.78**	9.88**	12.18**	-4.48**	1.39	5.13**	-8.88	-6.90	6.10
RKPV-912-1 × UPAS-120	-2.07	7.00**	9.24**	-3.57**	1.58	5.34**	3.25	3.74	22.21**
RKPV-916-1 × UPAS-120	9.58**	17.70**	20.17**	6.36**	6.79**	9.86**	-1.72	-0.05	14.97
RKPV-917-1 × UPAS-120	-4.00**	3.70*	5.88**	1.58	1.78	5.54**	-15.33*	-11.11	-3.87
RKPV-918-1 × UPAS-120	7.90**	15.23**	17.65**	1.43	5.35**	9.24**	17.97**	25.38**	32.46**
RKPV-1011-1 × UPAS-120	4.12**	14.40**	16.81**	5.18**	8.51**	12.53**	-13.77*	-8.95	-2.60
RKPV-1013 × UPAS-120	-4.00**	-1.23	0.84	-5.13**	-4.75**	-1.23	-10.88	-9.83	4.78
RKPV-1015-1 × UPAS-120	-9.09**	-1.23	0.84	-2.31**	-0.82	-0.21	-13.70*	-11.28	-0.08
RKPV-0527 × ICPL-88039	-1.02	7.78**	22.27**	-0.92	7.83**	10.27**	0.07	2.45	23.68**
RKPV-901-2 × ICPL-88039	5.95**	8.89**	23.53**	8.19**	10.04**	12.53**	-13.77*	-13.44	3.70
RKPV-904-1 × ICPL-88039	-7.22**	0.00	13.45**	-3.10**	3.61**	5.95**	-6.25	-3.47	10.01
RKPV-912-1 × ICPL-88039	-7.53**	-4.44**	8.40**	-3.50**	2.41*	4.72**	-18.47**	-17.46*	-2.76
RKPV-916-1 × ICPL-88039	7.10**	8.89**	23.53**	11.71**	12.05**	14.58**	-16.27**	-14.20	-1.30
RKPV-917-1 × ICPL-88039	-5.43**	-3.33*	9.66**	3.28**	4.22**	6.57**	-8.19	-2.85	5.06
RKPV-918-1 × ICPL-88039	-1.47	-0.37	13.03**	1.15	5.82**	8.21**	1.05	8.26	14.37
RKPV-1011-1 × ICPL-88039	-2.67*	1.11	14.71**	1.84*	5.82**	8.21**	-8.96	-3.11	3.65
RKPV-1013 × ICPL-88039	10.44**	13.23**	22.27**	9.43**	10.64**	13.14**	-4.59	-2.73	13.03
RKPV-1015-1 × ICPL-88039	-1.98	0.74	14.29**	7.69**	8.57**	9.24**	-1.45	2.09	14.98
RKPV-0527 × PA-291	-6.38**	7.32**	10.92**	-7.01**	-0.39	4.93**	1.15	7.44	20.85*
RKPV-901-2 × PA-291	14.50**	23.58**	27.73**	4.67**	4.87**	10.47**	-13.17*	-10.35	0.84
RKPV-904-1 × PA-291	-16.49**	-5.28**	-2.10	-11.30**	-6.63**	-1.64	-13.99*	-13.42	-2.61
RKPV-912-1 × PA-291	3.37*	12.20**	15.97**	-3.17**	1.17	6.57**	-13.68*	-11.64	-0.61
RKPV-916-1 × PA-291	13.14**	20.73**	24.79**	10.65**	11.98**	15.20**	-0.36	0.77	13.35
RKPV-917-1 × PA-291	4.55**	12.20**	15.97**	3.14**	3.75**	8.01**	-1.66	0.32	8.49
RKPV-918-1 × PA-291	3.83**	10.16**	13.87**	2.93**	6.04**	11.70**	-11.11	-8.23	-3.05
RKPV-1011-1 × PA-291	-0.19	8.94**	12.61**	-1.33	0.97	6.37**	1.76	4.37	11.66
RKPV-1013 × PA-291	3.78*	6.10**	9.66**	4.11**	4.52**	9.24**	-7.23	-5.70	6.07
RKPV-1015-1 × PA-291	-5.84**	1.63	5.04**	0.90	3.27**	3.90**	-6.11	-6.05	5.68

*, **Significant at 5% and 1% level of significance, respectively.

plant, number of seeds per pod, pod length (cm), 100 seed weight (g), grain yield per plant (g), biological yield per plant and harvest index (%). The observation on days to 50% flowering and days to 75% maturity was recorded on whole plot basis. Mid parent heterosis was calculated as per the procedure suggested by Matinzinger (1968). Similarly, better parent and standard heterosis was calculated as per the procedure suggested by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

Results and Discussion

For the character days to flowering, the cross combinations RKPV 904-1 × PA 291 and RKPV 912-1 × ICPL 88039 showed significant heterosis as well as heterobeltiosis in desired direction while the cross RKPV 904-1 × PA 291 also exhibited non-significant economic heterosis but in desired direction. The cross RKPV 1015-1 × UPAS 120 also appeared promising with significant

average heterosis as well as non-significant heterobeltiosis in desired direction. The significant negative heterosis also observed by Pandey *et al.* (2013), Gite *et al.* (2014), Patel and Tikka (2014), Baban (2015), Patil *et al.* (2015), Singh and Singh (2015), Pagi *et al.* (2016). and Mallikarjuna *et al.* (2018).

Heterosis in negative direction is desirable for days to maturity. Early maturity coupled with high yield is desirable in pigeonpea, mostly under rainfed cultivation. As evident from Table-1 significant heterosis as well as heterobeltiosis in desired direction were noted for RKPV 904-1 × PA 291 and RKPV 1013 × UPAS 120 for days to maturity however, the cross combination RKPV 1015-1 × UPAS 120 also appeared promising because it exhibited significant heterosis and non-significant heterobeltiosis as well as economic heterosis but in desired direction with high *per se* for seed yield per plant. The significant heterosis desired direction also observed by Pandey *et al.* (2013), Gite *et al.* (2014), Patel and Tikka (2014), Baban

Table-2 : Extent of heterosis over mid parent (MP), better parent (BP) and standard check (SC) for number of primary branches per plant, number of pods per plant and number of seeds per pod in pigeonpea.

Crosses	Primary branches per plant			Pods per plant			Seeds per pods		
	MP	BP	SC	MP	BP	SC	MP	BP	SC
RKPV-0527 × UPAS-120	-22.75**	-25.10**	-17.92	-15.73*	-24.32**	-12.35	-17.95**	-20.00**	-9.43*
RKPV-901-2 × UPAS-120	-11.03	-12.50	-0.83	9.23	5.02	4.94	-10.26**	-12.50**	-0.94
RKPV-904-1 × UPAS-120	-12.11	-25.48**	-18.33	5.36	-1.28	-8.96	1.89	-10.00*	1.89
RKPV-912-1 × UPAS-120	-33.21**	-34.07**	-25.83**	-37.72**	-45.32**	-33.29**	-29.28**	-34.97**	-12.26**
RKPV-916-1 × UPAS-120	-16.70*	-19.39*	-11.67	-1.86	-4.93	-6.49	-12.93**	-15.83**	-4.72
RKPV-917-1 × UPAS-120	-23.47**	-31.18**	-24.58**	-23.83**	-25.10*	-28.54**	-13.51**	-20.00**	-9.43*
RKPV-918-1 × UPAS-120	-22.05**	-29.19**	-5.00	-11.15	-25.65**	1.76	-20.61**	-26.76**	-1.89
RKPV-1011-1 × UPAS-120	-30.02**	-38.40**	-32.50**	-37.50**	-39.88**	-44.56**	-1.85	-11.67**	0.00
RKPV-1013 × UPAS-120	-33.61**	-39.92**	-34.17**	-35.40**	-36.42**	-39.46**	-19.30**	-23.33**	-13.21**
RKPV-1015-1 × UPAS-120	-0.36	-5.15	15.00	8.04	-5.54	16.35	2.44	0.00	18.87**
RKPV-0527 × ICPL-88039	-3.91	-11.03	7.50	-6.10	-6.50	8.28	-6.78	-9.84*	3.77
RKPV-901-2 × ICPL-88039	-34.16**	-36.21**	-22.92*	-33.74**	-38.03**	-28.85**	-18.64**	-21.31**	-9.43*
RKPV-904-1 × ICPL-88039	37.00**	11.72	35.00**	26.94**	8.01	24.02*	23.36**	8.20*	24.53**
RKPV-912-1 × ICPL-88039	20.00**	15.86*	40.00**	9.39	6.17	29.53**	7.17*	-0.70	33.96**
RKPV-916-1 × ICPL-88039	25.00**	15.52*	39.58**	26.27**	17.21*	34.59**	29.91**	24.59**	43.40**
RKPV-917-1 × ICPL-88039	8.00	-6.90	12.50	8.41	-0.76	13.95	7.14	-1.64	13.21**
RKPV-918-1 × ICPL-88039	14.38*	8.70	45.83**	15.23*	5.95	45.01**	13.64**	5.63	41.51**
RKPV-1011-1 × ICPL-88039	-24.08**	-35.86**	-22.50*	-19.84*	-30.18**	-19.84*	-6.42	-16.39**	-3.77
RKPV-1013 × ICPL-88039	20.87**	4.83	26.67**	17.58*	7.54	23.48*	24.35**	17.21**	34.91**
RKPV-1015-1 × ICPL-88039	-18.76**	-18.90*	-1.67	-17.43*	-20.23**	-1.74	-17.74**	-19.05**	-3.77
RKPV-0527 × PA-291	19.49*	14.17	17.50	18.44*	-0.06	15.74	17.54**	17.54**	26.42**
RKPV-901-2 × PA-291	-37.22**	-42.65**	-35.00**	-36.78**	-43.21**	-43.25**	-18.42**	-18.42**	-12.26**
RKPV-904-1 × PA-291	-26.47**	-33.33**	-37.50**	-32.94**	-33.34**	-46.28**	-9.71*	-18.42**	-12.26**
RKPV-912-1 × PA-291	-39.39**	-44.44**	-37.50**	-47.95**	-56.99**	-47.53**	-17.51**	-25.87**	0.00
RKPV-916-1 × PA-291	11.25	6.50	9.17	28.66**	16.41	14.49	3.54	2.63	10.38*
RKPV-917-1 × PA-291	-20.92*	-23.56*	-28.33**	-23.03*	-29.40**	-32.64**	-14.81**	-19.30**	-13.21**
RKPV-918-1 × PA-291	-12.61	-25.78**	-0.42	-6.53	-26.08**	1.18	-20.31**	-28.17**	-3.77
RKPV-1011-1 × PA-291	-16.71	-21.33*	-26.25**	-16.16	-18.90	-30.92**	-12.38**	-19.30**	-13.21**
RKPV-1013 × PA-291	-20.55*	-22.67*	-27.50**	-25.23**	-31.36**	-34.64**	-15.32**	-17.54**	-11.32*
RKPV-1015-1 × PA-291	-37.21**	-44.33**	-32.50**	-38.53**	-49.40**	-37.67**	-25.00**	-28.57**	-15.09**

*, **Significant at 5% and 1% level of significance respectively.

(2015), Patil *et al.* (2015), Singh and Singh (2015), Pagi *et al.* (2016). and Mallikarjuna *et al.* (2018).

For traits plant height, the cross RKPV 912-1 × ICPL 88039 was observed significant negative heterosis over better parent while, non of the hybrid showed significant negative standard heterosis over the check PAU-881.

The number primary branches per plant are believed to be positively associated with high seed yield per plant resulting high productivity. Therefore, the cross combinations with more primary branches per plant were to be identified. For primary branches per plant, cross combination RKPV 912-1 × ICPL 88039 and RKPV 916-1 × ICPL 88039 exhibited significant heterosis at all the three level in desired direction whereas, RKPV 918-1 × ICPL 88039, RKPV 904-1 × ICPL 88039 and RKPV 1013 × ICPL 88039 showed significant average heterosis as well as heterobeltiosis in desired direction while RKPV 918-1 × ICPL 88039 exhibited highest economic

heterosis with high *per se* performance. Singh and Singh (2015), Pagi *et al.* (2016), Sudhir *et al.* (2016), Mudaraddi and Saxena (2017), Shrivarsha *et al.* (2017), Mallikarjuna *et al.* (2018) and Patel *et al.* (2020) also reported significant positive heterosis for number of primary branches per plant.

Heterosis in positive direction is desirable for the trait number of pods per plant as more number of pods can accommodate high seed yield per plant. The number pods per plant is the direct component of seed yield therefore improvement in pods per plant will increase seed yield. Regarding the number of pods per plant, RKPV 916-1 × ICPL 88039 depicted significant average heterosis, heterobeltiosis and standard heterosis in desired direction while the cross combinations RKPV 918-1 × ICPL 88039, RKPV 904-1 × ICPL 88039 and RKPV 1013 × ICPL 88039 exhibited significant mid parent as well as economic heterosis in desired direction. Cross

Table-3 : Extent of heterosis over mid parent (MP), better parent (BP) and standard check (SC) for pod length (cm), 100- seed weight (g) and seed yield per plant (g) in pigeonpea.

Crosses	Pod length (cm)			100-Seed weight (g)			Seed yield per plant (g)		
	MP	BP	SC	MP	BP	SC	MP	BP	SC
RKPV-0527 × UPAS-120	-10.53**	-11.11**	13.33*	7.63**	2.23	8.70**	-10.21	-15.50	-16.61
RKPV-901-2 × UPAS-120	2.07	-1.99	23.33**	8.40**	5.04	7.11**	4.47	-0.18	-4.60
RKPV-904-1 × UPAS-120	0.75	-10.60*	12.50*	1.07	-2.48	-6.72*	2.68	-2.16	-14.82
RKPV-912-1 × UPAS-120	-14.01**	-15.38**	10.00	-13.91**	-21.89**	-8.30**	-45.13**	-52.67**	-43.19**
RKPV-916-1 × UPAS-120	-2.37	-4.64	20.00**	-1.61	-4.30	-3.16	2.25	0.96	-9.82
RKPV-917-1 × UPAS-120	-1.43	-8.61*	15.00**	-7.69**	-8.26**	-12.25**	-26.23**	-27.97**	-37.29**
RKPV-918-1 × UPAS-120	-9.72**	-14.29**	20.00**	-0.37	-10.00**	6.72*	-9.69	-22.25*	-6.23
RKPV-1011-1 × UPAS-120	-15.87**	-24.50**	-5.00	13.80**	10.74**	5.93*	-42.44**	-44.79**	-51.93**
RKPV-1013 × UPAS-120	-18.49**	-21.19**	-0.83	-14.11**	-14.46**	-18.18**	-40.83**	-41.62**	-49.17**
RKPV-1015-1 × UPAS-120	1.65	1.32	28.33**	0.00	-9.40**	6.72*	10.90	-4.26	14.70
RKPV-0527 × ICPL-88039	-7.55*	-10.91**	22.50**	9.74**	2.60	9.09**	9.18	8.58	7.16
RKPV-901-2 × ICPL-88039	-12.50**	-19.39**	10.83*	-3.25	-7.75**	-5.93*	-36.74**	-37.40**	-38.89**
RKPV-904-1 × ICPL-88039	9.93*	-6.06	29.17**	27.23**	24.79**	15.42**	38.57**	25.25**	22.26**
RKPV-912-1 × ICPL-88039	1.56	-1.21	35.83**	17.89**	5.39*	23.72**	24.80**	13.15	35.80**
RKPV-916-1 × ICPL-88039	4.85	-1.82	35.00**	22.04**	16.80**	18.18**	54.17**	47.62**	44.10**
RKPV-917-1 × ICPL-88039	2.04	-9.09*	25.00**	14.59**	13.39**	7.11**	26.34**	16.86	14.07
RKPV-918-1 × ICPL-88039	2.70	1.79	42.50**	15.36**	2.67	21.74**	37.82**	24.68**	50.38**
RKPV-1011-1 × ICPL-88039	-8.07*	-20.61**	9.17	3.24	2.14	-5.53*	-13.66	-21.48*	-23.35**
RKPV-1013 × ICPL-88039	1.96	-5.45	30.00**	22.78**	21.25**	15.02**	32.87**	24.12**	21.16*
RKPV-1015-1 × ICPL-88039	-9.78**	-13.33**	19.17**	0.75	-10.07**	5.93*	-16.05*	-23.83**	-8.74
RKPV-0527 × PA-291	10.87**	0.00	27.50**	-1.94	-6.71**	9.88**	39.90**	22.33*	20.73*
RKPV-901-2 × PA-291	-8.40*	-13.67**	0.00	-11.87**	-17.79**	-3.16	-42.21**	-48.76**	-51.03**
RKPV-904-1 × PA-291	-3.33	-5.69	-3.33	-2.87	-14.77**	0.40	-37.75**	-39.71**	-52.46**
RKPV-912-1 × PA-291	-16.13**	-25.00**	-2.50	-15.29**	-15.44**	-0.40	-38.62**	-50.42**	-40.49**
RKPV-916-1 × PA-291	13.11**	4.86	25.83**	-8.30**	-14.77**	0.40	32.91**	21.43*	8.47
RKPV-917-1 × PA-291	1.59	-0.78	6.67	-6.15**	-15.44**	-0.40	-25.72**	-29.78**	-41.75**
RKPV-918-1 × PA-291	-0.34	-13.69**	20.83**	-9.36**	-9.67**	7.11**	-2.47	-21.34*	-5.13
RKPV-1011-1 × PA-291	2.88	1.63	4.17	-25.62**	-34.23**	-22.53**	-21.60*	-24.56*	-39.70**
RKPV-1013 × PA-291	-9.09*	-14.89**	0.00	-22.68**	-30.20**	-17.79**	-29.49**	-34.01**	-44.07**
RKPV-1015-1 × PA-291	-11.27**	-19.74**	1.67	-21.81**	-21.81**	-7.91**	-45.08**	-55.60**	-46.81**

*, **Significant at 5% and 1% level of significance respectively.

RKPV-912-1 × ICPL 88039 also appeared promising with significant standard heterosis. The results are in harmony with the findings of Mhasal *et al.* (2015), Singh and Singh (2015), Joshi *et al.* (2016), Pagi *et al.* (2016), Sudhir *et al.* (2016), Ashutosh *et al.* (2017), Mudaraddi and Saxena (2017), Shrivarsha *et al.* (2017), Soni and Patel (2017) Mallikarjuna *et al.* (2018) and Patel *et al.* (2020).

The hybrids with positive heterosis for number of seeds per pod are desirable to increase the yield. For number of seeds per pod, cross combination RKPV 916-1 × ICPL 88039, RKPV 1013 × ICPL-88039, RKPV 0527 × PA 291 and RKPV 904-1 × ICPL 88039 exhibited significant heterosis at all the three level in desired direction while the cross RKPV 918-1 × ICPL 88039 appeared promising as it exhibited significant average as well as economic heterosis. These findings were in agreement with the findings of Patil *et al.* (2015), Mhasal

et al. (2015) and Patel *et al.* (2020) which focusing number of seeds per pod as vital yield contributing character.

Positive heterosis for pod length is highly desirable, as more pod length, more will be the number of seeds can accommodate. Heterosis for pod length revealed that cross combinations RKPV 916-1 × PA 291, RKPV 0527 × PA 291 and RKPV 904-1 × ICPL 88039 showed significant average as well as economic heterosis in desired direction however, the crosses RKPV 918-1 × ICPL 88039 and RKPV 916-1 × ICPL 88039, RKPV 912-1 × ICPL 88039 also appeared promising with highly significant standard heterosis with superior *per se* performance. The significant positive heterosis for pod length in promising hybrids were also reported by Patel and Tikka (2014), Baban (2015), Singh and Singh (2015), Joshi *et al.* (2016), Pagi *et al.* (2016), Sudhir *et al.* (2016), Ashutosh *et al.* (2017) and Mudaraddi and Saxena (2017).

Table-4 : Extent of heterosis over mid parent (MP), better parent (BP) and standard check (SC) for biological yield per plant (g) and Harvest index (%) in pigeonpea.

Crosses	Biological yield per plant (g)			Harvest index (%)		
	MP	BP	SC	MP	BP	SC
RKPV-0527 × UPAS-120	-10.85	-19.52	-19.86	0.79	-3.76	4.58
RKPV-901-2 × UPAS-120	12.49	0.48	2.49	-8.25	-14.49**	-7.08
RKPV-904-1 × UPAS-120	0.38	-8.19	-11.18	0.77	-12.07*	-4.45
RKPV-912-1 × UPAS-120	-37.04**	-45.99**	-39.47**	-13.79**	-14.43**	-7.02
RKPV-916-1× UPAS-120	2.61	-5.36	-10.12	-1.54	-7.99	-0.01
RKPV-917-1× UPAS-120	-24.41*	-28.96*	-35.22**	-1.50	-9.60	-1.77
RKPV-918-1× UPAS-120	-6.18	-23.76**	-2.18	-14.87**	-17.70**	-4.20
RKPV-1011-1× UPAS-120	-38.58**	-41.70**	-47.95**	-6.28	-13.88**	-6.42
RKPV-1013 × UPAS-120	-39.33**	-44.12**	-46.77**	-0.66	-9.68	-1.85
RKPV-1015-1× UPAS-120	18.22*	1.41	13.68	-6.40	-7.20	0.85
RKPV-0527 × ICPL-88039	11.14	7.47	14.57	-1.56	-5.31	-6.39
RKPV-901-2 × ICPL-88039	-29.67**	-31.19**	-26.64*	-9.88	-11.11	-16.53**
RKPV-904-1 × ICPL-88039	15.90	10.53	17.84	20.59**	13.75*	3.89
RKPV-912-1× ICPL-88039	13.80	11.03	24.43*	9.99*	1.92	9.10
RKPV-916-1× ICPL-88039	31.80**	24.60*	32.84**	17.04**	15.12*	8.71
RKPV-917-1× ICPL-88039	14.07	5.82	12.81	10.98*	10.65	1.06
RKPV-918-1× ICPL-88039	7.68	-1.43	26.47*	14.62**	2.28	19.05**
RKPV-1011-1× ICPL-88039	-12.76	-19.85*	-14.55	-1.52	-1.68	-10.20
RKPV-1013 × ICPL-88039	17.49*	11.23	18.58	14.17**	12.67*	2.90
RKPV-1015-1× ICPL-88039	-17.16*	-19.19*	-9.41	1.52	-5.84	0.58
RKPV-0527 × PA-291	31.64**	17.34	16.83	6.74	4.53	3.34
RKPV-901-2 × PA-291	-43.90**	-50.52**	-49.53**	3.33	2.86	-2.52
RKPV-904-1 × PA-291	-42.47**	-48.06**	-49.76**	9.42	1.46	-3.85
RKPV-912-1 × PA-291	-37.28**	-46.83**	-40.41**	2.57	-3.31	3.50
RKPV-916-1× PA-291	36.34**	24.12*	17.87	-2.71	-2.88	-7.96
RKPV-917-1× PA-291	-28.22**	-33.43**	-39.29**	3.85	1.68	-3.65
RKPV-918-1× PA-291	-5.92	-24.38**	-2.98	-7.18	-15.80**	-2.00
RKPV-1011-1× PA-291	-28.02**	-32.59**	-39.82**	9.02	6.88	1.28
RKPV-1013 × PA-291	-28.07**	-34.61**	-37.71**	-2.05	-5.06	-10.04
RKPV-1015-1× PA-291	-42.15**	-50.96**	-45.03**	-3.45	-8.90	-2.68

*, ** Significant at 5% and 1% level of significance respectively.

The 100-seed weight is an important trait, which determines the *per se* performance in pigeonpea having direct positive association with seed yield. The 100- seed weight is an important yield component and heterosis in positive direction is desirable for this trait. Heterosis over mid parent was positive and significant in ten hybrids. Regarding the character 100-seed weight, cross combinations viz., RKPV 912-1 × ICPL 88039 and RKPV 916-1 × ICPL 88039, RKPV 904-1 × ICPL-88039, RKPV-1013 × ICPL-88039 and RKPV 917-1 × ICPL 88039 exhibited significant heterosis at all the three level in desired direction whereas, RKPV-918-1 × ICPL 88039 and RKPV 0527 × PA 291 showed significant average heterosis as well as heterobeltiosis in desired direction while RKPV 912-1 × ICPL 88039 noted highest standard heterosis with high *per se* performance. Gite *et al.* (2014),

Patel and Tikka (2014), Baban (2015), Patil *et al.* (2015), Pagi *et al.* (2016) and Patel *et al.* (2020) reported significant heterosis in desired direction for 100-seed weight.

Seed Yield is the complex character and depends on all other yield contributing traits. All changes in yield must be accompanied by changes in one or more characters have been pointed out by Grafius (1959). Higher yield can be achieved by improvement of one or more direct component of yield. Heterosis for seed yield per plant revealed that hybrids RKPV 918-1 × ICPL 88039, RKPV 916-1 × ICPL 88039, RKPV 904-1 × ICPL-88039, RKPV-1013 × ICPL 88039 and RKPV 0527 × PA 291 were observed significant heterosis at all the three level in desired direction while, RKPV 912-1 × ICPL 88039 showed significant average heterosis as well as

heterobeltiosis in desired direction moreover, RKPV 918-1 × ICPL 88039 noted highest standard heterosis with high *per se* performance. Hybrid with significant heterosis in desired direction with high *per se* performance for seed yield per plant could be utilized in future breeding programme to exploit better segregant. Pandey *et al.* (2013), Patil *et al.* (2015), Mhasal *et al.* (2015), Joshi *et al.* (2016), Pagi *et al.* (2016), Sudhir *et al.* (2016), Ashutosh *et al.* (2017), Mudaraddi and Saxena (2017), Shrivarsha *et al.* (2017), Soni and Patel (2017), Mallikarjuna *et al.* (2018) and Patel *et al.* (2020) also observed significant heterosis in desired direction. Hybrid with significant heterosis in desired direction with high *per se* performance for seed yield per plant could be utilized in future breeding programme to exploit better segregant.

Significant positive heterosis is desirable for biological yield per plant. For biological yield per plant, cross combination RKPV 916-1 × ICPL 88039 exhibited significant average heterosis, heterobeltiosis and standard heterosis in desired direction with high *per se* performance however, RKPV 916-1 × PA 291 showed significant mid parent heterosis as well as heterobeltiosis in desired direction. The cross combination RKPV 918-1 × ICPL-88039 and RKPV 912-1 × ICPL-88039 also appeared promising with significant standard heterosis as well as high *per se* performance in desired direction. These results are supported by the findings of Pandey *et al.* (2013), Patel and Tikka (2014), Shrivarsha *et al.* (2017), Soni and Patel (2017) and Patel *et al.* (2020).

Harvest index indirectly influences the seed yield through partitioning photosynthates in source and sink. Regarding the harvest index, cross combination RKPV 916-1 × ICPL 88039 exhibited significant heterosis at all the three levels in desired direction while cross RKPV 904-1 × ICPL 88039 showed significant heterosis as well as heterobeltiosis however, RKPV 918-1 × ICPL 88039 noted highest value of standard heterosis. Positive heterosis is desirable as high harvest index will result in high economic yield. The results are akin to the findings of Pandey *et al.* (2013), Patel and Tikka (2014), Ashutosh *et al.* (2017) Soni and Patel (2017), Mallikarjuna *et al.* (2018) and Patel *et al.* (2020).

Conclusions

The results of heterosis revealed that the cross combinations, RKPV 918-1 × ICPL 88039, RKPV 916-1 × ICPL 88039, RKPV 904-1 × ICPL 88039, RKPV 1013 × ICPL 88039, RKPV 0527 × PA 291 and RKPV 912-1 × ICPL 88039 were identified as promising hybrids having significant heterosis with high *per se* performance in desired direction for seed yield and most of the yield contributing traits. These crosses could be utilized for

comprehensive pigeonpea breeding programme to get potential transgressive segregants in the advanced generations.

References

1. Ashutosh, Bhanu, A.N., Singh, M.N., Alaka, T. And Kumar, S. 2017. Estimation of heterosis for yield and yield traits in long duration pigeonpea [*Cajanus cajan* (L.) Millspaugh]. *Journal of Food Legumes* 30(4): 245-250.
2. Baban, V.G. 2015. Genetic analysis of physiological parameters, yield and yield contributing characters in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Ph.D Thesis, Navsari Agricultural University, Navsari*.
3. Fonseca, S. and Petterson, F.L. 1968. Hybrid vigour in seven diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Science*, 8: 85-88.
4. Gite, V.K., Madrap, I.A., Patil, D.K. and Kamble, K.R. 2014. Exploitation of heterosis in CMS based hybrids in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *J. Agri. Res. Tech.*, 39(1): 138-140.
5. ICAR-AICRP on Pigeonpea, Project Coordinator's Report, 2020-21. *Online Annual Kharif Pulses Group Meet*, pp-33.
6. Joshi, H.K., Chauhan, D.A., Pathak, A.R. and Viradiya, Y.A. 2016. Heterosis for quality parameters in direct and reciprocal crosses of dual purpose pigeonpea. *Electronic Journal of Plant Breeding*, 7(4): 1169-1178.
7. Mallikarjuna, S.J., Naidu, N.V., Sameer Kumar, C.V., Hariprasad Reddy, K., Raja Rajeswari, V. and Koteswara Rao, S. R. 2018. Heterosis studies for yield and its components in CGMS based hybrids of pigeonpea (*Cajanus cajan* (L.) Millsp). *Int. J. Pure App. Biosci.*, 6(5): 1255-1263.
8. Matinzinger, D.F. 1968. Genetic variability in cured variety of *Nicotiana tabacum* L. III. Sc. 58 x Dixie Bright, 244. *Crop Sci.*, 14: 287-290.
9. Meredith, W.E. and Bridge, R.R. 1972. Heterosis and gene action in cotton (*Gossypium hirsutum* L.). *Crop sci.*, 12: 304-310.
10. Mhasal, G.S., Marawar, M.W., Solanke, A.C. and Tayade, S.D. 2015. Heterosis and combining ability studies in medium duration pigeonpea F₁ hybrids. *J. Agric. Res.*, 53(1):11-22.
11. Mudaraddi, B. and Saxena, K.B. 2017. Heterosis in relation to molecular diversity in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Journal of Food Legumes*, 30(2): 9-13.
12. Pagi, N.K., Ravindrababu, Y., Dharajiya, D.T., Patel, J.M. and Patel, M.P. 2016. Heterosis for seed yield and its component characters in Pigeonpea [*Cajanus cajan* L. Millsp.]. *International Journal of Agriculture Sciences*, 8(60): 3391-3395.
13. Patel, H.S., Patel, A.M., Chaudhary, N.B., Patel, P.C. and Viradiya, Y.A. 2020. Investigation of combining ability and gene action for seed yield and its component traits in pigeonpea [*Cajanus cajan* (L.) Millspaugh]. *Int. J. Curr. Microbiol. App. Sci.*, 9(8): 1095-1103.
14. Pandey, P., Kumar, R., Pandey, V.R., Jaiswal, K.K. and Tripathi, M. 2013. Studies on heterosis for yield and its component traits on CGMS based pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids. *Int. J. Agri.Res.*, 8(4): 158-171.
15. Patel, P.T. and Tikka, S.B.S. 2014. Hybrid vigor in

- cytoplasmic geneic male sterility system based hybrids for seed yield and its associated traits in pigeonpea (*Cajanus cajan* (L.) Millsp.). *Indian Journal of Genetics and Plant Breeding*. 74(2): 257-260.
16. Saxena, K.B and Sharma, D.1990. Pigeonpea genetics. In: The pigeonpea, Nene YL, Hall SD and Sheila VK (Eds). *CAB International, Wallingford, Oxon, UK* Pp. 137-158.
 17. Saxena, K.B., Singh, L and Gupta M.D. 1990. Variation for natural outcrossing in pigeonpea. *Euphytica*, 46: 143-148.
 18. Shrivarsha, J., Jahagirdar, J.E., Kumar, S., Hingane, A.J., Paitl, D.K., Gite, V.K., Shruthi, H.B., Bhosle, T.M. 2017. Study of CGMS based short Duration Hybrids pigeonpea (*Cajanus cajan* (L.) Millsp.) in terms of Heterosis. *Int. J. Curr. Microbiol. App. Sci.*, 6(11): 682-692.
 19. Singh, R.S. and Singh, M.N. 2015. Heterosis and Inbreeding Depression for Yield and Yield Traits in Pigeonpea (*Cajanus cajan* L.) *Environment & Ecology* 34(1A): 395-399.
 20. Soni, N. and Patel, P.T. 2017. Study of heterosis and pollen fertility in CGMS based pigeonpea [*Cajanus cajan* (L.) Millsp.] hybrids. *Int.J.Curr.Microbiol. App.Sci.*, 6(6): 956-969.
 21. Sudhir K., Debnath, M. K., Sameer Kumar, C.V., Singh, P.K. and Sultana. R. 2016. Study of heterosis and pollen fertility in CGMS based pigeonpea [*Cajanus cajan* (L.) Millspaugh] hybrids. *Res. Environ. Life Sci.*, 9(1) 107-110.
 22. Swindell, R.E and Poehlman, J.M. 1976. Heterosis in the mungbean (*Vigna radiata* (L.) Wilezek). *Tropical Agriculture*, 53: 25-30.
 23. Van der Maesen, L.J.G. 1990. Pigeonpea: Origin, history, evolution and taxonomy.
 24. Varshney, R.K., Roorkiwal, M and Nguyen T. 2013. Legume genomics: from genomic resources to molecular breeding. *The Plant Genome*, 6(3): 1-7.



Effect of Optimum Levels of Organic and Inorganic Fertilizer on the Plant Growth and Pod's Yield of French Bean (*Phaseolus vulgaris* L.) Cv. Arka Sharath in Uttarakhand

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Abstract

The experiment was conducted at the vegetable research farm of Uttaranchal (PG) College of Bio-Medical Sciences and Hospital, Dehradun in the Department of Horticulture during August 2018 to monitor the effect of optimum levels of fertilizer treatments on plant height, number of branches plant⁻¹, pod length, pod weight and pod yield of French bean variety (Arka Sharath). The experimental results revealed that all the fertilizer treatments increased the days taken to 50% flowering, maturity, number of branches plant⁻¹, number of leaves per plant, plant height (cm), number of nodules per plant, number of seeds per pod, root length (cm), pod length (cm), pod weight (g per plant), pod yield (q per ha) and number of pods per plant of French bean significantly over control treatment. The data were analyzed according to procedure of Analysis for Randomized Block Design (RBD). Minimum days taken to 50% flowering (37.67 days), maturity (70.00 days) and maximum number of branches plant⁻¹ (8.60), number of leaves per plant (33.53), plant height (45.77 cm), number of nodules per plant (28.40), number of seeds per pod (7.20), root length (26.09 cm), pod length (11.65 cm), pod weight g plant⁻¹ (169.27 g), pod yield quintal ha⁻¹ (128.63 quintal) and number of pods per plant (52.27) were recorded in the treatment receiving 25 tons, 90 kg N, 120 kg P₂O₅ and 70 kg K₂O ha⁻¹ (T₅ treatment). The economics of fertilizers were also worked out on the basis of current market prices and it was found that use of fertilizer was profitable.

Key words : Organic, in-organic, french bean, growth, yield.

Introduction

French bean (*Phaseolus vulgaris* L.) is an important legume vegetable belongs to the family leguminosae and grown during the rabi season in plain's and kharif season in hill's for its tender green pods which form a rich source of protein, calcium and iron. It is grown twice during a year, once as a full-season crop in the month of March and secondly as a offseason crop in the month of August. Its green pods are cooked as a vegetable, being rich in proteins, vitamins, calcium, iron etc. The requirement of fertilizer for any crop varies with the cultivars and soil types in agro-ecological zones (Mitra *et al.*, 1990). Being a shy nodulator, French bean crop readily responds to large doses of Nitrogen and optimum Nitrogen was as high as 125.6 kg per hectore (Srinivas and Naik, 1990). Ivanove *et al* (1987) reported that the pod yield of French bean was increased with the increase nitrogen levels up to 150 kg per hectore. Short growth cycle of this crop is one of the reasons that Nitrogen fixation is not as efficient as other legumes because carbohydrate production by the French bean plant occurs at the same time as the plants and the rhizobium needs a maximum carbohydrate supply and there is a heavy competition for Carbohydrate between the bacteria and French bean (Van Schoonhoven and Voysests, 1991). This crop responds to the application of phosphorous more and

production increases with the increasing Phosphorous doses because with Phosphorous fertilizer, the plant develops its roots better and increases penetration with a better root system of deeper penetration and thus absorbs more Phosphorus which the bean plants need up to the physiological maturation phase (Malavolta, 1967) and optimum Phosphorus level was found to be as high as 123 kg per hectore (Srinivas and Rao, 1984). Projapoti *et al* (2004) recorded higher pod yield of French bean from 120 kg nitrogen per hectore. Dhanjal *et al* (2001) found significantly higher branches plant⁻¹ at 120 kg nitrogen per hectore. Singh (2000) got maximum pod length from the application of 125 kg nitrogen per hectore. Continuous cropping without the proper application of plant nutrients to the soil causes a substantial decrease in crop yield. Supply of plant nutrients, especially nitrogen, phosphorus and potash through fertilizer application is one of the best methods to increase the French bean plant growth and pods yield. Arka sharath has round, string less, smooth pods suitable for steamed beans. Pods are crisp, fleshy with no parchment and perfectly round on cross section. Plants are bushy and photo insensitive and it is suitable for both karif and rabli seasons. It gives maximum number of pods per plant (44.50) compared to checks. It has high pod yield potential of 18.5 tonnes per hectore in 70 days. The present study was, therefore conducted to monitor the effect of various levels of nitrogen, phosphorus and

Table-1a: Effect of optimum levels of organic and inorganic fertilizer on the plant growth and pod's yield of French bean (*Phaseolus vulgaris* L.) cv. Arka sharath in Uttarakhand.

Sl. No.	Treatments	Days to 50% flowering	Maturity	No of branches	No of leaves per plant	Plant height (cm)	No of nodules per plant
1.	T ₁ (20t: 75: 60: 70 kg ha ⁻¹ FYM:N:P:K)	43.33	76.67	6.00	28.40	31.65	23.60
2.	T ₂ (20t: 130: 120: 50 kg ha ⁻¹ FYM:N:P:K)	37.67	71.00	7.47	31.47	43.97	28.27
3.	T ₃ (20t: 90: 90: 90 kg ha ⁻¹ FYM:N:P:K)	41.00	74.00	6.93	30.53	27.66	25.93
4.	T ₄ (25t: 130: 90: 0 kg ha ⁻¹ FYM:N:P:K)	39.67	73.00	7.13	29.53	39.81	26.87
5.	T ₅ (25t: 90: 120: 70 kg ha ⁻¹ FYM:N:P:K)	37.67	70.00	8.60	33.53	45.77	28.40
6.	T ₆ (25t: 90: 90: 70 kg ha ⁻¹ FYM:N:P:K)	38.33	72.00	7.47	32.73	41.96	27.80
7.	T ₇ (130: 90: 90 kg ha ⁻¹ N:P:K)	44.67	77.67	5.27	25.53	29.61	23.20
8.	T ₈ (110: 120: 70 kg ha ⁻¹ N:P:K)	42.33	76.00	5.73	27.93	33.69	24.13
9.	T ₉ (90: 120: 90 kg ha ⁻¹ N:P:K)	41.67	75.00	5.80	26.53	35.81	25.20
10.	T ₁₀ (Control)	45.67	78.67	4.60	24.80	27.52	20.27
	GM	41.20	74.40	6.50	29.10	35.75	25.37
	Sem ±	0.45	0.16	0.24	0.13	3.18	0.60
	CV %	1.88	0.38	6.30	0.77	15.43	4.07
	CD at 5%	1.33	0.48	0.70	0.38	9.46	1.77

Table-1b: Effect of optimum levels of organic and inorganic fertilizer on the plant growth and pod's yield of French bean (*Phaseolus vulgaris* L.) cv. Arka sharath in Uttarakhand.

Sl. No.	Treatments	No of seeds per pod	Root length (cm)	Pod length (cm)	Pod weight (g per plant)	Pod yield q per ha	No of pods per plant
1.	T ₁ (20t: 75: 60: 70 kg ha ⁻¹ FYM:N:P:K)	5.87	19.59	8.13	116.43	100.43	39.13
2.	T ₂ (20t: 130: 120: 50 kg ha ⁻¹ FYM:N:P:K)	6.87	25.01	10.59	155.47	120.50	51.33
3.	T ₃ (20t: 90: 90: 90 kg ha ⁻¹ FYM:N:P:K)	5.73	22.20	9.71	133.37	110.30	45.00
4.	T ₄ (25t: 130: 90: 0 kg ha ⁻¹ FYM:N:P:K)	6.47	22.93	9.87	143.33	116.77	47.40
5.	T ₅ (25t: 90: 120: 70 kg ha ⁻¹ FYM:N:P:K)	7.20	26.09	11.65	169.27	128.63	52.27
6.	T ₆ (25t: 90: 90: 70 kg ha ⁻¹ FYM:N:P:K)	6.53	24.35	10.54	149.10	120.23	49.33
7.	T ₇ (130: 90: 90 kg ha ⁻¹ N:P:K)	5.40	18.45	7.47	110.00	90.50	37.33
8.	T ₈ (110: 120: 70 kg ha ⁻¹ N:P:K)	5.67	20.45	8.85	121.90	104.50	41.07
9.	T ₉ (90: 120: 90 kg ha ⁻¹ N:P:K)	5.53	21.14	9.53	130.23	105.27	42.80
10.	T ₁₀ (Control)	4.93	17.60	6.97	92.47	79.87	31.00
	GM	6.02	21.78	9.33	132.56	107.70	43.67
	Sem ±	0.23	0.68	0.31	3.31	3.99	1.72
	CV %	6.72	5.41	5.65	4.34	6.43	6.81
	CD at 5%	0.69	2.02	0.91	9.84	11.88	5.10

potash on the growth parameters and green pod yield of French bean.

Materials and Methods

The experiment was conducted at the vegetable research farm of Uttaranchal (PG) College of Bio-Medical Sciences and Hospital, Dehradun in the Department of Horticulture during August 2018 using French bean variety Arka sharath. The experiment were 10 treatment combinations consisting of three levels of Farm yard Manure (0, 20 and 25 tonnes per hectore), five levels of nitrogen (0, 75, 90, 110 and 130 kg per hectore), four levels of phosphorus (0, 60, 90 and 120 kg per hectore) and four levels of potassium (0, 50, 70 and 90 kg per hectore) was laid out in randomized block design with three replications. The seeds were sown at a distance of 30 cm × 15 cm in plot size of 3.0 m × 2.4 m in last week of August 2018. Full quantity of phosphorus and half dose of nitrogen according to treatments were

applied to each plot at the time of sowing on 28 August 2018. Before sowing of crop, the land was prepared thoroughly and nitrogen, phosphorus, and potash were applied in the form of farm yard manure, urea, di-ammonium phosphate and muriate of potash respectively. All phosphorus, potash and half dose of nitrogen was applied at the time of sowing while remaining half dose of nitrogen was applied after one month of sowing and all farm yard manure (FYM) was applied before three weeks of sowing. During the course of experiment, the data was recorded on the days taken to 50% flowering, maturity, number of branches plant⁻¹, number of leaves per plant, plant height (cm), number of nodules per plant, number of seeds per pod, root length (cm), pod length (cm), pod weight (g per plant), pod yield (q per ha) and number of pods per plant. The data were analyzed according to procedure of Analysis for Randomized Block Design (RBD).

Results and Discussion

Growth and Yield Parameters : The data presented in (Table-1) show the effect of optimum levels of organic and in-organic fertilizer treatments on the days taken to 50% flowering, maturity, number of branches plant⁻¹, number of leaves per plant, plant height (cm), number of nodules per plant, number of seeds per pod, root length (cm), pod length (cm), pod weight (g per plant), pod yield (q per ha) and number of pods per plant. The minimum days taken to 50% flowering of 37.67 days was observed in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment and T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment, followed by 38.33 days was observed in T₆ (25 tons: 90: 90: 70 kg ha⁻¹ FYM: N: P: K) treatment and the maximum days taken to 50% flowering of 45.67 days was observed in T₁₀ (control) treatment. The minimum days taken to maturity (pods harvesting days) of 70.00 days was observed in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment followed by 71.00 days was observed in T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment and the maximum days taken to maturity of 78.67 days was observed in T₁₀ (control) treatment. While observing the consequence of optimum levels of fertilizer on enlargement and yield of vegetable pea Bahuguna *et al.*, (2014) reported the earliest flowering and early maturity at 20: 90: 60 kg nitrogen, phosphorus and potash per hectore. Maximum number of branches plant⁻¹ 8.60 was found in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment followed by 7.47 were observed in T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) and T₆ (25 tons: 90: 90: 70 kg ha⁻¹ FYM: N: P: K) treatments. These results are in conformity with the findings of Sharma (2001) and Dhanjal *et al.* (2001). Whereas lowest number of branches (4.60) was measured for T₁₀ (control) treatment. Maximum number of leaves per plants of 33.53 was observed in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment, followed by 32.73 in T₆ (25 tons: 90: 90: 70 kg ha⁻¹ FYM: N: P: K) treatment. Least number of leaves per plants 24.80 was observed for T₁₀ (control) treatment. By comparing the various fertilizer treatments with one another, maximum plant height of 45.77 cm was observed in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment, followed by 43.97 cm in T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment. These results are in agreement with the findings of Sharma (2001). The plant height varied from 27.52 to 45.77cm (Table 1). While observing the consequence of optimum levels of fertilizer on enlargement and yield of vegetable pea Bahuguna *et al.*, (2014) reported the maximum plant height at 90 kg phosphorus per hectore. In French bean, Rana and Singh (1998) and Chandra *et al.*, (1987) recorded maximum height with 100 and 80 kg phosphorus per hectore, respectively. A farm yard manure, nitrogen,

phosphorus and potash level also influences the number of pods per plant (Table 1). The highest number of pods (52.27) was obtained with in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment under the present study and numbers of pod per plant ranged from 31.00 to 52.27. The result an increase in pod increasing per plant increasing levels of phosphorus per treatment Bahuguna *et al.*, 2014 (Vegetable pea), Rana and Singh 1998 (French bean), respectively. Number of nodules per plant ranged from 20.27 to 28.40 showed considerable variation (Table-1). The significantly maximum root length (26.09 cm) were found for T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment while, least value of root length 17.60 cm was observed in control. An increasing trend in number of grains per pod was observed in French bean with increasing levels of fertilizers and the maximum seeds (7.20) being under T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) level, whereas, number of grains per pod varied from 4.93 to 7.20 per pod (Table-1). Similar trends have also been reported by Bahuguna *et al.*, 2014 in pea and Ghakravati *et al.*, (1990) in French bean with the maximum number of seeds per pod under 75 kg phosphorus per hectore, respectively. The maximum pod length of 11.65 cm was observed in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment, followed by 10.59 cm in T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment. These results are in agreement with the findings of Begum *et al* (2003) and Singh (2000). Similarly maximum pod weight gram per plant (169.27 gm) was recorded in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment, followed by (155.47 gm) in T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment. The highest pod yield of 128.63 quintal per hectore was recorded in T₅ (25 tons: 90: 120: 70 kg ha⁻¹ FYM: N: P: K) treatment, followed by T₂ (20 tons: 130: 120: 50 kg ha⁻¹ FYM: N: P: K) treatment, wherein pod yield was 120.50 quintal per hectore. These results can be attributed to the fact that the French bean responded well to the enhanced doses of fertilizers. These increases in the yield component may be the result of better utilization of NPK which resulted in increased biosynthesis of the photosynthates and ultimately the yield. These results are in consonance with the findings of Prajapati *et al* (2004), Begum *et al* (2003), Sharma (2001), Singh and Singh (2000), Sangakkra (1996), Neuval *et al* (1994), Ivanov *et al* (1987), Islam *et al* (2004) and Chandra (1987).

Conclusions

Application of the correct level of fertilizer is necessary to achieve maximum yield of French bean and the present study, growth and yield correctors of French bean as days taken to 50% flowering, pods maturity, number of branches, number of leaves per plant, plant height (cm),

number of nodules per plant, number of seeds per pod, root length (cm), pod length (cm), pod weight (g per plant), pod yield quintal per hectare and number of pods per plant were significantly affected by the application of farm yard manure, nitrogen, phosphorus and potash 25 tons FYM ha⁻¹, 90 kg N ha⁻¹, 120 kg P₂O₅ ha⁻¹ and 70 kg K₂O ha⁻¹ yielded good results in number of grain per pod and pods per plants. In universal it is suggested with the purpose of investigate the similar study in different localities to have genuine information for the optimum level of fertilizer to produce French bean.

References

1. Bahuguna A., Singh B. and Bahuguna S. (2014). Consequence of optimum levels of fertilizer on enlargement and yield of vegetable pea cv. VL ageti mater 7 under Uttarakhand Hills condition. *Journal of Agronomy*, ISSN 1812-5379, 13 (3): 153-157.
2. Begum, A., A.Ahad, M.O. Kaisar, M.M.Islam and M.K. Anam. 2003. Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean (*Phaseolus vulgaris*) *Pak. J. of Biological Sci.* 6(22): 1897-1901.
3. Chandra, R., C.B.S. Rajput, K.P. Singh and S.J.P. Singh 1987. A note on the effect of nitrogen phosphorus and Rhizobium culture of the growth and yield of French bean (*Phaseolus vulgaris* L.) cv. Contender. *Haryana J. Hort. Sci.*, 16: 146-147.
4. Dhanjal, R., O. Parkash and S.P.I. Ahlawat. 2001. Response of French bean (*Phaseolus vulgaris* L.) varieties to plant density and nitrogen application. *Indian J Agron* 46(2), 277-281.
5. Islam, M.S., M.M.Haque, M.M.Khan, T. Hidaka, and M.A. Karim 2004. Effect of fertilizer potassium on growth, yield and water relations of bush bean (*Phaseolus vulgaris* L.) under water stress conditions. *Japanese Journal of Agriculture*. 48(1):1-9.
6. Ivanov, L., V. Rankov, B. Veler, K.H. Manuelyan, I. Porayajov, M. Benevshi and R. Petrove 1987. Optimizing mineral fertilization in commercial green bean production. *Rasteniev "dui-Nauk"* 24, 45-49.
7. Neuvel, J.J., H.W.G. Floot, S.Postma, and M.A.A. Evers. 1994. Research on reducing nitrogen fertilizer application to snap beans (*Phaseolus vulgaris* L.) by inoculation with Rhizobium phaseoli. Verslag Proefstation Voor de Akkerbouw en de Groenteteelt in de Vollegrond. (168): 120 pp.
8. Prajapati, M.P., H.A. Patel, B.A. Prajapati and L.R. Patel. 2004. Studies of nutrient uptake and yield of French bean (*Phaseolus vulgaris* L.) as affected by weed control methods and nitrogen levels. *Legume Res* 27(2), 99-102.
9. Srinivas, K. and L.B. Naik. 1988. Response of vegetable French bean (*Phaseolus vulgaris* L.) to nitrogen and phosphorus fertilization. *Indian J. Agril. Sci.*, 58: 707-708.
10. Sangakkara, U.R. 1996. Response of French bean (*Phaseolus vulgaris* L.) to rate and ratio of potassium fertilizer application. *Pertanika Journal of Tropical Agricultural Science*. 19(1): 61-67.
11. Sharma, S.K. 2001. French bean green pod and seed production as influenced by nitrogen and phosphorus application. *Annals of Agricultural Research*. 22(1): 130-132.
12. Singh, R.V. 2000. Response of French bean (*Phaseolus vulgaris* L.) to plant spacing and nitrogen, phosphorous fertilization. *Indian J Hort* 57(4): 338-341.
13. Singh, A.K, and S.S. Singh. 2000. Effect of planting dates, nitrogen and phosphorus levels on yield contributing factors in French bean. *Legume Research*. 23(1): 33-36.
14. Mitra, S.K., Sadhu, M.L. and Bose, T.K. 1990. "Nutrition of Vegetable Crops". Nayapokash, Calcutta. pp. 157-159.
15. Van Schoonhoon, A. and Voysests. O. 1991. "Common Bean: Research for Crop Improvement". CAB International, Oxon. 980 pp.
16. Malavolta, E. 1967. "Manual de Quimica Agricola Adubos e Adubacao" (Second Edn.) Agronomica Ceros, Sao Paulo.
17. Srinivas, K. and Rao, J.V. 1984. Response of French bean to nitrogen and phosphorous. *Indian J Agron* 29, 146-149.
18. Rana, N.S. and Singh, R. 1998. Effect of nitrogen and phosphorous on growth and yield of French bean (*Phaseolus vulgaris* L.). *Indian J Agron* 43(2): 2367-2370.
19. Ghakravati, K.N., Singh T. and Bahabur, 1990. Yield and quality response of French bean (*Phaseolus vulgaris* L.) to date of sowing and phosphorus levels under Faizabad condition. *Prog. Hortic.*, 22: 176-181.



Impact of Varying Levels of Nitrogen, Phosphorous and Potassium on Soil Fertility and Interactive Effect on Indian Mustard

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Abstract

A field experiment was carried out during the rabi season of 2019-20 at College of Agriculture Ummadganj, Kota to evaluate the effect of different levels of NPK on the status of available macronutrients in soil and interactive effect of nitrogen and potassium on 1000- seed weight of Indian mustard. Results revealed that the application of 120 kg N ha⁻¹ and 45 kg K₂O ha⁻¹ increased significantly the available NPK in soil as compared to 80 kg N ha⁻¹ and 15 kg K₂O ha⁻¹ respectively, whereas the non- significant effect of phosphorus fertilization on soil fertility. The interactive effect of 120 kg N ha⁻¹ along with 30 kg K₂O ha⁻¹ significant increased 1000-seed weight of mustard as compared to 80 kg N ha⁻¹ and 15 kg K₂O ha⁻¹.

Key words : Nitrogen, phosphorus, potassium, nutrient, 1000-seed weight.

Introduction

Indian mustard (*Brassica juncea* L.) has been categorized under the family Brassicaceae and is a worldwide essential source of cooking oil (Rahman *et al.*, 2018). The production of oil along with good quality forage such as stems and leaves, owing to their low fiber and high protein concentration, increases the importance of Indian mustard. India is one of the dominant oilseed production countries across the globe. Oilseed production is the second largest after cereals in India. Rapeseed and mustard are the main oilseed crops grown in the rabi season in India. Mustard is the chief edible oilseed crop of the semi-arid area after groundnut, contributing nearly 26.1% of total oilseed production. The oil is used for edible purpose, soap making, frying, the seed is used for pickles, curries, vegetables. The stem and leaves are used for fodder and fuel purposes (Prasad *et al.*, 2018). It is one of the predominant crops in Gujarat, Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh of India. Oil quantity and quality are the most important parameters of Indian mustard, being largely controlled by mineral fertilization of the plants.

The fertilizer sector is the major input factor in improving crop yield over the current trends in recent times. Developed countries already reached the peak of agriculture production, on the other hand developing countries like India is still far behind. The fertilizer sector is the major deciding factor which can speed up the agriculture production as it accounts for 50% of crop yields (Ahmed *et al.*, 2017). As per facts, nitrogenous fertilizers are mobile in soil and because of this nature

split application is recommended instead of full dose as basal application. Application of N in split doses and a single dose of P & K at the time of sowing can alter optimum NPK ratio which is very important for plants. High dose of nitrogenous fertilizer improve the N status of soil but the effects are limited in oilseed crop because of low P & K status. The high value of NPK ratio than optimum prevent efficient uptake of various essential nutrients by plants. Under such condition, the optimum quantity application of NPK fertilizers can provide the efficient use of nutrient by reducing the losses of nutrients throughout the crop growth. Addition of NPK fertilizers increase the crop yield as well as nutritional quality generally (Zhao *et al.*, 2008).

Materials and Methods

A field experiment was conducted at Agriculture Research Station, Kota (26° North latitude, 76°-6' East longitude and 260 m above mean sea level) during the *rabi* seasons of 2019-20. The experimental soil was clay loam in texture with a pH of 7.95, medium in organic carbon (5.4 g kg⁻¹), available nitrogen (280 kg ha⁻¹), phosphorus (40.3 kg ha⁻¹) and high in potassium (400 kg ha⁻¹), zinc (0.92 mg kg⁻¹ soil) and low in sulphur (8.85 kg ha⁻¹). The experiment comprised of 18 treatments with three levels of nitrogen *viz.*, 80, 100 and 120 kg ha⁻¹, two levels of phosphorus *viz.*, 40 and 50 kg ha⁻¹ in main plots, and three levels of potassium *viz.*, 15, 30 and 45 kg ha⁻¹ in sub plots and laid out in split-plot design with 3 replication. Uniform application of FYM was applied in experimental area and treatment doses of nitrogen, phosphorus and potassium were supplied through urea, dia-ammonium phosphate,

Table-1 : Effect of nitrogen phosphorous and potassium fertilization on nutrient status (kg/ha) in soil after harvest of Indian mustard.

Treatment	N	P ₂ O ₅	K ₂ O
Nitrogen (kg/ha)			
80	286.33	49.50	451.94
100	298.28	53.61	454.94
120	306.33	57.89	456.78
SEm ±	1.86	1.27	1.79
CD (P=0.05)	7.31	4.97	NS
Phosphorus (kg/ha)			
40	294.30	47.11	453.33
50	299.67	53.15	455.78
SEm ±	2.42	1.87	2.88
CD (P=0.05)	NS	NS	NS
Potassium (kg/ha)			
15	291.72	48.11	445.89
30	297.28	50.22	454.17
45	301.94	52.06	464.61
SEm ±	2.56	1.65	2.90
CD (P=0.05)	7.46	NS	8.46

Table-2 : Interactive effects between different levels of nitrogen and potassium fertilization on 1000-seed weight of Indian mustard.

K	N	N ₈₀	N ₁₀₀	N ₁₂₀
K ₁₅		4.13	5.07	5.13
K ₃₀		4.53	5.08	5.33
K ₄₅		4.90	5.01	5.23
SEM±			0.12	
CD (P=0.05)			0.50	

muriate of potash, respectively. Full dose of P₂O₅, K₂O and half N were applied as basal at planting and half dose of N was top-dressed at 40 days after planting of the crop as per treatments. 'DRMRIJ 31' variety of mustard was sown with 5 kg ha⁻¹ seed rate. All the recommended agronomic practices were adopted throughout the crop season. The crop was harvested manually at physiological maturity. Soil samples collected after harvest of mustard crop were analysed for available N (Subbiah and Asija, 1956), P (Olsen's *et al.*, 1954) and K (Jackson, 1973) following standard procedures. The data statistically analysed by using standard procedures of ANOVA at 5% level of significance.

Results and Discussion

Available Nitrogen : The data pertaining to N status of soil as affected by levels and sources of NPK are presented in Table-1. With the application of different levels of N&K fertilizer, the available nitrogen status varied significantly. The maximum available nitrogen was found under the 120 kg N/ha (306.33 kg/ha) application which was significantly higher by 6.98 and 2.69 per cent over 80 and 100 kg N/ha, respectively. Further application of 100

kg N/ha (298.82 kg/ha) significantly increased available nitrogen in soil by 4.17 per cent over 80 kg N/ha. Non-significant differences were recorded for available nitrogen between application of 40 kg and 50 kg P₂O₅/ha. The maximum available nitrogen was recorded under 45 kg K₂O/ha (301.94 kg /ha) which was significantly higher by 3.50 per cent as compared to 15 kg K₂O/ha. Although, the differences between 15 and 30 kg K₂O, 30 and 45 kg K₂O were observed non-significant differences in this respect. Chetry *et al.* (2018) reported that the available N content in soil after the harvest of yellow sarson was not significantly affected by various levels of phosphorus whereas significantly affected due to different levels of nitrogen and potassium fertilization.

Available Phosphorus : The application of various levels of N show significant effect on available phosphorus whereas, levels of phosphorus and potassium did not show any noteworthy effect on the dynamics of phosphorus content in soil in between treatments (Table-1). The maximum P₂O₅ in soil (57.89 kg/ha) was recorded with the application of 120 kg N/ha which was significantly higher by 16.43 per cent over 80 kg N/ha. However, application of phosphorus and potassium levels increased the available phosphorus with their application the results are close conformity with Churasiya *et al.* (2019).

Available Potassium : Effect of fertilization on difference of K content was prominent in between treatments except with different levels of phosphorus application (Table-1). The nitrogen levels (80, 100 and 120 kg N/ha) and phosphorous levels (40 and 50 kg P₂O₅/ha) none of them could not bring significant differences on available potassium in soil. Available K₂O increased significantly with the levels of potassium fertilization. The maximum available K₂O was found under the application of 45 kg K₂O/ha (464.61 kg/ha) which was 4.19 per cent higher over 15 K₂O/ha. Nevertheless, the non-significant differences were recorded between 15 and 30 kg K₂O/ha, 30 and 45 kg K₂O /ha application, the similar finding are close conformity with Chetry *et al.* (2018).

Interactive effects between different levels of nitrogen and potassium fertilization on 1000- seed weight :

Interaction effect between nitrogen and potassium was found significant with respect to 1000- seed weight (Table-2). Significantly maximum 1000- seed weight was noted at 120 kg N/ha along with 30 kg potassium/ha over 80 kg N along with 15 and 30 kg K₂O/ha, irrespectively and on a par with rest of treatments combination. Minimum 1000-seed weight (5.30 g) was recorded under the application of 120kg N/ha along with 30 kg K₂O/ha, while lowest seed weight obtained at 80 kg N/ha with 15 kg K₂O/ha application.

References

1. Ahmed, H.P., Schoenau, J.J., King, T. and Kar, G. 2017. Effects of seed-placed sulfur fertilizers on canola, wheat, and pea yield; sulfur uptake; and soil sulfate concentrations over time in three prairie soils. *Journal of Plant Nutrition* 40(4): 543-557.
2. Chaurasiya A., Singh S., Singh V., Singh N. and Singh A. 2019. Effect of nitrogen and sulphur nutrition on interaction effect, quality parameters, nutrient content or uptake & economics of Indian mustard (*Brassica juncea* L.) in western UP. *International Journal of Chemical Studies* 7(1): 787-791.
3. Chetry S., Ojha N. J., Gogoi B. and Kurmi K. 2018. Performance of yellow sarson (*Brassica rapa* var. trilocularis) under different levels of phosphorus and potassium in rainfed condition of Assam. *Annals of Agricultural Research* 39(3): 1-6.
4. Jackson M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi, India.
5. Prasad, A., Swaroop N, Thomas T, Rao PS. 2018. Effect of various level of phos, and sulphur on soil physical and chemical properties, mustard yield and growth (*Brassica juncea* L.) Cv. Varuna, *International Journal of Chemical Studies*, 6(3): 2109-2111.
6. Olsen S.R., Cole C.V., Watnable, F.S and Dean L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate.
7. Rahman, M.; Khatun, A.; Liu, L.; Barkla, B.J. 2018. Brassicaceae Mustards: Traditional and agronomic uses in Australia and New Zealand. *Molecules*, 23, 231
8. Subbiah B.V. and Asija G.L. 1956. A rapid procedure for estimation of available N in soils. *Current Science* 25: 259-260.
9. Zhao H., Wang S., Xiu L. and Sukhed M. (2008) Effect of fertilization and other agronomic measures on nutritional quality of crops. *J. Sci. Food & Agri.* 88(1), 7-23.



Correlation and Association Analysis for Yield and Yield Related Traits in Fine Slender Rice Genotypes (*Oryza sativa* L.)

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Abstract

The goal of the study was to determine the relationship between grain yield and yield component in 39 fine slender rice genotypes. Correlation study indicated high positive and significant correlation of grain yield with panicles per hill followed by tillers per hill, biological yield ($q\ ha^{-1}$) and harvest index %. The Path analysis revealed that the traits like biological yield ($q\ ha^{-1}$), harvest index %, tillers per hill and grain length (mm) showed high positive direct effect on grain yield. Hence, these characters are helpful to determine the higher grain yield and can be used for improvement of grain yield in fine slender rice using further selection.

Key words : Slender grain rice, correlation coefficient analysis, path analysis.

Introduction

Rice, the most important cereal crop, feeds nearly 70% of the world's population. India ranks second in the world in rice production, producing approximately 142 MT "(FAOSTAT, 2018)". Since the country has achieved self-sufficiency in rice grain production, an increase in demand of quality grain rice is inevitable. As a result, rice breeders' primary goal is to create high-quality cultivars with increased yield and other desirable agronomic characteristics. The association study assists breeders in understanding the mutual constituent characters on which selection for genetic improvement selection can be rooted. Many economically important plant characteristics are usually related in one or more ways. Correlation and path analysis studies will allow us to quantify the magnitude and direction of their relationship, as well as other direct and indirect components responsible towards grain yield. Correlation and path analysis studies will thus aid in the identification of appropriate selection criteria for increasing yield.

Materials and Methods

The present investigation was conducted during kharif season of 2020-21 at experimental farm, "B.T.C. College of Agriculture and Research Station (IGKV) Bilaspur, (CG)". Thirty nine fine slender rice accessions consisting four checks namely Dubraj, Chhattisgarh Sugandhit Bhog, Chhattisgarh Dev Bhog, Indira Sugandhit Dhan-1 were raised as a seedling in nursery bed and transplanted

in Randomized Block Design (RBD) with three replications.

Important agronomic traits including days to 50% flowering, days to maturity, plant height (cm), tillers per hill, panicles per hill, main panicle length (cm), peduncle length (cm), grains per main panicles, 1000 grain weight (g), biological yield ($q\ ha^{-1}$), harvest index %, grain length (mm), grain width (mm), L/B ratio of grain and yield per ha ($q\ ha^{-1}$) were recorded for rice genotypes. Correlation was estimated using the "Miller et al.(1958)" formula, and it was partitioned into path coefficients using the "Dewey and Lu(1959)" technique.

Results and Discussion

The correlation study [Table-1] revealed that grain yield per hectare had strong positive association with tillers per hill, panicles per hill, 1000 grain weight (g), biological yield ($q\ ha^{-1}$), harvest index % and grain width (mm). The association studied indicated that grain yield of rice can be improved by selecting genotypes having higher performances for the above characters. The results obtained were in agreement with "Bhattacharya *et al.* (2019), Lakshmi *et al.* (2017), Sharma *et al.* (2016) and Mishu *et al.* (2015)". The trait of days to 50% flowering was strongly and positively correlated with days to maturity. The tillers per hill and panicles per hill were strongly and positively correlated with each other and were also strongly correlated with harvest index %. The L/B ratio of grain was strongly and positively correlated with grain length (mm) and was strongly and negatively

Table-1 : Genotypic (below diagonal) and Phenotypic (above diagonal) Correlation Matrix.

	DFF	DM	PH (cm)	TPH	PPH	MPL (cm)	PL (cm)	GPMP	TGW (g)	BY (q ha ⁻¹)	HI %	GL(mm)	GW (mm)	L/B Ratio	YPH (q ha ⁻¹)
DFF	1.000	0.890**	0.356**	-0.153	-0.178	-0.194*	-0.024	0.334**	-0.314**	-0.061	-0.162	-0.526**	0.261**	-0.491**	-0.219*
DM	0.987**	1.000	0.333**	-0.112	-0.106	-0.158	-0.088	0.301**	-0.262**	-0.088	-0.112	-0.477**	0.225*	-0.432**	-0.186*
PH (cm)	0.396**	0.413**	1.000	-0.325**	-0.308**	0.242**	0.339**	0.068	-0.309**	-0.400**	-0.180	0.067	-0.205*	0.147	-0.471**
TPH	-0.155	-0.132	-0.375**	1.000	0.949**	0.054	-0.410**	0.264**	0.436**	0.369**	0.588**	0.081	0.156	-0.046	0.764**
PPH	-0.184*	-0.170	-0.370**	0.991**	1.000	0.082	-0.395**	0.171	0.455**	0.369**	0.526**	0.075	0.145	-0.039	0.726**
MPL (cm)	-0.308**	-0.258**	0.279**	0.070	0.101	1.000	0.239**	0.137	0.008	-0.026	0.056	0.187*	-0.045	0.139	0.054
PL (cm)	-0.031	-0.025	0.390**	-0.475**	-0.469**	0.417**	1.000	-0.059	-0.415**	-0.361**	-0.248**	-0.033	-0.306**	0.137	-0.458**
GPMP	0.384**	0.379**	0.052	0.312**	0.217*	0.115	-0.069	1.000	-0.015	0.113	0.147	-0.269**	0.115	-0.247**	0.175
TGW (g)	-0.352**	-0.310**	-0.347**	0.493**	0.551**	0.034	-0.532**	-0.031	1.000	0.372**	0.218*	0.331**	0.355**	0.015	0.494**
BY (q ha ⁻¹)	-0.066	-0.079	-0.443**	0.489**	0.522**	-0.057	-0.540**	0.154	0.397**	1.000	-0.144	-0.306**	0.475**	-0.447**	0.641**
HI %	-0.307**	-0.330**	-0.377**	0.857**	0.818**	-0.006	-0.347**	0.172	0.455**	0.144	1.000	0.187*	0.006	0.092	0.648**
GL(mm)	-0.633**	-0.564**	0.050	0.098	0.108	0.316**	-0.023	-0.310**	0.417**	-0.344**	0.250**	1.000	-0.390**	0.857**	-0.040
GW (mm)	0.324**	0.331**	-0.248**	0.202*	0.212*	-0.077	-0.423**	0.132	0.362**	0.658**	0.073	-0.403**	1.000	-0.793**	0.352**
L/B Ratio	-0.593**	-0.551**	0.169	-0.055	-0.049	0.261**	0.198*	-0.282**	0.089	-0.558**	0.107	0.880**	-0.785**	1.000	-0.231*
YPH (q ha ⁻¹)	-0.280**	-0.296**	-0.566**	0.891**	0.895**	-0.007	-0.596**	0.193*	0.589**	0.773**	0.735**	-0.027	0.487**	-0.275**	1.000

correlated with grain width (mm). This demonstrates the significance of these characteristics in efficient selection.

The path coefficient analysis [Table-2] revealed that highest positive direct effect on grain yield per hectare at genotypic level was exhibited by biological yield (1.1392) followed by harvest index % (1.0023), tillers per hill (0.5183), grain length (0.3673), main panicle length (0.2627), days to 50% flowering (0.2586) and remaining traits showed direct effect of low magnitude. At phenotypic level highest positive direct effect was exhibited by biological yield (0.6950) and harvest index % (0.6811) and remaining traits showed direct effect of low magnitude. The highest direct but negative effect at genotypic level was exhibited by panicles per hill (-1.0155), grain width (-0.6296) and L/B ratio of grain (-0.4575). The remaining characters showed direct effect of low magnitude. The results obtained were in accordance with "Lakshmi et al. (2017), Sharma et al. (2016), Karim et al. (2014), Jaiswal et al. (2007) and Bhattacharya et al. (2019)".

The indirect effect on grain yield at genotypic level was shown by tillers per hill having high to moderate positive indirect effect via, panicle per hill (0.5135), harvest index % (0.4440), 1000 grain weight (0.2556) and biological yield (0.2534). The panicle per hill at genotypic level showed high to moderate positive indirect effect through peduncle length (0.4763) and plant height (0.3758). The biological yield at genotypic level showed high positive indirect effect through panicle per hill (0.5948), tillers per hill (0.557), grain width (0.7497) and 1000 grain weight (0.4517) and at phenotypic level it showed high to moderate indirect positive effect through grain width (0.3300), 1000 grain weight (0.2584), tillers per hill (0.2567) and panicle per hill (0.2566). The harvest index % showed high positive indirect effect through tillers per hill (0.8586), panicle per hill (0.8197), 1000 grain weight (0.4561) and grain length (0.2501) and at phenotypic level it showed high positive indirect effect through (0.4003) and panicles per hill (0.3584). The grain width at genotypic level showed high to moderate positive indirect effect through L/B ratio of grain (0.4941), peduncle length (0.2665) and grain length (0.2535) at genotypic level. The L/B ratio of grain at genotypic level showed high to moderate positive indirect effect through grain width (0.3590), days to 50% flowering (0.2712), biological yield (0.2554) and days to maturity (0.2522). The remaining traits showed indirect effect of low magnitude.

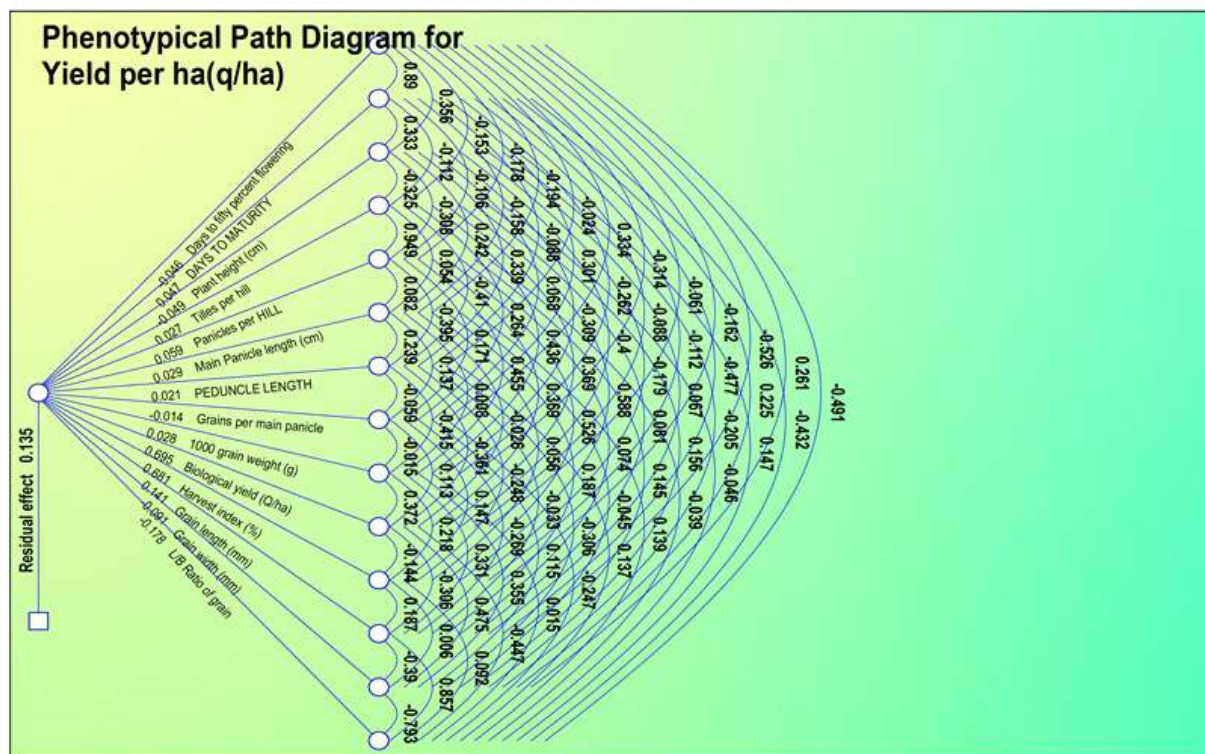
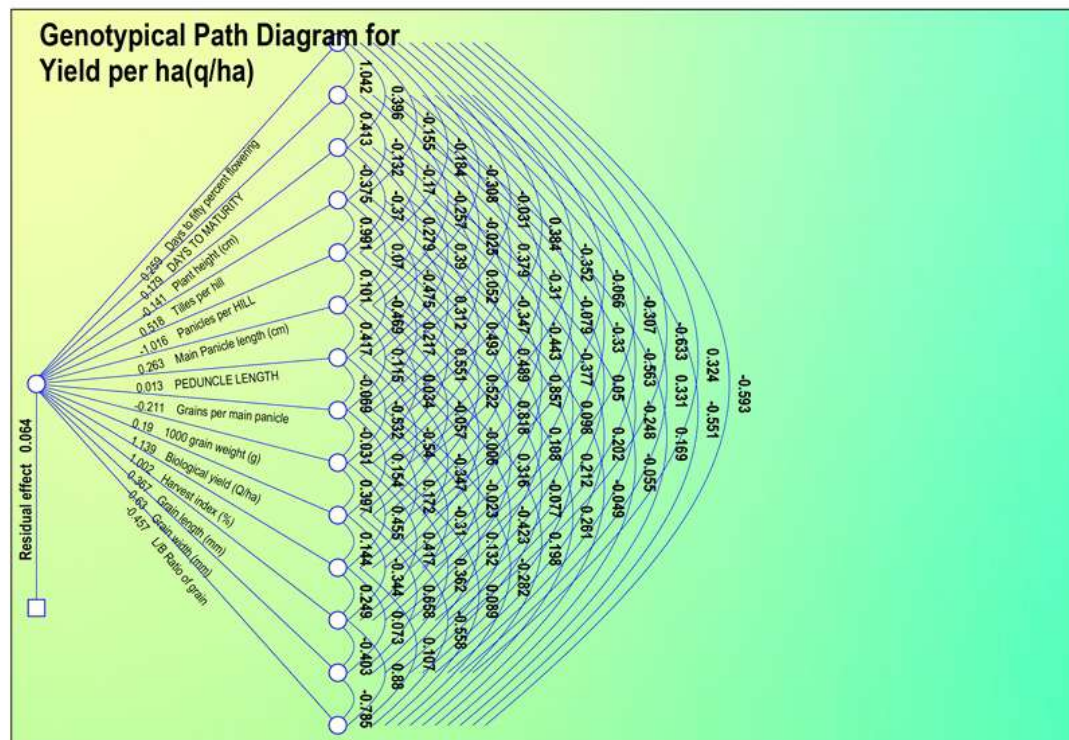
Conclusions

From the analysis of correlation and path coefficient, it is envisaged that the harvest index %, biological yield (q/ha), tillers per hill, panicles per hill and 1000 grain weight(g)

Table-2 : Path coefficient analysis for grain yield (q/ha).

	Direct effects	Path Matrix														Resultant correlation
		Indirect effects														
		DFF	DM	PH (cm)	TPH	PPH	MPL (cm)	PL (cm)	GPMP	TGW (g)	BY (q ha ⁻¹)	HI %	GL (mm)	GW (mm)	L/B RATIO	
DFF	G 0.259	-	0.270	-0.040	-0.048	-0.080	-0.008	0.099	-0.091	-0.017	-0.079	-0.164	0.084	-0.153	-0.280**	
	P -0.046	-	-0.041	0.007	0.008	0.009	0.001	-0.015	0.015	0.003	0.008	0.024	-0.012	0.023	-0.219*	
DM	G 0.179	0.187	-	0.074	-0.024	-0.031	-0.046	0.068	-0.056	-0.014	-0.059	-0.101	0.059	-0.099	-0.296**	
	P 0.047	0.042	-	0.016	-0.005	-0.005	-0.007	0.014	-0.012	-0.004	-0.005	-0.022	0.011	-0.020	-0.186*	
PH (cm)	G -0.141	-0.056	-0.058	-	0.053	0.052	-0.039	-0.007	0.049	0.062	0.053	-0.007	0.035	-0.024	-0.566**	
	P -0.049	-0.018	-0.016	-	0.016	0.015	-0.012	-0.003	0.015	0.020	0.009	-0.003	0.010	-0.007	-0.471**	
TPH	G 0.518	-0.080	-0.069	-0.194	-	0.514	0.036	0.162	0.256	0.253	0.444	0.051	0.105	-0.029	0.891**	
	P 0.027	-0.004	-0.003	-0.009	-	0.025	0.001	0.007	0.012	0.010	0.016	0.002	0.004	-0.001	0.764**	
PPH	G -1.016	0.187	0.173	0.376	-1.006	-	-0.103	0.476	-0.560	-0.530	-0.831	-0.110	-0.215	0.050	0.895**	
	P 0.059	-0.011	-0.006	-0.018	0.056	-	0.005	-0.023	0.010	0.022	0.031	0.004	0.009	-0.002	0.726**	
MPL (cm)	G 0.263	-0.081	-0.068	0.073	0.018	0.027	-	0.110	0.030	0.009	-0.002	0.083	-0.020	0.069	-0.0073	
	P 0.029	-0.006	-0.005	0.007	0.002	0.002	-	0.007	0.004	0.000	0.002	0.005	-0.001	0.004	0.0537	
PL (cm)	G 0.014	0.000	0.000	0.005	-0.006	-0.006	0.006	-	-0.001	-0.007	-0.005	0.000	-0.006	0.003	-0.596**	
	P 0.021	-0.001	-0.002	0.007	-0.009	-0.008	0.005	-	-0.001	-0.008	-0.005	-0.001	-0.007	0.003	-0.458**	
GPMP	G -0.211	-0.081	-0.080	-0.011	-0.066	-0.046	-0.024	0.015	-	0.007	-0.033	0.066	-0.028	0.060	0.193*	
	P -0.014	-0.005	-0.004	-0.001	-0.004	-0.002	-0.002	0.001	0.000	-0.002	-0.002	0.004	-0.002	0.004	0.1748	
TGW (g)	G 0.190	-0.067	-0.059	-0.066	0.094	0.105	0.006	-0.101	-0.006	0.075	0.086	0.079	0.069	0.017	0.589**	
	P 0.028	-0.009	-0.007	-0.009	0.012	0.013	0.000	-0.012	0.000	0.011	0.006	0.009	0.010	0.000	0.494**	
BY(q ha ⁻¹)	G 1.139	-0.075	-0.090	-0.504	0.557	0.595	-0.065	-0.615	0.175	0.452	-	-0.392	0.750	-0.636	0.773**	
	P 0.695	-0.042	-0.061	-0.278	0.257	0.257	-0.018	-0.251	0.079	0.258	-	-0.213	0.330	-0.311	0.641**	
HI %	G 1.002	-0.307	-0.331	-0.378	0.859	0.820	-0.006	-0.348	0.173	0.456	0.145	0.250	0.073	0.108	0.735**	
	P 0.681	-0.110	-0.076	-0.122	0.400	0.358	0.038	-0.169	0.100	0.149	-	0.127	0.004	0.063	0.648**	
GL (mm)	G 0.367	-0.233	-0.207	0.018	0.036	0.040	0.116	-0.009	-0.114	0.153	0.092	-	-0.148	0.323	-0.0268	
	P 0.141	-0.074	-0.067	0.010	0.011	0.011	0.026	-0.005	-0.038	0.047	0.026	-	-0.055	0.121	-0.0398	
GW (mm)	G -0.630	-0.204	-0.208	0.156	-0.127	-0.133	0.049	0.267	-0.083	-0.228	-0.046	0.254	-	0.494	0.487**	
	P -0.091	-0.024	-0.021	0.019	-0.014	-0.013	0.004	0.028	-0.011	-0.032	-0.001	0.035	-	0.072	0.352**	
L/B RATIO	G -0.458	0.271	0.252	-0.077	0.025	0.022	-0.120	-0.091	0.129	-0.041	-0.049	-0.403	0.359	-	-0.275**	
	P -0.179	0.088	0.077	-0.026	0.008	0.007	-0.025	-0.024	0.044	-0.003	-0.016	-0.153	0.142	-	-0.231*	

"P= Phenotypic, G= Genotypic, DFF= Days to 50% flowering, DM= Days to maturity, PH= Plant height (cm), TPH= Tillers per hill, PPH= Panicles per hill, MPL= Main panicle length (cm), PL= Peduncle length (cm), GPMP= Grains per main panicle, TGW= 1000 grain weight (g), BY= Biological yield (q ha⁻¹), HI%= Harvest index percentage, GL= Grain length (mm), GW= Grain width (mm), L/B Ratio= L/B ratio of grain, YPH= Yield per ha (q ha⁻¹)."



were most important traits which should be given proper emphasis during selection programmes for the improvement of grain yield in fine slender rice.

References

1. Bhattacharya, S. and Chakraborty, N.R. (2019). Assessment of genetic variability, correlation and path association for yield and yield components in aromatic non-basmati rice. *J. Pharmacogn. Phytochem.*, 8(3): 1907-1914.
2. Dewey, O.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of crested wheat grass seed production. *J. of Agron.*, 51(9) : 515-518.
3. FAOSTAT (2018), Food and Agriculture Organization of the United Nations. Retrieved on 24, November, 2020 from <http://www.fao.org/faostat>.
4. Jaiswal, H.K., Shrivastava, A.K. and Dey, A. (2007). Variability and association studies in indigenous aromatic rice (*Oryza sativa* L.), *Oryza*, 44(4): 351-353.
5. Karim, D., Siddique, M.N.A, Sarkar, U., Hasnat, M.Z. and Sultana, J. (2014). Phenotypic and genotypic correlation co-efficient of quantitative characters and character association of aromatic rice. *J. biosci. agric. res.*, 01(01): 34-46.
6. Lakshmi, L., Rao, M.V.B., Raju, C.S. and Reddy, S.N. (2017). Variability, Correlation and Path Analysis in Advanced Generation of Aromatic Rice. *Int. J. Curr. Microbiol. Appl. Sci.*, 6(7): 1798-1806.
7. Miller, P.A., Willams, C., Robiwsen, H.F. and Comstock, R.E. (1958). Estimates of genotypic and environmental variance and covariance and their implication in section. *Agron. J.*, 50: 126-131.
8. Mishu, M.F.K., Rahman, M.W., Azad, M.A.K., Biswas, B.K., Talukder, M.A.I., Kayess, M.O., Islam, M.R. and Alam, M.R. (2015). Study on Genetic Variability and Character Association of Aromatic Rice (*Oryza sativa* L.) Cultivars. *Int. J. of Plant & Soil Science*, 9(1): 1-8.
9. Sharma, D.J., Parihar, R., Agrawal, A.P., Minz, M.G. and Neelofar, S., (2016). Correlation and Path Coefficient Studies for Grain Yield and Other Yield Attributes on Aromatic Short Grain Rice (*Oryza sativa* L.) Genotypes. *Int. J. of Agric. Sci.*, 8(51): 2318-2320.



Efficacy of Plant Leaves Powder as Seed Treatment to Check the Initial Infection of Reniform Nematode, *Rotylenchulus reniformis* on Summer Mungbean (*Vigna radiata* L.)

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Abstract

Reniform nematode, *Rotylenchulus reniformis* received greater attention due to its polyphagous nature, cosmopolitan distribution and adaptability to different agro-ecological condition. It causes great losses to pulses including Mungbean (Singh, 2015). Therefore, an experiment was carried out to test the efficacy of botanicals to manage the reniform nematode infecting summer mungbean. Dry leaves powder *i.e.* Vilayati babul (*Prosopis juliflora*) and Bougainvillea (*Bougainvillea spectabilis*) were used at 5%, 10% and 20% as seed treatment. Neem (*Azadirachta indica*) seed kernel powder at 10% was kept as standard check. An untreated check was also maintained to compare the experimental findings. The experiment was conducted in completely randomized design with five replications. Results revealed that Vilayati babul (*Prosopis juliflora*) at 20 % w/w as seed treatment significantly improve the plant growth parameters (35.18–73.17 %) of summer mungbean followed by Bougainvillea at 20% (25.14– 65.37 %) and Vilayati babul at 10% (22.19–61.22 %) as compared to untreated check .These treatments reduced the infestation of reniform nematode, *R. reniformis* on mungbean to the tune of 32.25-44.44%.

Key words : *Rotylenchulus reniformis*, summer mungbean, vilayati babul, bougainvillea, seed treatment.

Introduction

Plant parasitic nematodes are considered as one of the major constraint in Kharif pulses *i.e.* mungbean, black gram, cowpea and cluster bean production (Grewal, 1988 ; Baheti & Yadav, 1990 ; Ram and Baheti, 2003; Nagar *et al.*, 2009 and Yadav *et al.*, 2009). Plant parasitic nematodes *viz.* *Rotylenchulus reniformis*, *Meloidogyne incognita*, *M. javanica*, *Heterodera cajani*, *Pratylenchus thornei*, *Helicotylenchus spp.*, *Hoplolaimus spp.* and *Tylenchorhynchus spp.* have been found to be associated with pulses mainly mungbean, black gram, cowpea and clusterbean (Baheti and Yadav, 1991; Zareena Beghum and Shivkumar, 2005 and Khoraniya & Baheti, 2020) . Among these nematodes, *R. reniformis* is considered to be the more serious pest causing not only direct losses but also indirect by interacting with other fungal pathogens.

Linford and Oliveira (1940) detected and described reniform nematode, *Rotylenchulus reniformis* for the first time from the roots of cowpea grown in pineapple field in the Island of Ohio, Hawaii (U.S.A.). In India, it was first reported by Siddiqi and Basir (1959) on the roots of coffee from South India. It causes serious losses in vegetables, fruits, pulses, oilseeds, cereals, millets and other ornamental crops (Seshadri and Shiva Kumar, 1963). Swarup *et al.* (1967) were first to report this important nematode from the state of Rajasthan. Verma and Prasad (1969) while studying pathogenic effect of the reniform nematode on different hosts found castor as highly

preferred host for this nematode. Reniform nematode has been reported to cause 13.2 and 8.7 percent loss in yield of cowpea and black gram, respectively (Jonathan, 2001). Singh (2015) reported yield losses to the tune of 10.0 - 28.7 percent in mungbean due to reniform nematode, *R. reniformis* in Rajasthan. Recently, Kumar *et al.* (2020) reported losses to the tune of 29.00% in green gram by *Meloidogyne incognita* with estimated monetary loss of Rs 2001.00 million in India. However, at present very less information is being available on management of reniform nematode, *Rotylenchulus reniformis* - An important nematode pest of mungbean through botanicals. Keeping this view, the present investigation was under taken to find out the low cost and eco-friendly protection technology against reniform nematode, *R. reniformis* on mungbean through dry plant leaves powder which earlier reported as nematicidal properties against plant parasitic nematodes.

Materials and Methods

An experiment was carried out to test the efficacy of botanicals *viz.*, Vilayati babul (*Prosopis juliflora*) and Bougainvillea (*Bougainvillea spectabilis*) leaves powder as seed treatment to check the initial infection of reniform nematode, *R. reniformis* on summer mungbean. Dry plant leaves powder were used at 5%, 10% and 20% w/w as seed treatment. Standard treated (Neem seed kernel at 10% w/w) and untreated checks were also taken for comparison and to interpret the experimental findings. Weighed quantity of seeds were taken in a beaker, added few drops of gum and stirred with the help of glass rod and

thereafter required quantity of plant leaves powder were added to it and mix thoroughly to provide uniform smooth coating of leaves powder over seeds. The chalk powder was used as drying agent. The experiment was laid out in completely randomized design and all the treatments were replicated five times. Earthen clay pots were filled with soil infested with test nematode having an initial inoculum of 440 larvae/100 cc soil. After 10 days of mungbean (cv. SML-668) sowing, one healthy plant in each pot was maintained and watered regularly as and when required. Fungicide and insecticide were sprayed to safeguard the crop from insect pest and pathogens. Weeding and hoeing was done as per agronomic practices for better growth of plants. The experimental pots were regularly rotated to avoid sun and shade effect. Observations on plant growth parameters viz., shoot length (cm), shoot weight (g), root length (cm), root weight (g) and nodules per plant as well as nematode reproduction parameters i.e., number of egg masses per plant, number of females per plant and final nematode population per 200cc soil were taken. Statistical analysis was done to interpret and see significance of the treatment effects.

Results and Discussion

Botanicals play an important role in nematode management. Botanicals products are economical, effective and environmentally safe for human beings and domestic animals as well as to manage plant parasitic nematode in agri-horticultural crops. Therefore, in present investigation effect of dry leaves powder of Vilayati babul (*Prosopis juliflora*) and Bougainvillea (*Bougainvillea spectabilis*) were tested as seed treatment at 5%, 10% and 20% w/w to check the infection of reniform nematode, *Rotylenchulus reniformis* on summer mungbean. Neem seed kernel at 10% w/w as seed treatment was kept as treated check. Observations on plant growth parameters as well as nematode parameter were recorded to interpretate the experimental findings. Results has been presented in Table-1 and illustrated through Fig: 1-2, Plate-1.

Results revealed that all the treatments significantly enhanced shoot length of summer mungbean over untreated check. Among plant leaves powder, maximum shoot length (44.96 cm) was recorded with application of Vilayati babul at 20% (w/w) followed by Bougainvillea at 20% (41.62 cm) and Vilayati babul at 10% w/w (40.64 cm). These treatments significantly enhanced shoot length of mungbean over rest of the treatments. Bougainvillea (37.86 cm) was found least effective when applied at 5% w/w but found significantly superior over untreated check (33.26 cm). Among all the treatments, maximum shoot length (48.76 cm) was observed with

Neem seed kernel at 10% w/w which was taken and maintained as standard check. It differed significantly from rest of the treatments. Maximum increase in shoot length (35.18%) was recorded with Vilayati babul at 20% w/w followed by Bougainvillea at 20% (25.14%) and Vilayati babul at 10% (22.19%). Minimum increase in shoot length was obtained with Bougainvillea (13.83%) when applied at 5% w/w over untreated check. However, highest increase in shoot length (46.60%) was observed with Neem seed kernel at 10% (w/w). Almost similar trend was noticed with regards to other plant growth parameters i.e. shoot weight (g), root length (cm), root weight (g) and nodules per plant.

Nematode reproduction parameters were also recorded to compare the treatment effects. Data pertaining to number of egg masses per plant produced by *R. reniformis* on summer mungbean reduced significantly with all the dry leaves powder treatments when used as seed treatment compared to untreated check. Among different leaves powder, minimum number of egg masses per plant (10.40) was observed with Vilayati babul at 20% (w/w) followed by Bougainvillea at 20% (12.20) and Vilayati babul at 10% (12.40). These treatments significantly decreased number of egg masses/plant over untreated check. Maximum number of egg masses per plant (18.40) was obtained in untreated check. Bougainvillea at 5% (16.00) was found least effective. However, Neem seed kernel powder at 10% w/w was found best with respect to reducing number of egg masses per plant (9.60) of *R. reniformis* on summer mungbean. Results showed that maximum reduction in number of egg masses per plant (43.47%) was recorded with the seed treatment of Vilayati babul at 20% (w/w) followed by Bougainvillea at 20% (33.69%) and Vilayati babul at 10% (32.60%). Minimum reduction (13.04%) was noticed with Bougainvillea when applied at 5% over check. However, highest reduction (47.82%) was recorded with Neem seed kernel powder at 10% w/w. The similar trend was noticed with respect to number of females per plant and final nematode population per 200cc soil. Experimental findings also shows that application of higher dose of vilayati babul and bougainvillea (20%) is more effective as seed treatment to enhanced plant growth and crop yield in nematode infested areas. Reduced germination percentage has been recorded when dosage of more than 20% w/w were applied to the seeds.

Experimental findings of present investigation are in accordance with the findings of previous workers who reported that application of botanicals improved plant growth of agri-horticultural crops in nematodes prone areas. Sunderbabu *et al.* (1990) tested the efficacy of chopped leaves of bougainvillea, *ocimum*, onion,

Table-1 : Efficacy of dry leaves powder as seed treatment against reniform nematode, *R. reniformis* on Summer Mungbean.

Treatments	Dose	Shoot length (cm)*	Root length (cm)*	Shoot weight (g)*	Root weight (g)*	No. of nodules /plant*	No. of egg masses/ plant**	No. of females/ plant**	No. of larvae/ 200 cc soil**
Vilayati babul T ₁	5%	38.64 (16.18)	11.20 (36.59)	14.28 (17.05)	4.00 (14.32)	20.00 (25.00)	15.80 (14.13)	10.20 (17.74)	620.00 (18.95)
Vilayati babul T ₂	10%	40.64 (22.19)	13.22 (61.22)	17.30 (41.80)	4.60 (31.43)	22.40 (40.00)	12.40 (32.60)	8.40 (32.25)	495.00 (35.29)
Vilayati babul T ₃	20%	44.96 (35.18)	14.20 (73.17)	19.66 (61.15)	5.50 (57.14)	26.40 (65.00)	10.40 (43.47)	7.60 (38.70)	425.00 (44.44)
Bougainvillea T ₄	5%	37.86 (13.83)	10.20 (24.39)	13.48 (10.49)	3.80 (8.62)	19.20 (20.00)	16.00 (13.04)	10.80 (12.90)	665.00 (13.07)
Bougainvillea T ₅	10%	39.50 (18.76)	12.14 (48.05)	15.92 (30.49)	4.30 (22.86)	22.00 (37.50)	14.20 (22.82)	9.00 (27.41)	520.00 (32.02)
Bougainvillea T ₆	20%	41.62 (25.14)	13.56 (65.37)	18.10 (48.36)	5.00 (42.89)	23.80 (48.75)	12.20 (33.69)	7.80 (37.09)	460.00 (39.86)
Neem Seed Kernel T ₇	10%	48.76 (46.60)	15.02 (83.17)	21.04 (72.46)	6.34 (81.14)	28.20 (76.25)	9.60 (47.82)	6.80 (45.16)	390.00 (49.01)
Untreated Check T ₈	—	33.26	8.20	12.20	3.50	16.00	18.40	12.40	765.00
SEm+	—	1.23	0.407	0.585	0.179	0.702	0.608	0.332	20.494
CD at 5%	—	3.54	1.174	1.680	0.516	2.022	1.752	0.957	59.036

Prosopis, *Calotropis* and subabul at 5g/kg soil against the root-knot nematode on tomato and reniform nematode on green gram. All the leaf products tested were able to enhance the plant growth and suppress the final nematode population in the soil. Among them *Prosopis* was found superior followed by Subabul, *Calotropis* and bougainvillea. Parvathreddy *et al.*, (1993) applied chopped leaves of neem, lantana, *Calotropis*, castor, marigold *Parthenium*, sesamum and periwinkle each at 100g/2kg infested soil against *Meloidogyne incognita* on papaya cv. Coorg Honey Dew under glass house conditions and observed that castor and neem leaves gave highest shoot length and shoot weight. Similarly, Mojumder (1998) conducted an experiment on seed coating of mungbean cv. PS-16 with neem seed kernel, neem seed coat and neem cake (20%), Achook, neemark and nimbecidine (5%) against *M. incognita* and *R. reniformis* and found that neem seed kernel was most effective in reducing root-knot galls, juveniles of *M. incognita* and all stages of *R. reniformis* and enhanced the plant growth and crop yield. Ram and Baheti (2004) tested the efficacy of Neem, Castor and Karanj products (leaf and seed kernel) as seed treatment (10% w/w) alongwith soil applicant (2.5 q/ha) for the management of *Rotylenchulus reniformis* on cowpea (Pusa Barsati). Results revealed that plant products were effective in improving plant growth and reducing nematode reproduction over untreated check. However, neem seed kernel was found to be the most effective and superior among all the plant products. Trivedi *et al.* (2015) conducted an experiment in vitro in the form of aqueous extract and in vivo as dry leaf powder against root-knot y nematode, *M. incognita*. Minimum gall formation was

observed in *Aegle marmelos* and *Prosopis cineraria* treated plants. Use of *Aegle marmelos* and *Prosopis cineraria* (both as aqueous extracts and dry powder) are recommended for the management of root-knot disease both in vitro and in vivo. Mehta *et al.*, (2015) observed maximum increase in plant growth parameters with neem (*Azadirachta indica*) leaves powder at 4 g/plant followed by aak (*Calotropis procera*) and water hyacinth (*Eichornia crassipes*) leaves powder at 4 g/plant as soil application over untreated control on maize infested with *H. zaeae*. Similar results have also been reported by Baheti *et al.*, (2015) on sweet corn, Nama *et al.* (2017) on Clusterbean, Kumar *et al.* (2018) on maize infested by various plant parasitic nematodes. Fabiyi (2019) reported the nematicidal property of *Prosopis africana* against root-knot nematode, *M. incognita* on groundnut. He reported that *Prosopis Africana* leaves powder at 600 g/15 sq.m. before two weeks of sowing significantly reduced nematode infection and enhanced grain yield of groundnut in field infested with *M. incognita* (300 eggs & larvae/100 cc soil). Similarly Ram and Baheti, 2006 on cowpea; Nama and Baheti 2017 on clusterbean and Khoarniya and Baheti (2020) reported the efficacy of botanicals for the management of reniform and root-knot nematode infecting cowpea, cluster bean and chickpea, respectively.

These findings exhibited that seed treatment with plant products reduced initial infection of nematode might be due to number of nemato-toxic compounds released during decomposition. Vilayati babul contains alkaloids, tannins, hydrocarbons, waxes, steroids, phenolic acid whereas Bougainvillea contains flavinoids, phenolic acid etc. Neem seed kernel contains azadirachtin, alkaloids,

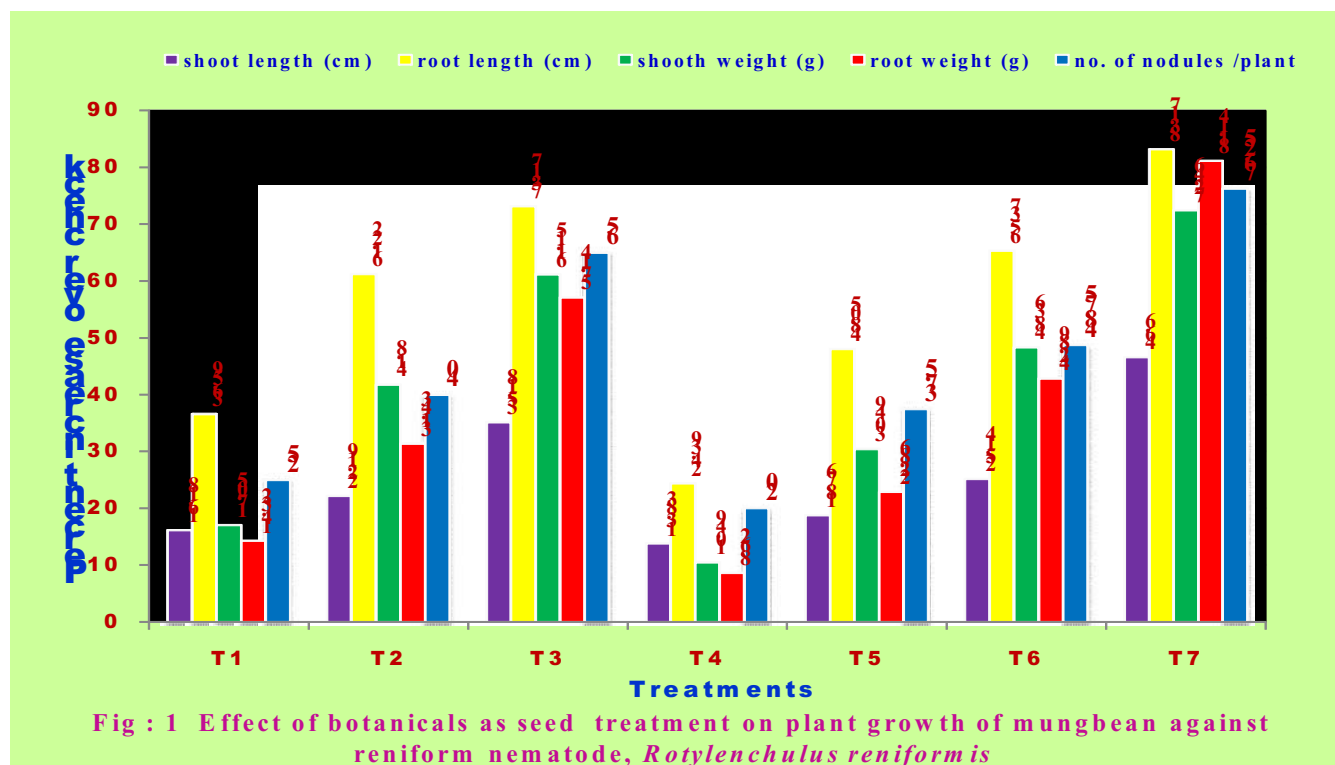
Initial nematode population: 440 juveniles/200 cc soil

Design of experiment : C.R.D.

Crop variety: SML-668

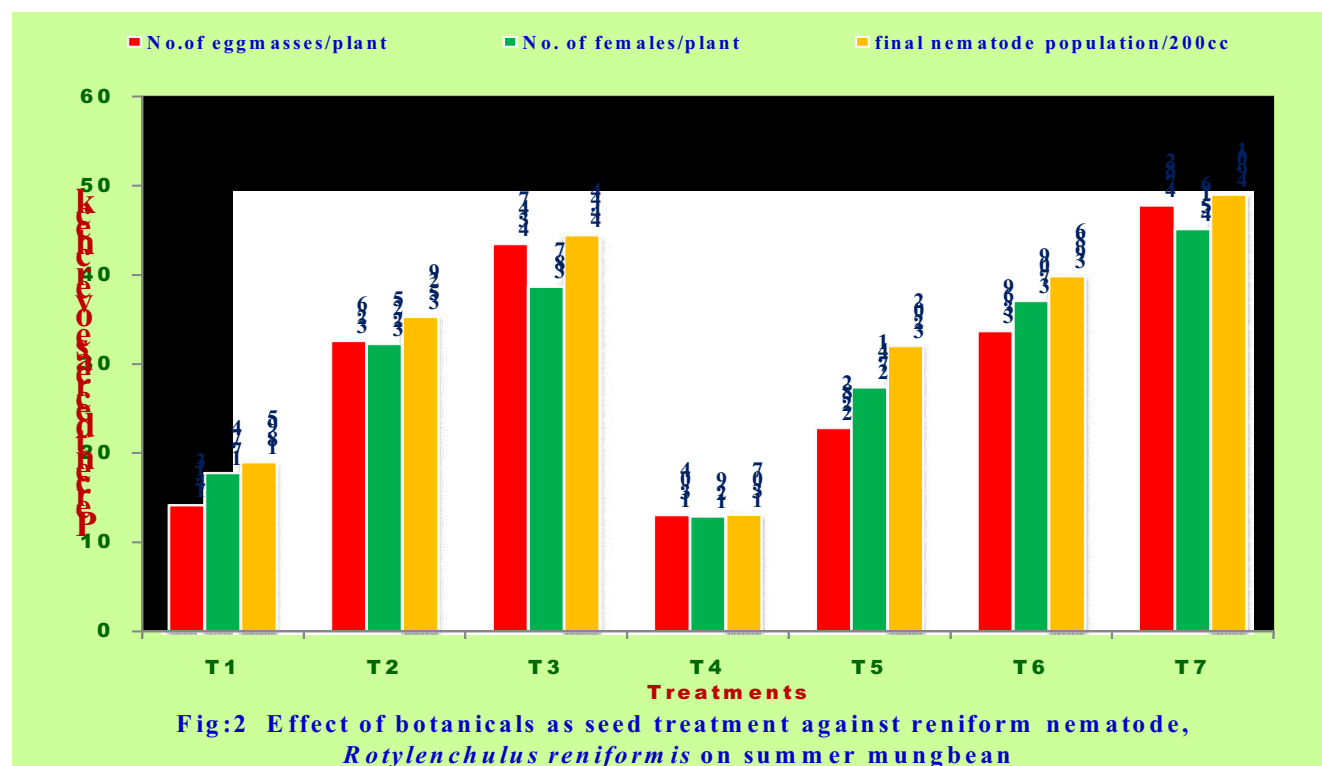
Data are the average value of five replications.

Figures in parantheses are % increase(*) or decrease(**) over check.



steroids, thionemone phenolic acid (salicylic acid, vanilic acid, ferulic acid) etc. which may have nematocidal properties. The suppression of nematodes may be due to effect of several combined factors during decomposition of plant products which may cause inhibitory effect to the phyto-nematodes. Botanical treatments also enhance

activity of number of beneficial microbes, predators and parasites which may cause great competition for nutrition, space, aeration and ultimately feed and kill or reduce the infection of plant parasitic nematodes directly as well as indirectly.



Acknowledgement

The authors are highly grateful to The Dean, Rajasthan College of Agriculture and The Director Research, MPUAT, Udaipur (Raj) for guidance and providing necessary facilities during the course of investigation.

References

- Baheti, B.L. and Yadav, S.M.1990. Multiplication of root-knot nematode, *Meloidogyne incognita* on black gram (*Vigna mungo* L.) in different soil types. *Indian Journal of Mycology and Plant Pathology*.20 (2): 183-184.
- Baheti, B.L. and Yadav,S.M.1991. Studies on the life cycle of root-knot nematode, *Meloidogyne incognita* on black gram. *Current Nematology* 2(2): 191-192.
- Baheti, B.L., Dodwadia, M., Rathore, B.S. and Bhati, S.S., 2015. Management of maize cyst nematode, *Heterodera zae* on sweet corn (*Zea mays* L. *saccharata*) through soil amendment. *The Ecoscan*, 7: 305-309.
- Baheti, B.L., Dodwadiya, M. and Bhati, S.S. 2017. Eco-friendly management of maize cyst nematode, *Heterodera zae* on sweet corn (*Zea mays* L. *saccharata*). *Journal of Entomology and Zoology Studies*. 5: 989-993.
- Fabiya, O.A. (2019). Effect of *Prosopis africana* for the Management of root-knot nematode, *M. incognita* on groundnut (*Arachis hypogea*).*Indian Journal of Nematology*, 49(2): 214-216.
- Grewal, J.S. (1988). Disease of pulse crops: An overview. *Indian Phytopathology*, 41: 1-14.
- Jonathan. E.I. (2001). Nematology Fundamental Applications, *New India publishing Agency, New Delhi*.
- Khoraniya, P. and Baheti, B.L.2020. Bio-efficacy of botanical based seed treatment against root-knot nematode, *Meloidogyne incognita* infecting Chickpea (*Cicer arietinum* L). *Journal of Entomology and Zoology Studies* 8(3): 09-12.
- Kumar, V., Khan, M.R. and Wallia, R.K. 2020.Crop loss estimation due to plant parasitic nematodes in major crops of India. *National Academy of Science Letter* 43(5): 409-412.
- Kumhar R.N., Baheti B.L. and Chandrawat, B.S. 2018. Eco-Friendly Management of Maize Cyst Nematode (*Heterodera zae*) on Maize by Using Botanicals. *International Journal of Current Microbiology and Applied Sciences*.7 (6): 199-204.
- Linford, M.B. and J.M. Oliveira. (1940). *Rotylenchulus reniformis*, Nov. Gen., N. Sp., A Nematode parasite of roots. *Proceeding of the Helminthological Society of Washington*, 7: 35-39.
- Mehta, S.K., Baheti, B.L., Rathore, B.S. and Nama, C.P., 2015. Botanicals-An effective tool for the management of maize cyst nematode, *Heterodera zae* on maize (*Zea mays* L.). *Journal of Biopesticides*, 8(2): 62-67.
- Mojumder, V. (1998). Effect of seed coating of mungbean with crude neem products and neem based pesticidal formulations for the management of *Meloidogyne incognita* and *Rotylenchulus reniformis*. *IARI Neem Newsletter*, 15: 12-13.
- Nagar, M.K.; Baheti, B.L. and Rathore, B.S. 2009. Efficacy of salicylic acid and ascorbic acid against root-knot nematode, *Meloidogyne incognita* on mungbean (*Vigna radiata* L.). *Indian Journal of Nematology* 39(1): 116-118.
- Nama, C.P. and Baheti, B.L. 2021. Assessment of losses due to root-knot nematode, *Meloidogyne incognita* on

- Cluster bean (*Cyamopsis tetragonoloba* L.). *Journal of Entomology and Zoology Studies* 9 (2) : 855-858.
16. Nama, C.P.; Sharma, H.K.; Baheti, B.L. and Siddiqui, A.U. 2017. Bio-management of root-knot nematode, *Meloidogyne incognita* on Cowpea (*Vigna unguiculata* L.). *Current Nematology* 28(1): 39-43.
 17. Parvathareddy, P., Khan, R.M. and Rao, M.S., 1993. Management of root knot nematode infesting papaya by incorporating some plant leaves, Botanical pesticides in integrated pest management, *Proceedings of National Symposium held at Central Tobacco Research Institute, Rajahmundry, India*: 421-423.
 18. Ram, Budh and Baheti, B.L. 2003. Management of reniform nematode, *Rotylenchulus reniformis* on cowpea through seed dressing treatment. *Indian Journal of Nematology*, 33(1): 40-42
 19. Ram, Budh and Baheti, B.L. 2003. Management of reniform nematode, *Rotylenchulus reniformis* on cowpea through seed treatment with botanicals. *Current Nematology* 14(1,2): 27-30.
 20. Ram, Budh and Baheti, B.L. 2004. Management of reniform nematode, *Rotylenchulus reniformis* on cowpea through seed and soil treatment with plant products. *Indian Journal of Nematology* 34 (2): 193-195.
 21. Ram, Budh and Baheti, B.L. 2006. Management of reniform nematode, *Rotylenchulus reniformis* on cowpea through plant products. *Indian Journal of Nematology* 36 (1) : 140-142.
 22. Seshadri, A.R. and Sivakumar, C.V. (1963). A preliminary note on the occurrence of reniform nematode, *Rotylenchulus reniformis* (Linford and Oliveira, 1940) on a number of cultivated crops in South India. *Madras Agricultural Journal*, 50: 134-137.
 23. Siddiqui, M.R. and Basir, M.R. 1959. On some plant parasitic nematodes occurring in South India with the description of two new species of the genus *Tylenchorhynchus*. *Proceedings of 46th Indian Sciences Congress Part-IV*. 35 p.
 24. Singh, A.U. (2015). Crop loss estimates due to plant parasitic nematodes. In : Technical bulletin of All India Coordinated Research Project on Nematodes in Agriculture, Division of Nematology, IARI, New Delhi-110012.
 25. Sunderbabu R., Sankaranarayana C. and Vadivelu S. (1990). Nematode management with plant products. *Indian Journal of Nematology*, 20(2): 177-178.
 26. Swarup, G., Nath, R.P. and Sethi, C.L. (1967). The plant parasitic nematode genus *Rotylenchulus* in India. *Indian Phytopathology*, 20: 118-123.
 27. Trivedi, L., Datta, S. and Trivedi, P.C. (2015). Sustainable use of medicinal plants to control *Meloidogyne incognita* a strategy to fight root knot disease of crops in Rajasthan, India. *World Journal of Pharmacy and Pharmaceutical Sciences*, 4(8): 818-829.
 28. Verma, S.K. and Prasad, S.K. (1969). The reniform nematode, *Rotylenchulus reniformis* (Linford and Oliveira, 1940). Biological studies. *Indian Journal of Entomology*, 31: 36-47.
 29. Yadav, P.K.; Baheti, B.L. and Rathore, B.S. 2009. Pathogenicity of root-knot nematode, *Meloidogyne incognita* on cluster bean (*Cyamopsis tetragonoloba*). *Journal of Mycology and Plant Pathology* 39(1): 172-173.
 30. Zareena Begum, M. and Sivakumar, M. (2005). Management of the disease complex involving *Heterodera cajani* and *Macrophomina phaseolina* on greengram (*Vigna radiata* L.). *Indian Journal of Nematology*, 35: 192-94.



Knowledge Level of Tribal Women About Kitchen Gardening of Chhotaudepur District of Gujarat

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Abstract

The main point of building up a kitchen garden is to safeguard formal beliefs and social character of joint families. Potential benefits such as income and enhanced rural employment through additional or off season production, enhanced food security, increased availability of food and better nutrition through food diversity. To popularize the kitchen gardening among the farming community in rural areas, KVK Vadodara conducted large number of training programmes for the farmers to educate them about the importance of kitchen gardening and distribution of vegetable seeds and seedling to farm women. After getting training many farmers established kitchen garden and started growing vegetables for their domestic requirement. Kitchen gardens have helped to improve the food and nutritional security of tribal women as well as their family members. The kitchen garden has acted as a trap to this natural resource for the benefit of mankind in tribal area. From the study we concluded that 85 per cent of tribal women have medium to high knowledge level about kitchen gardening. We can suggest the kitchen gardening in the tribal region is an important for increasing the income, improving the intake of fresh fruit & vegetables and health's. It helps in raise the standard of living of the tribes.

Key words : Knowledge level, tribal women, kitchen gardening.

Introduction

Farmwomen are the backbone of Indian agriculture. Growing food has been an interminable saga of her life. It is a well recognized fact that more than 60 % of agricultural operations have been traditionally handled by women. Even cultural anthropological literature suggests that agriculture is invention of women. Rural woman are extensively involved in agricultural activities. The nature and extent of their involvement differs with the variations in agro-production systems. The mode of female participation in agricultural production varies with the land-owning status of farm household. Their roles range from managers to landless labourers. Women are doing almost all the agricultural work starting from sowing of seeds to harvesting and processing the agricultural produce.

Kitchen gardening is an important component for household food security contributes to household income and savings and improves the health and nutritional well-being of the family. Kitchen Gardening is commonly a family activity including women, men, children and elderly persons. Kitchen Garden is one of the world's most ancient agricultural practices. Planting and maintaining a kitchen garden brings families together and kids naturally gravitate to gardening. A kitchen garden is cost saving activity that can be enjoyed as a hobby. It acts as a source of relaxation during high stress period and reduction in illness and stress. Further, it is important to stay healthy to minimize health care expenses. Eating fresh vegetables

and fruits in sufficient quantity will boost one's immune system which helps to stay healthy. Kitchen garden gives dual benefits of providing food and healthy life. Therefore, kitchen garden is like a doctor/ clinic/ medicine cabin wrapped in to one, expanding fresh vegetable intake, supplementing the diet with vegetables containing rich nutrient which increases immunity, cures illness and improves the quality of life. One way to offer a great potential for improving household food security and elevating micronutrient deficiencies is to grow vegetables in own kitchen garden at home and eat fresh vegetables and fruits. This will enhance food security by direct access to a diversity of fresh vegetables at fingertips.

Research Methodology

The present study was conducted in Chhotaudepur district of Gujarat State. This is located in the eastern part of the State of Gujarat. The boundary of Chhotaudepur district touches to Vadodara, Panchmahal, Dahod, Narmada and State of Madhya Pradesh and Maharashtra. The Chhotaudepur district is an important tribal pocket in the Gujarat state. Chhotaudepur district consist 6 taluka, out of these two taluka *Sankheda* and *Bodeli* was selected purposively. From Sankheda taluka two and from Bodeli taluka four villages were selected purposively for the study. Among each village 20 tribal farm women were selected randomly. Hence, total sample size was 120 tribal women. The data were collected through personal interview. The interview schedule was prepared by keeping the objectives of the study in mind. The

Table-1 : Distribution of tribal women according to their knowledge about kitchen gardening. n=120

S. No.	Category	No. of Tribal Women	Percent
1.	Low Level (Up to 22)	18	15.00
2.	Medium level (22 to 30)	82	68.33
3.	High level (Above 30)	20	16.67
	X= 26.0 (Scores), = 4.0 (Scores)	120	100.00

Table-2 : To measure the knowledge level of tribal women about kitchen gardening. n=120

S. No.	Selected scientific approaches	Frequency	Per cent	Rank
1.	Which of the following crop/s is/are grown through seedlings?	119	99.17	I
2.	Which of the following vegetables can be grown in winter season?	116	96.67	II
3.	What is sowing time of monsoon vegetables for kitchen garden?	115	95.83	III
4.	Which of the following vegetables can be grown as perennials?	114	95.00	IV
5.	What is sowing time for winter vegetables for kitchen garden?	113	94.17	V
6.	Which of the following crop/s are grown through seeds?	110	91.67	VI
7.	Which of the following vegetables can be grown in summer season?	99	82.50	VII
8.	Which among the following are vines?	98	81.67	VIII
9.	How to prepare soil for kitchen garden?	95	79.17	IX
10.	What is sowing time for summer vegetables for kitchen garden?	93	77.50	X
11.	Which of the following vegetable crop can be grown through seeds?	91	75.83	XI
12.	Which type of soil is most suitable for kitchen garden?	90	75.00	XII
13.	Which of the following crops are grown by maintaining proper spacing between two rows and plants?	79	65.53	XIII
14.	Which of the following fruit crops can be grown in kitchen garden?	69	57.50	XIV
15.	Which of the following vegetable crops can be grown all the seasons, viz. winter, monsoon, summer season?	67	55.83	XV
16.	Which of the following insect/s appear/s in chilli?	65	54.17	XVI
17.	Which of the following insect/s appear/s in tomato?	59	49.17	XVII
18.	Compost made by earth worm is known as	50	41.67	XVIII
19.	Which of the following is/are source vitamin C?	49	40.83	XIX
20.	Which of the following insect/s appear/s in the vines vegetable?	41	34.17	XX

necessary care was taken to collect the un- biased and correct data. The data were collected, tabulated and analyzed to find out the findings and drawing the conclusion. The statistical tools like frequency, percentage and rank were employed to analyze the data.

Results and Discussion

The data in Table-1 indicate that tribal women (68.33 per cent) had medium knowledge level, whereas 15.00 and 16.67 per cent tribal women were having low and high knowledge level about kitchen gardening, respectively.

The data in table-2 indicates that knowledge of tribal women like “Which of the following crop/s is/are grown through seedlings?”, “Which of the following vegetables can be grown in winter season?”, “What is sowing time of monsoon vegetables for kitchen garden?”, “Which of the following vegetables can be grown as perennials?”, “What is sowing time for winter vegetables for kitchen garden?”, “Which of the following crop/s are grown through seeds?”, “Which of the following vegetables can be grown in summer season?”, “Which among the following are

vines?” and “What is sowing time for summer vegetables for kitchen garden?” were found to be 99.17, 96.67, 95.83, 95.00, 91.67, 82.50, 81.67, 79.17 and 77.50 percent and ranks were assigned I to X, respectively. The table also show the result of rank XI to XX in decreasing order means the tribal women have the low knowledge of these practices. They are accordingly “Which of the following vegetable crop can be grown through seeds?, Which type of soil is most suitable for kitchen garden?, Which of the following crops are grown by maintaining proper spacing between two rows and plants?, Which of the following fruit crops can be grown in kitchen garden?, Which of the following vegetable crops can be grown all the seasons, viz. winter, monsoon, summer season?, Which of the following insect/s appear/s in chilli?, Which of the following insect/s appear/s in tomato?, Compost made by earth worm is known as, Which of the following is/are source vitamin C? And which of the following insect/s appear/s in the vines vegetable? and obtain the score of 75.83, 75.00, 65.83, 57.50, 55.83, 54.17, 49.17, 41.67, 40.83 and 34.17 respectively.

Conclusions

Kitchen gardens have helped to improve the food and nutritional security of tribal women as well as their family members. The kitchen garden has acted as a trap to this natural resource for the benefit of mankind in tribal area. From the study we concluded that 85 per cent of tribal women have medium to high knowledge level about kitchen gardening. We can suggest the kitchen gardening in the tribal region is an important for increasing the income, improving the intake of fresh fruit and vegetables and health's. It helps in raise the standard of living of the tribes.

References

1. Khatri, K.D. and Patel, Arun (2018) Development of the test to measure the knowledge about research recommendations of Anand Agricultural University. *Guj. J. Ext. Edu.* 29(2):137-142.
2. Patel G.J., Patel D.P. and Ramjiyani D.B. (2016). Knowledge of nutritional practices among the tribal women. *Guj. J. Ext. Edu.* 27(1): 24-26
3. Saini, Hemlata and Chauhan, N.B. (2019) Development and standardization of a test to measure knowledge level of women about kitchen gardening: *Guj. J. Ext. Edu. Vol. 30 : Issue 2 : December 2019*, pp101-105.
4. Srinivas A, V. Sudha Rani and P. Archana (2014) Construction of Knowledge Test to Measure the Knowledge of Agriculture Officers on IPM, INM and IWM Practices: *Global journal for research analysis*, 3(1): 2277-8160.



Determinants of Total Factor Productivity of Milch Animals in Arid Western Rajasthan

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Abstract

Dairying is one of the important sub-sectors of agriculture, next only to field crops. Milch animals are kept as farming household from very long time in India. Milk production from these milch animals is a very low input and low output farming activity. More than 80 per cent rural families keep livestock in their households. About 35 per cent of the income to small and marginal farmers comes from dairy and animal husbandry. In arid areas the contribution is as high as 50 per cent. Productivity can be defined as the ratio of output to input. Often, the main objective of determinants of total factor productivity of milch animals in arid western Rajasthan. It can be seen from the results that average milk productivity per animal per day was affecting TFP positively in all the categories of milch animals which is quite obvious. Concentrate per kg of milk per animal per year affected TFP negatively in all the categories of animals showing that it was not effective in some categories in increasing TFP and in some categories it was being fed at a level more than optimum. Area under fodder crops established positive effect only in Indigenous cow and overall population of milch animals.

Key words : Dairying, milch animal, milk, TFP.

Introduction

Livestock rearing is one of the most important economic activities in the rural areas providing stable and supplementary income round the year. (Birthal and Taneja, 2006). Milch animals are kept as farming household from very long time in India. Milk production from these milch animals is a very low input and low output farming activity. Productivity can be defined as the ratio of output to input. Often, the main objective of measuring productivity is to make inferences about the efficiency of a firm, industry, organization, production system or sector. Increasing partial productivity through factor substitution is a reasonable goal, although increasing total factor productivity (TFP). As per FAO data, productivity of an average milch animal in India is even less than half of the world average (Barthan and Sharma, 2013). In spite of high livestock population and total milk production in India, per animal average milk production is low. In an era of privatization and de-licensing there is increasing number of private dairies and livestock population, causing more pressure on natural resources. Efficient use of resources, increasing productivity and profits by various means will be of great importance in near future. It is not possible to achieve higher productivity in a milch animal by merely increasing its genetic potential, due attention needs to be improved technologies and improvement in technical efficiency (Chand, *et al.*, 2018, Kalamkar *et al.* 2020). The substantial capital investment is required for technological developments which is having a lagged effect (Lal and

Chandel, 2017). Some studies on dairy in India, such as Sharma and Kalamkar 2020, Sharma *et al.* 2019, Elumalai, K., and Pandey, U.K. 2004 enumerate multiple causes (at the national and international level) that can explain the evolution of dairy productivity. The milch animals have a significant contribution in the economy of country for the poor people of rainfed agro-ecosystem for their sustainable living because of severe risk involved in the crop production due to uncertainty of rain and drought (Misra and Ramakrishna, 2007). There is great diversity in Indian agro-climatic zones. The agriculture is more severely affected by drought rather than livestock. In the years of drought, crop production can be as low as 10 percent of normal year, in the same situation milk production may still remain same or more than 50 per cent. Thus, the milch animal rearing activity provides source of livelihood and supplementary occupation to majority of farmer living in the drought prone rainfed areas where crop production on its own way not be very productive and engaging them fully or partially (Samra *et al.*, 2006). There are large inter-regional and inter-state variations in milk production as well as per capita availability in India. The total milk production in Rajasthan was 23.68 million tonnes in 2018-19, and ranked second in India. In spite of high livestock population and total milk production in India, per animal average milk production is low. Rajasthan is considered as 'Denmark of India'. The total bovine population in Rajasthan was 27.60 million numbers in 2019. It has increased by 13 per cent over the previous census previous (2012). (GOI (2019),

Table-1 : Region wise per household average herd size of livestock and milch animals. (SAUs/Household)

Herd Size Category	Lunkaransar Region		Nokha Region		Kolayat Region	
	Livestock Animals	Milch Animals	Livestock Animals	Milch Animals	Livestock Animals	Milch Animals
Overall	10.19	6.73	8.12	5.79	6.33	4.31

Table-2 : Estimates of the coefficients of determinants of total factor productivity of milch animals as a whole.

S. No.	Variable	Coefficients	Std. Error	t'-value	p-value
1.	Constant	-3.113	.097	-31.933	.000
2.	Average milk productivity of milch animal	0.542***	.035	15.356	.000
3.	Concentrate per kg milk	-0.517***	.026	-19.797	.000
4.	Herd size (Number of animal)	-0.058***	.020	-2.846	.005
5.	Area under fodder crops	0.017**	.008	2.237	.026
6.	Number of Vaccinations and de-worming	0.056***	.011	4.973	.000
7.	Number of cases treated in veterinary institution	-0.020	.012	-1.636	.103
8.	Number of veterinary institution per 100 sq km	0.069***	.015	4.741	.000
9.	Number of dairy co-cooperative societies	-0.087***	.025	-3.505	.001
10.	Fixed cost	0.033**	.014	2.401	.017
	Adjusted R ²	0.830			
	F-value	108.19***			

***, ** and * indicate significance at 1, 5 and 10 per cent level of probability, respectively.

Table-3 : Estimates of the coefficients of determinants of total factor productivity for Indigenous Cows.

S. No.	Variable	Coefficients	Std. Error	t'-value	p-value
1.	Constant	-2.703	.152	-17.744	.000
2.	Average milk productivity of milch animal	0.384***	.054	7.148	.000
3.	Concentrate per kg milk	-0.631***	.041	-15.395	.000
4.	Herd size (Number of animal)	0.040*	.022	1.829	.069
5.	Area under fodder crops	0.043***	.012	3.654	.000
6.	Number of Vaccinations and de-worming	0.004	.019	.229	.819
7.	Number of cases treated in veterinary institution	-0.015	.019	-.771	.442
8.	Number of veterinary institution per 100 sq km	0.011	.030	.378	.706
9.	Number of dairy co-cooperative societies	-0.168***	.035	-4.858	.000
10.	Fixed cost	-0.066**	.029	-2.304	.023
	Adjusted R ²	0.864			
	F-value	119.59***			

***, ** and * indicate significance at 1, 5 and 10 per cent level of probability, respectively.

www.dahd.nic.in). Animal husbandry is a major economic activity contributing approximately 11.19 percent to the total GSDP of the state in 2018-19. Of the total milk produced, 53 per cent is buffalo milk, 36 per cent is cattle milk and 11 per cent is goat milk (National Dairy Development Board, 2014). In Rajasthan, livestock sector plays major role in improving socio-economic status of rural households and fulfilling nutritional needs of rural masses. Milch animal development in India has been acknowledged as one of the India's most successful developmental program; however, there are a large number of limitations in milk development such as most of rural areas has been found not encouraging, because of rearing of low productive bovine, inadequate health and breeding practices, care and management. A serious

issue i.e. low productivity has been playing a major role for dairying from a very long time. India's productivity of the animal is very low as compared to the other countries. This gap which is very serious may cause health problems and other related problems in this country. For proper nutritional requirements of our country, there is a basic need to increase milk production. It is crucial to know the policies, and what kind of steps are to be taken for increasing productivity before investing capital. To see determinants of total factor productivity of milch animals should be identified for reaching the millennium development goals.

Materials and Methods

The Bikaner district of Rajasthan was selected for the

Table-4 : Estimates of the coefficients of determinants of total factor productivity for crossbred cows.

S. No.	Variable	Coefficients	Std. Error	't'-value	p-value
1.	Constant	-2.121	.254	-8.355	.000
2.	Average milk productivity of milch animal	0.172*	.088	1.960	.056
3.	Concentrate per kg milk	-0.448***	.067	-6.724	.000
4.	Herd size(Number of animal)	-0.009	.027	-.317	.753
5.	Area under fodder crops	0.004	.014	.311	.757
6.	Number of Vaccinations and de-worming	0.086***	.020	4.323	.000
7.	Number of cases treated in veterinary institution	0.009	.016	.556	.581
8.	Number of veterinary institution per 100 sq km	-0.016	.033	-.488	.628
9.	Number of dairy co-cooperative societies	0.040	.040	.999	.323
10.	Fixed cost	-0.042	.029	-1.446	.154
	R ²	0.824			
	F-value	31.099***			

***, ** and * indicate significance at 1, 5 and 10 per cent level of probability, respectively.

Table-5: Estimates of the coefficients of determinants of total factor productivity for buffaloes.

S. No.	Variable	Coefficients	Std. Error	't'-value	p-value
1.	Constant	-2.780	.199	-13.992	.000
2.	Average milk productivity of milch animal	0.142**	.068	2.070	.042
3.	Concentrate per kg milk	-0.692***	.070	-9.843	.000
4.	Herd size (Number of animal)	0.049**	.022	2.268	.026
5.	Area under fodder crops	-0.009	.018	-.522	.603
6.	Number of Vaccinations and de-worming	0.037**	.018	2.035	.046
7.	Number of cases treated in veterinary institution	0.008	.016	.519	.605
8.	Number of veterinary institution per 100 sq km	0.008	.017	.475	.636
9.	Number of dairy co-cooperative societies	0.067	.070	.959	.341
10.	Fixed cost	0.011	.033	.348	.729
	R ²	0.855			
	F-value	54.01***			

***, ** and * indicate significance at 1, 5 and 10 per cent level of probability, respectively.

study purposively as in having largest in cattle population. Another reason for selecting the district was that it has higher Indigenous Cattle population, and livestock production in the area is second largest enterprise after crop production. (Govt. of Rajasthan, 2019). The Bikaner district of Rajasthan is selected for the study purposively. There are three distinct types of agricultural situations in the region viz., canal irrigated (Lunkaransar Tahsil), tubewell (Kolayat Tahsil) irrigated and unirrigated (Nokha) were selected. The primary data were collected from 180 milk producer households of selected three region of Bikaner district. The data collected have been analyzed using different statistical measures and interpreted across herd-size categories of milk producers as well as overall. In order to have an appropriate comparison, herd size maintained by different categories of households were converted into standard animal units using the conversion factors suggested by Sirohi et al., (2015). Thus, the sample was comprised of 88 small herd size milk producers category (2-7 SAUs), 61 medium herd size

(more than 7-12 SAUs) and 31 large herd size milk producers category (more than 12 SAUs). The primary data were collected from the sample farmers for the year 2018-19. Therefore, total 180 farmers were selected from the six selected villages. Primary data relating to various aspects of rearing milch animals (bovine only) were collected from selected farmers by personal interview method using a well designed and pre-tested interview schedule. The data collected have been analyzed using Regression analysis was conducted to find out the factors determining the TFP. Double log linear regression equation was fitted to analyse the factors associated with the total factor productivity (TFP) measures and interpreted across herd-size categories of milk producers as well as overall.

Analytical Tool

Regression analysis : The regression analysis was conducted to find out the factors determining the TFP at a household in per milch animal. To analyse the factors

associated with the total factor productivity (TFP) the following multiple double log linear regression equation was fitted where both the dependent variable and independent variable(s) are log-transformed variables, the interpretation is a combination of the linear-log and log-linear cases above. In other words, the interpretation is given as an expected percentage change in Y when X increases by some percentage. Such relationships, where both Y and X are log-transformed, are commonly referred to as elastic in econometrics, and the coefficient of log X is referred to as an elasticity. As units of independent and dependent variables are different, comparing percentage change is better. To get the proportional change in Y associated with a p percent increase in X, calculate $a = \log([100 + p]/100)$ and take e^a . Following double log multiple regression technique was followed using log function carried out.

$$\text{Log } T_y = A + b_i \log X_i + u$$

T_y = TFP of milk production

A = Constant term

B_i = Regression coefficients

X_i = Independent variables

u = Random disturbance term

In this context, many factors were used, but followings were retained in the final regression keeping in view their level of significance, expected relationship and the value of coefficient of multiple determinations.

The TFP value was regressed on the following variables

X_1 = Productivity of milch animal (litre/day)

X_2 = Concentrates (kg/litre of milk)

X_3 = Herd size (Number of animal)

X_4 = Area under permanent fodder crop (ha)

X_5 = Number of vaccinations and de-worming (number per year)

X_6 = Number of cases treated in veterinary institution (number per year)

X_7 = Number of veterinary institutions per 100 sq km

X_8 = Number of dairy co-cooperative societies collecting milk in the area

X_9 = Fixed cost (Rs/per year/per animal)

Results and Discussion

The region wise per household average herd size of livestock and milch animals in three region wise representing canal irrigated, tube well irrigated and rainfed areas were presented in Table-1. Herd strength

and the number of milch animals in the household directly affect the economy of the milk producers. Different types of animals were maintained in various households. On an average, a milk producer household maintained a herd size of 6.73 standard animal units in canal irrigated area (Lunkaransar Region) as compared to 5.79 standard animal units in tube well irrigated area (Nokha Region) and 4.31 in un-irrigated area (Kolayat Region). Size of herd was slightly higher in canal irrigated area, followed by tube well irrigated area and un-irrigated area, respectively, which implied that households in irrigated areas had more number of livestock and milch animals on farm.

Estimates of the Coefficients of Determinants of TFP of milch animals as a whole :

The results of log linear regression are presented in table-2 for different categories of bovine population (milch animals) in Bikaner district. A close perusal of table-2 shows that Adjusted R^2 value (coefficient of multiple determination) is 0.830, which means that the regression coefficient is explaining 83 per cent of total variation observed in TFP value of milk by the variables included in the multiple regression model. Remaining 17 per cent of variation was due to other factors not included in the model. The productivity of milk yield per animal unit was observed to be most important explanatory variable having statistically significant and positive effect on TFP value in case of bovine population as a whole. It explains that one per cent increase in productivity of milk yield resulted in an increase of TFP value by 0.542 per cent. It was found that the regression coefficient of number of vaccinations and de-worming done of milch (bovine) animals under study was found to be significant with positive influence on TFP value. With increase in number of vaccinations and de-worming, value of TFP increased by 0.056 per cent. It was observed as per the expected sign, obvious when the increase number of vaccination and de-worming, TFP value also increased. It can be indicating effectiveness of vaccinations and de-worming in either decrease in cost of maintenance or increase in milk yield or both. Another important explanatory variable having positive effect on TFP was found to be the number of veterinary institution within the area of 100 sq km. The coefficients of veterinary institution were found significant for overall bovine population; it was significant at one per cent level of probability explaining 0.069 per cent increase in TFP with 1 per cent increase in number of veterinary institution. The fixed cost which shows expenditure on infrastructure was also having positive effect on TFP and was found significant for overall milch animals where TFP increase 0.033 per cent with 1 per cent increase in fixed cost. This finding indicates if farmer invest more on infrastructure for milch animals (animal housing, animal cost and

infrastructure management) that the incremental benefits from that will increase incremental return on. The regression coefficient of concentrate per kg milk was found significant for bovine population as a whole but its coefficient was carrying negative value which indicates that the feeding of concentrate was in the state where it was not able to generate additional TFP as compared to its additional cost. The value of coefficient -0.517 indicated the one per cent increase in concentrate per kg milk (marginal cost) the progressive benefits or marginal returns decrease by 0.517 per cent animal unit. Farmers are needed to be trained and educated on balanced feeding practices to improve total factor productivity and efficient use for feeding management practices. The number of dairy co-operative societies was found to be another important determining factor in TFP value.

The regression coefficient of number of dairy co-operative societies was found significant and contributing negatively on the TFP value indicating that purchase of milk from cooperatives was not more remunerative or private traders were giving more remunerative prices of milk to the milk producers. There are some other factors like cooperative agencies are at higher distance and other agencies may be collecting milk from households at lesser prices. Herd size (Number of animal) of households was found to be another determining factor in TFP in milk. The regression coefficient of herd-size was found to be positive with a value of .029 which shows that increasing animal in herd increases the TFP which may be because of meeting more economies of scale. Most of the determinants showed significant relationship with TFP either negative or positive.

Estimates of the coefficients of Determinants of TFP of milch animals in Indigenous Cows : The log regression analysis for Indigenous cow is presented in table 3. The adjusted R^2 value for regression equation for TFP of Indigenous cow was 0.864, showing good explanation power of the variations in TFP explained in the regression by the factors included. It can be observed that important explanatory variables having positive effect on TFP were milk productivity of animals, area under fodder crops and herd size. Negatively affecting variables were concentrate per kg of milk, number of cases treated in veterinary institutions, number of dairy cooperative societies available in the area and investment if fixed cost. The coefficient for average milk productivity was 0.384 showing that 1 per cent increase in productivity of milk per animal will increase TFP by 0.384 per cent. Area under fodder crops also affected TFP positively for Indigenous cow with a coefficient of 0.04 showing that there is positive effect on TFP by feeding green fodder to Indigenous cow and there is still economic scope to increase feeding of

green fodder. Another positively affecting variable was herd size with a 0.04 value of coefficient which shows that increasing size of herd in Indigenous cow will increase the economies of scale. Most important negatively affecting factor was feeding concentrate per kg of milk with a value of -0.631 showing that feeding concentrate does not affect efficiency of milk production but just increasing cost because data shows that Indigenous cow are not fed much quantity of concentrate.

Another important factor affecting TFP negatively was number of dairy cooperatives collecting milk in the area which is having -0.168 value of coefficient. It shows that 1 per cent increase in number of dairy cooperatives will decrease the TFP by 0.168 per cent. It shows that either price received from cooperatives is lower or the farmers are not motivated to manage the milch animals in better way. Fixed investment also showed negative effect on TFP showing that incurring cost on fixed investment in Indigenous cow is not directly increasing TFP and 1 per cent increase in fixed investment is causing TFP to decrease by -0.066 per cent.

Estimates of the coefficients of Determinants of Total Factor Productivity of milch animals in Crossbred Cows :

The estimates of the multiple log regression model are presented in table 4 which shows that the adjusted R^2 was 0.824 which shows 82.4 per cent explanation power of variations in TFP value of the equation. This means that for variables in the model collectively explained 82.4 per cent of the variance observed in crossbred cow milk production in the study area. Positively affecting determinants to TFP were only average productivity of milk with 0.172 regression coefficient and number of vaccinations and de-worming with regression coefficient of 0.086.

Increase in both the determinants increased the value of TFP. Only concentrate per kg of milk was the determinant which established negative relationship with TFP. 1 per cent increase in concentrate per kg of milk decreased the TFP by -0.448 per cent. This shows that already feeding of concentrate to crossbred cows is more than optimum level causing less increase in TFP with increase in cost. For crossbred cows the significant relationship could be established with only three variables which may be because of much variability in the rearing habits for crossbred cows and less number of farmers having crossbred cows that too not much economic herd sizes.

Estimates of the coefficients of determinants of total factor productivity for buffaloes :

The log linear regression results for the determinants of total factor productivity for buffaloes are presented in table 5. It could be observed in the table that the adjusted R^2 value was

the 0.855 explaining 85.50 % of the variation observed in milk TFP in the model. It can be observed from the results that the important explanatory variables having positive effect on TFP were average milk productivity of buffaloes, herd size and, number of vaccinations and de-worming per year per animal with regression coefficients 0.142, 0.049 and 0.037, respectively.

Only one determinant negatively affecting the TFP in buffaloes was concentrate per kg of milk showing that 1 per cent increase in the value of concentrate per kg of milk will decrease the TFP by -0.692 which is quite a high value indicating that buffaloes are being fed more than required concentrate. In buffaloes also not many factors could establish significant coefficients may be because of less number of buffaloes as compared to Indigenous cow. Another reason may be less number of farmers having crossbred cows that too not much economic herd sizes.

Conclusions

The result conclusion determinants of TFP for different categories of milch animals indicated that average milk productivity per animal per day was affecting TFP positively in all the categories of milch animals which is quite obvious. Concentrate per kg of milk per animal per year affected TFP negatively in all the categories of animals showing that it was not effective in some categories in increasing TFP and in some categories it was being fed at a level more than optimum. Increasing herd size affected positively in local cows and buffaloes only but on overall animals basis it affected TFP negatively. Area under fodder crops established positive effect only in local cows and overall population of milch animals. Number of vaccinations and de-worming was not significant for local cows only. Number of cases treated in veterinary institutions and number of veterinary institutions within 100 square kilometers were not significant for any type of milch animals except later was found positively affecting TFP for overall milch animals. Number of dairy cooperatives negatively affected the TFP in local cows and to overall category. Increasing herd size affected positively in Indigenous cows and buffaloes only but on overall animals basis it affected TFP negatively. Area under fodder crops established positive effect only in Indigenous cow and overall population of milch animals. Number of vaccinations and de-worming was not significant for Indigenous cows only. Number of cases treated in veterinary institutions and number of veterinary institutions within 100 square kilometers were not significant for any type of milch animals except later was

found positively affecting TFP for overall milch animals. Number of dairy cooperatives negatively affected the TFP in Indigenous cows and to overall category.

References

1. Bardhan, D., and Sharma, M.L. (2013). Technical efficiency in milk production in underdeveloped production environment of India. *Springer Plus*, 2(1), 1-7.
2. Birthal, P.S. and V.K. Taneja (2006), "Livestock Sector in India: Opportunities and Challenges for Smallholders", National Centre for Agricultural Economics and Policy Research, New Delhi, and International Livestock Research Institute, Nairobi.
3. Chand P and Sirohi S. 2012. Dairying in semi-arid eastern zone of Rajasthan: Input productivity and net returns. *Indian Journal of Dairy Science* 65(1): 79–83.
4. Chand, P., Sirohi, S., Saxena, R., and Mishra, A., (2018) How profitable is dairying in tribal Chhattisgarh?. *Indian Journal of Animal Sciences*, 88(6): 749-754
5. Elumalai, K., and Pandey, U.K. (2004) Technological change in livestock sector of Haryana. *Indian Journal of Agricultural Economics*, 59(902-2016-68049).
6. Government of India (2014). 19th livestock census 2012 All India Report, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Government of India, New Delhi.
7. Government of India (2019). Basic Animal Husbandry Statistics. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, New Delhi.
8. Kalamkar, S.S., Sharma, H. and Makwana M. (2020). Assessment of livestock feed and fodder in Gujarat. *Agricultural Situation in India*. Volume LXXVII (4), 36- 41.
9. Lal P. and Chandel B.S. (2017). Total factor productivity in milk production in Haryana. *Agricultural Economics Research Review*, 30(2): 279-284.
10. Misra, A.K., Rama Rao, C.A., Subrahmanyam, K. V., Vijay Sankar Babu, M., Shivarudrappa, B., and Ramakrishna, Y.S., (2007) Strategies for livestock development in rainfed agro-ecosystem of India. *Livestock Research for Rural Development*, 19(6): 1-5.
11. Samra, J.S., Singh, G., and Dagar, J.C., (2007). Drought management strategies in India. *Drought management strategies in India*.
12. Sharma, Hemant and Kalamkar, S.S. (2020). A Comparative Economic Analysis of Milk Production of Dairy Cooperatives Society and Non-Dairy Cooperatives Society Household of Rajasthan. *Indian Journal of Economics and Development*. 16(SS): 17-27
13. Sirohi, S., Saxena, R., Chauhan, A.K., Dhaka, J.P., Sirohi, S.K., Kumar, N., and Kumar, S., (2015). Costs and Returns in Milk Production: Developing Standardized Methodology and Estimates for Various Dairy Production Systems. Project report submitted to Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi.



Effect of Irrigation Levels and Genotypes on Growth Indices of Chickpea (*Cicer arietinum* L.)

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Abstract

The field experiment was conducted during the *Rabi* season of 2019-20 and 2020-21 at drought plots area, crop physiology lab, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The soil of the experimental site was sandy in texture, alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in split plot design with four irrigation levels (Only pre-sowing, Pre-sowing + Pre-flowering stage, Pre-sowing + Pod-filling stage, Pre-sowing + Pre-flowering stage + Pod-filling stage) in main plots and five chickpea genotypes (H 15-04, H 15-11, H 08-18, H 12-55, HC-1) in sub-plots with three replications. During both the crop seasons, growth indices viz. crop growth rate (CGR), relative growth rate (RGR) and leaf area duration (LAD) were maximum in chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage and was minimum in chickpea crop grown with only pre-sowing irrigation during most of the crop growth stages. Among genotypes, maximum crop growth rate (255.3 mg/plant/day, 237.6 mg/plant/day) and maximum relative growth rate (0.034 g/g/day, 0.034 g/g/day) during 60-90 DAS was recorded with H 08-18 in both the crop seasons. Also, chickpea genotype H 08-18 recorded maximum leaf area duration at 90 and 120 DAS followed by H 12-55.

Key words : Irrigation levels, genotypes, CGR, RGR, LAD.

Introduction

Chickpea (*Cicer arietinum* L.), also known as bengal gram is the world's earliest grain legume crop. The agronomical importance of chickpea for the human and animal diet is based on its high protein concentration (19.3–25.4 %), carbohydrates (52-70 %), fat (4-10%), minerals (calcium, phosphorous and iron), vitamin (niacin) and trace elements (1). Chickpea is grown worldwide on an area of 13.7 million hectare with a production of 14.2 million tonnes (2). India is the world's largest producer and consumer of chickpeas, accounting for 69.75 percent of global output and chickpea contributes for more than a third of country's total pulses area and almost 45% of pulse output. In India, chickpea is sown on an area of about 9.7 million hectare with a production of 11.08 million tonnes with an average productivity of 1142 kg ha⁻¹ (3). In Haryana, it is grown over an area of 0.44 lakh hectare with total production of 0.47 lakh tonnes and productivity of 1072 kg ha⁻¹ (3). Chickpea is mostly cultivated under dryland condition and water availability is the major environmental factor affecting crop yield in dryland conditions. In dryland areas, the crop suffered from moisture stress due to the insecurity of rainfall. The combination of stored soil moisture and high temperatures results in the creation of various degrees of moisture stress during the duration of crop growth, therefore restricting the expression of growth and development characteristics, resulting in a significant loss of crop output

(4). So, keeping in view, present study was aimed at determining the impact of the irrigation levels and genotypes on the growth indices of chickpea.

Material and Methods

The field experiment was conducted during the *Rabi* season of 2019-20 and 2020-21 at drought plots area, crop physiology lab, Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The soil of the experimental site was sandy in texture, alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The experiment was laid out in split plot design with four irrigation levels (Only pre-sowing, Pre-sowing + Pre-flowering stage, Pre-sowing + Pod-filling stage, Pre-sowing + Pre-flowering stage + Pod-filling stage) in main plots and five chickpea genotypes (H 15-04, H 15-11, H 08-18, H 12-55, HC-1) in sub-plots with three replications. Sowing of different genotypes of chickpea was done manually with the help of hand plough by *Pora* method. Recommended dose of fertilizers was applied to all the plots at the time of sowing. Irrigation was applied at pre-flowering and pod-filling stage in the main plots according to the treatments. Other management practices were adopted as per recommendations for the chickpea crop.

Crop growth rate (CGR) : The crop growth rate (mg/plant/day) for each specified stage was calculated using the standard formula given by Radford (5).

Table-1 : Effect of irrigation levels and genotypes on crop growth rate and relative growth rate of chickpea.

Treatments	Crop growth rate (mg/plant/day)				Relative growth rate (g/g/day)			
	60-90 DAS		90-120 DAS		60-90 DAS		90-120 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Irrigation levels								
Only pre-sowing	206.7	183.3	333.4	323.4	0.031	0.029	0.023	0.023
Pre-sowing + Pre-flowering stage	228.5	213.5	514.9	481.6	0.033	0.033	0.029	0.029
Pre-sowing + Pod-filling stage	209.3	189.0	537.4	491.1	0.031	0.030	0.030	0.031
Pre-sowing + Pre-flowering stage + Pod-filling stage	233.3	221.3	536.9	505.5	0.032	0.033	0.031	0.030
SEm±	4.1	3.7	9.8	6.4	0.001	0.001	0.001	0.000
CD (p=0.05)	14.4	13.1	34.7	22.7	NS	NS	0.003	0.001
Genotypes								
H 15-04	220.3	202.7	480.4	450.1	0.033	0.032	0.028	0.028
H 15-11	205.0	187.3	480.7	450.5	0.031	0.030	0.029	0.029
H 08-18	255.3	237.6	481.4	451.1	0.034	0.034	0.026	0.026
H 12-55	250.0	232.3	480.3	450.0	0.034	0.034	0.026	0.027
HC-1	166.7	149.0	480.6	450.3	0.028	0.026	0.032	0.032
SEm ±	12.2	6.0	12.7	8.0	0.002	0.01	0.001	0.000
CD (p=0.05)	35.2	17.4	NS	NS	NS	0.003	0.002	0.001

Table-2 : Effect of irrigation levels on leaf area duration (days) of chickpea genotypes.

Treatments	Leaf area duration							
	30 DAS		60 DAS		90 DAS		120 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Irrigation levels								
Only pre-sowing	0.92	0.92	3.83	3.69	18.98	17.09	35.71	32.03
Pre-sowing + Pre-flowering stage	0.95	0.92	3.89	3.76	20.66	19.30	40.49	36.81
Pre-sowing + Pod-filling stage	0.93	0.91	3.85	3.72	19.35	17.71	37.49	34.12
Pre-sowing + Pre-flowering stage + Pod-filling stage	0.96	0.94	3.93	3.83	21.19	19.87	42.49	38.43
SEm±	0.01	0.01	0.04	0.04	0.21	0.20	0.41	0.38
CD (p=0.05)	NS	NS	NS	NS	0.74	0.71	1.46	1.34
Genotypes								
H 15-04	0.93	0.92	3.86	3.73	19.59	18.12	38.05	34.48
H 15-11	0.93	0.91	3.83	3.71	19.39	17.97	37.63	34.14
H 08-18	0.94	0.92	3.90	3.77	20.87	19.19	40.89	36.95
H 12-55	0.94	0.92	3.89	3.76	20.25	18.67	39.50	35.73
HC-1	0.94	0.93	3.90	3.78	20.11	18.54	39.16	35.42
SEm±	0.02	0.02	0.06	0.06	0.32	0.30	0.63	0.57
CD (p=0.05)	NS	NS	NS	NS	0.93	NS	1.83	1.65

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_2 = Dry weight of crop plant at the time interval T_2

W_1 = Dry weight of crop plant at the time interval T_1

Relative growth rate (RGR) : The relative growth rate (g/g/day) for each observational stage was worked out by substituting the corresponding dry matter accumulation values of that very stage in the formula given by Radford (5).

$$RGR = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1}$$

Where,

W_2 = Dry weight of crop plant at time interval T_2

W_1 = Dry weight of crop plant at time interval T_1

Leaf area duration (LAD) : The leaf area duration (days) for each observational stage was worked out as per formula given below (6).

$$LAD = \frac{(LAI_1 + LAI_2)(T_2 - T_1)}{2}$$

Where,

LAI_1 = Leaf area indices obtained at time interval T_1

LAI_2 = Leaf area indices obtained at time interval T_2

$T_2 - T_1$ = Time interval in days between two observations

The data collected were subjected to statistical analysis by using 'Analysis of Variance Technique' as suggested by Gomez and Gomez (7). Standard errors of mean and critical difference (CD) values at 5% level of probability were computed for making comparison between treatments.

Results and Discussion

Crop growth rate : The rate of crop growth (Table-1) of chickpea genotypes increased with the advancement of crop growth. This increase may be due to the acceleration of photosynthesis activity resulting in positive response of CGR. Similar results were also reported by (8) and (9). During both the years, crop growth rate between 60-90 DAS was recorded significantly higher in chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage (233.3 mg/plant/day, 221.3 mg/plant/day) as compared to other irrigation levels, but was at par with the chickpea crop irrigated at pre-sowing + pre-flowering stage (228.5 mg/plant/day, 213.5 mg/plant/day). Between 90-120 DAS, chickpea crop irrigated at pre-sowing + pod-filling stage (537.4 mg/plant/day) recorded significantly higher crop growth rate in first year as compared to chickpea crop that received only pre-sowing irrigation, but was at par with other two irrigation levels. During the second year, crop growth rate was recorded significantly higher in chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage (505.5 mg/plant/day), but was at par with the chickpea crop irrigated at pre-sowing + pod-filling stage (491.1 mg/plant/day). Lower water supply to the plants under water deficit, possibly resulted in a reduction in the photosynthetic rate, resulting in less crop growth. Moisture stress at different crop growth stages affected CGR differently. Fully irrigated crops indicated significantly greater CGR than moisture stressed crops throughout the season (10) and (11).

The maximum crop growth rate between 60-90 DAS was recorded in H 08-18 (255.3 mg/plant/day) and was at par with H 12-55 (250.0 mg/plant/day) and H 15-04 (220.3 mg/plant/day) in first year. Also, H 08-18 (237.6 mg/plant/day) gave at par results with H 12-55 (232.3 mg/plant/day) in second year. Differences in CGR among genotypes were also reported in past studies (11).

Relative growth rate : Relative growth rate between 90-120 DAS (Table 1) was recorded significantly higher in chickpea crop irrigated at pre-sowing + pre-flowering

stage + pod-filling stage (0.031 g/g/day) as compared to chickpea crop that received only pre-sowing irrigation (0.023 g/g/day), but was at par with the other two irrigation levels in the first year. During the second year, it was significantly higher in chickpea crop irrigated at pre-sowing + pod-filling stage (0.031 g/g/day) as compared to other irrigation levels, but was at par with chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage (0.030 g/g/day). In the initial stages of the crop growth the ratio between alive and dead tissues is high and almost the entire cells of productive organs are actively engaged in vegetative matter production. A declining trend in RGR values was observed with advancement in crop age at all the stages of observation with respect to its just preceding stage (8, 12). Among the chickpea genotypes, maximum relative growth rate between 60-90 DAS was recorded in H 08-18 (0.034 g/g/day, 0.034 g/g/day) and H 12-55 (0.034 g/g/day, 0.034 g/g/day) during both the years. Chickpea genotype HC-1 (0.032 g/g/day, 0.032 g/g/day) recorded maximum relative growth rate between 90-120 DAS during both the years which was significantly higher than all other genotypes under study. These findings are in line with those of (8, 12).

Leaf area duration : The leaf duration of chickpea genotypes increased with the advancement of crop growth with a steep increase seen between 60-90 DAS (Table 2). Both the irrigation levels and chickpea genotypes failed to show significant variation in terms of leaf area duration at 30 and 60 DAS. During both the years, it was recorded significantly higher in chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage as compared to other three irrigation levels at later growth stages, except at 90 DAS, where it gave at par results with the chickpea crop irrigated at pre-sowing + pre-flowering stage. Lowest leaf area duration at all stages was recorded in the chickpea crop where only pre-sowing irrigation was applied. The larger leaf area with the larger number of leaves in chickpea crop irrigated at pre-sowing + pre-flowering stage + pod-filling stage favored the greater leaf area index in this treatment that resulted in higher leaf area duration. Among the chickpea genotypes, significantly higher leaf area duration at 90 DAS was recorded in H 08-18 (20.87 days) which was at par with H12-55 (20.25 days) in the first year. At 120 DAS, H 08-18 (40.89 days, 36.95 days) recorded significantly higher leaf area duration which was at par with H12-55 (39.50 days, 35.73 days) and HC-1 (39.16 days, 35.42 days) in both the crop seasons. Lowest leaf area duration was recorded in H 15-11 at all crop growth stages in both the crop seasons. Previous researchers also concluded that high yielding varieties had highest LAD throughout the crop growth period (13).

Conclusions

It is concluded from the present study that RGR reduced with increasing age of the plant, while the CGR and LAD increased with the crop age up to 120 DAS. Drought stress in chickpea decreased the growth of chickpea as compared to irrigated crop. Among chickpea genotypes, H 08-18 and H 12-55 performed relatively better in terms of these growth indices.

References

1. Yadav, S.S.; Longnecker, N.; Dusunceli, F.; Bejjiga, G.; Yadav, M.; Rizvi, A.H.; Manohar, M.; Reddy, A.A.; Xaxiao, Z. and Chen, W. (2007). Uses, consumption and utilization. *Chickpea Breeding and Management*, 71–100.
2. FAO STAT (2020). Food and Agriculture Organization of the United Nations.
3. Anonymous (2020). Department of economics and statistics, Ministry of agriculture cooperation and farmers welfare, Government of India.
4. Brahmane, R.O.; Bharud, R. and Deshmukh, D. (2017). Study of growth and yield variation of chickpea genotypes under moisture stress condition. *International Journal of Genetics*, 9(4): 266.
5. Radford, P.J. (1967). Growth analysis formulae-their use and abuse. *Crop Science*, 3: 171-176.
6. Evans, L.T.; Wardlaw, J.F. and Fischer, R.A. (1975). Wheat in: *Crop physiology- some case histories*. 101-150, Evans, L.T. (ed.), Cambridge University Press, Cambridge.
7. Gomez, K.A. and Gomez, A.A. (1983). Statistical procedures for agricultural research, IRRI: A Wiley Publication, New York, pp: 199-201.
8. Kour, R.; Sharma, B.C.; Kumar, A.; Kour, P. and Nandan, B. (2016). Study of physiological growth indices of chickpea in chickpea (*Cicer arietinum*) + mustard (*Brassica juncea*) intercropping system under different weed management practices. *Legume Research*, 39(3): 453-458.
9. Jeffrey, T.; Edwards, C.; Purcell, E. and Earl, D. (2005). Light interception and yield potential of short season maize (*Zee mays* L.) hybrids in the midsouth. *Agronomy Journal*, 97: 225-234.
10. Akram, M. (2011). Growth and yield components of wheat under water stress of different growth stages. *Bangladesh Journal of Agricultural Research*, 36(3): 455-468.
11. Maheshankar. (2018). Screening of chickpea (*Cicer arietinum* L.) lines for drought tolerance. Thesis M.Sc. (Crop physiology), University of Agricultural Sciences, Raichur.
12. Azimi, S.M.; Kor, N.M.; Ahmadi, M; Shaaban, M.; Motlagh Z.R. and Shamsizadeh, M. (2015). Investigation of growth analysis in chickpea (*Cicer arietinum* L.) cultivars under drought stress. *International Journal of Life Sciences*, 9(5): 91-94.
13. Tandale, M.D. and Ubale, S.S. (2007). Evaluation of effect of growth parameters, leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR) on seed yield of soybean during *kharif* season. *International Journal of Agricultural Sciences*, 3(1): 119-123.



Assessment of Chemical Properties and Classification of Soils of Agriculture Technical School, Manjri Farm, Pune

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Abstracts

The aim of this study was to evaluate the chemical properties and classification of soils. The present study mainly focused on testing of soil samples at Agriculture Technical School, Manjri Farm, Pune to determine chemical properties and to provide information to farmers and extension functionaries during year 2018-2019. GPS based ninety four surface soil samples (0-22.5 cm depth) were collected. The chemical parameter viz., pH, EC, organic carbon, calcium carbonate, available nitrogen, phosphorus, potassium, sulphur and DTPA extractable micronutrients iron, manganese, zinc and copper, were 7.55, 0.38 dSm⁻¹, 0.70, 5.64 per cent, 211.25, 11.13, 360.62 kg ha⁻¹, 9.85 mg kg⁻¹, 1.0, 8.44, 3.43 and 5.71 mg kg⁻¹, respectively. The soils were neutral to alkaline in nature, normal in EC, low to medium in organic carbon, low to moderately in CaCO₃, low in available N, medium in available P₂O₅, high in available K₂O, deficient in available sulphur and iron sufficient in manganese, zinc and copper. From the total samples eighty seven (92.55 %) samples show normal soils, while seven (7.45 %) samples show pH greater than 8.5, EC was normal suitable for all types of field and fruit crop and the majority of the soils (89.36 %) were moderately calcareous followed by non-calcareous class (10.64 %).

Key words : Ninety four, soil samples, nature and EC

Introduction

The term "soil" refers to one of the planet's most dynamic and complex natural systems. It is necessary for the existence of many types of life, since it provides a substrate for plant development and satisfies the majority of the nutritional needs of creatures (Kumar *et al.*, 2019). The plant's capacity to extract water and nutrients is influenced by the physical and chemical qualities of the soil. High-quality soils assist to develop natural ecosystems and improve air and water quality, in addition to producing healthier food and fiber (Griffith *et al.*, 2010). The physical properties of the soil depend upon the amount, shape, structure, size, pore spaces, organic matter and mineral composition of soil. The chemical properties of the soil are the interactions of various chemical constituents among soil particles and the soil solution. These physical and chemical properties are soil texture, bulk density, soil structure, soil color, pH, electrical conductivity, cation exchange capacity, organic carbon, organic matter and soil nutrients. All soils have different properties and working with them requires understanding of these properties. The knowledge of the physical and chemical properties of soil helps in managing resources while working with a particular soil (Brady and Weil, 2002). They need to be studied for agricultural purpose, to increase the productivity and to improve the workability of the soil mass. The study of up-to-date status

of soil properties is a very important tool to enhance production on a sustainable basis (Brady and Weil, 2002).

The overall productivity and sustainability of a given agricultural sector is highly dependent up on the fertility and physico-chemical characteristics of soil resources (Priyanka *et al.*, 2018). Chemical characteristics of different soils vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities and several other biotic and abiotic variables (Tale *et al.*, 2015). The physical and chemical (physico-chemical) properties of the soil vary drastically in time and space, depending on the texture, climate, organic matter content, soil biological activity and tillage practices (Alletto *et al.*, 2010). Tillage is one of the main causes of spatial and temporal variability in soil physical properties, but its effects have not always been consistent depending on the location and soil type (Green *et al.*, 2003). Soil plays an important role in the formation and heterogeneity of habitats that may result into changes in vegetation structure and plant diversity (Rodrigues *et al.*, 2018). Therefore, the structure and diversity of vegetation are determined by the discontinuous distribution of biotic and abiotic factors in the habitat. Spatial variation in soil physico-chemical properties occurs as the result of soil forming factors, including time, nature of parent material, topography, climate and organisms (Sagølam *et al.*, 2011). Soil

physico-chemical properties have effects on plant growth and consequently plant morphology. Evaluation of soil spatial variation is important in agricultural and environmental researches, since the information on soil properties has agronomic applications (Sauer *et al.*, 2006).

The deficiency of nutrients directly effects on the growth of crops and crop response become poor (Jagtap *et al.*, 2018). Hence, for sustainability of the present agricultural system and for management of our soil resources, database regarding the fertility status of soils is required. Application of fertilizers by the farmers in fields without prior knowledge of soil fertility status might result in adverse effects on soils as well as crops both in terms of micronutrient deficiency and toxicity either by inadequate or over use of fertilizers. With the invent of modern technologies of remote sensing, GIS and GPS, it is now possible to monitor the soil fertility and crop health through systematic surveys. This will be helpful to monitor the changes in fertility status of the studied area site specific nutrient requirement of the crop. It is anticipated that with higher yields and more intensive agriculture the secondary and micronutrient deficiency will increase both in amount and extent (NAAS, 2018). Imbalanced and inadequate use of fertilizers coupled with low use efficiency of other inputs led to decline in the response efficiency of chemical fertilizer nutrients under intensive agriculture in recent years. Keeping this in view, present study was taken up in Manjri farm of Pune district of Maharashtra.

Materials and Methods

Agriculture Technical School, Manjri Farm, Pune, comes under plain zone of Maharashtra and is located at 18°29' to 18°30' N latitude and 73°58' to 73°59' E longitude. The elevation from mean sea level is 562 m. The climate is usually hot and is classified as semi-arid tropical the annual rainfall 545 mm. The mean maximum temperature ranged between 34°C to 42°C while annual mean minimum temperature varies from 8°C to 20°C. The mean humidity percentage ranged between 78-95 percent. The area under cultivation is 43.04 ha out of which 27.84 ha area under lift farm and 15.20 ha under central farm. GPS based ninety four surface soil samples (0-22.5 cm) were collected in cloth bags as per the standard procedure recommended by United States Department of Agricultural Sciences (USDA, 1954). Quartering technique was used for preparation of soil samples. The samples were dried in air and passed through 2 and 0.5 mm (for organic carbon) sieve. The processed soil samples were analyzed for their chemical characteristics as per the standard procedures. The soil samples were processed and analyzed for pH and EC in soil: water

Table-1 : pH, EC, Organic carbon and Calcium carbonate status of the soils of Manjri Farm, Pune.

	pH	EC (dSms)	OC (%)	CaCO ₃ (%)
Range	6.98-8.73	0.20-1.4	0.41-0.97	2.73-8.27
Average	7.55	0.38	0.70	5.64
S.D.	0.40	0.12	0.19	1.24

Table-2 : Classification of soils on the basis of pH.

pH range	Type	No. of soil samples
6.0	Acidic soil	Nil
6.0 to 8.5	Normal soil	87 (92.55%)
8.5	Alkali soil	7 (7.45%)

Table-3 : Classification of soils on the basis of EC.

EC (dSm ⁻¹)	Soil Typ	No. of Soil Samples
1.0	Normal soil	94 (100%)
1-2	Critical for germination	Nil
2-3	Critical for growth of salt sensitive crops	Nil
3	Severely injurious to crops	Nil

Table-4 : Classification of soils on the basis of calcium carbonate.

% CaCO ₃	Soil class	No. of soil samples
4.0	Non-calcareous	10 (10.64%)
4.0 to 10	Moderately calcareous	84 (89.36%)
10	Strongly calcareous	Nil

suspensions (1:2.5 w/v) as described by Jackson (1973). Organic carbon was determined by wet oxidation method (Nelson and Sommers, 1982) and free CaCO₃ was determined by Rapid titration method (Piper, 1966), available nitrogen by alkaline potassium permanganate (Subbaiah and Asija, 1956), available phosphorus by sodium bicarbonate method (Olsen *et al.*, 1954), available potassium by ammonium acetate method (Knudsen and Peterson, 1982), available sulphur was estimated by turbidimetric method (Chesnin and Yien, 1951). Soil samples were extracted with 0.005M diethylene triamine penta acetic acid (DTPA) for estimation of available Zn, Fe, Cu and Mn using Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). The data was analyzed with the help of Microsoft Excel 2010 and SPSS 16.0.

Results and Discussion

Chemical properties and classifications of soils : The chemical properties of soils are determined by the colloidal portion of soils i.e., clay and humus. The chemical environment of soil not only influences the crop growth but also it decisively determines the physical environment of soil. Therefore, in order to characterize the soils from the area, the chemical properties like pH, EC, organic carbon, calcium carbonate, Available N, P, K, S

Table-5 : Available nitrogen, phosphorus, potassium and sulphur status of the soils of Manjri Farm, Pune.

	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Available S (mg kg ⁻¹)
Range	125.39-282.05	6.84-18.17	236.39-622.87	6.69-12.49
Average	211.25	11.13	360.62	9.85
S.D.	39.50	2.89	78.39	1.71

Table-6 : Micronutrients (mg/kg) status of the soils of Manjri Farm, Pune.

	Iron (mg kg ⁻¹)	Manganese (mg kg ⁻¹)	Zinc (mg kg ⁻¹)	Copper (mg kg ⁻¹)
Range	0.62-3.53	0.75-18.39	0.93-7.77	2.51-11.53
Average	1.0	8.44	3.43	5.71
S.D.	0.12	0.27	0.17	0.21

and DTPA extractable micronutrients (Fe, Mn, Zn and Cu) were estimated and presented in Table 1 to 6.

pH, EC, organic carbon and calcium carbonate : Data pertaining to pH, EC, Organic carbon and calcium carbonate were presented in Table-1. Investigated soil are neutral to alkaline in reaction with pH varied from 6.98 to 8.73 with an average value of 7.55. Neutral to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the retention of basic cations on the exchangeable complex of the soil. Maximum soil samples were found slightly alkaline in nature. The electrical conductivity (EC) gives an indication about salt concentration of the soil and it varied from 0.20 to 1.40 dSm⁻¹ at 25°C with an average value of 0.38 dSm⁻¹. All the soil were non-saline in nature and suitable for healthy plant growth. The organic carbon content in soil ranged from 0.41 to 0.97 % with an average value of 0.70 %, the soil was low to medium in organic carbon and calcium carbonate content in soil varied from 2.73 to 8.27 % with an average value of 5.64 %, soil was moderately high in calcium carbonate. High calcium carbonate is harmful; it reduces the concentration of micronutrient cations in soils to such a level that the sensitive plant suffers from deficiency of micronutrients (Deb *et al.*, 2012).

Classification of soils on the basis of pH, EC and calcium carbonate : The characteristics of the soils show wide variations from one place to another depending upon the rainfall, topography, climate, geology and land use pattern of the area. Therefore, in order to know the exact situation at a particular location classification of soil is necessary. Different criteria based on different parameters such as pH, EC and CaCO₃ content of soil extract have been widely used to classify the soils (U.S.S.L.S., 1954).

It is observed from the table-2, that out of ninety-four soil samples eighty seven (92.55 %) samples shows normal soils, while seven (7.45 %) samples show pH greater than 8.5 leads to alkali soils. The electrical

conductivity (EC) in the saturation extract is used as an index for grading the soil type along with ESP and pH of the soils. It is characterized by cations like sodium, potassium, calcium, magnesium and anion like chlorides, sulphates, bicarbonates, phosphates and nitrates, it is observed from the table 3, that soil samples have normal EC, suitable for all type of field and fruit crops. Similar findings were reported by More *et al.* (1988). Impure calcium carbonate locally known as kankar usually occurs in natural state in irrigation soils. The presence of calcium carbonate in the soil is due to climatic factors. It is known that the soils in the areas characterized by semi-arid and arid climates usually show precipitation of calcium carbonate (Hausenbuiller, 1976). The calcareousness influences the pH of soil as well as the availability of micro and macronutrients required for plant growth. The physical conditions of the soils are also greatly influenced by the quantity and size of concretions. However, the effect of carbonate on soil fertility is not uniform. A moderate amount of CaCO₃ damages the physical properties of soils and cements the soil mass (Orlov, 1992). It is evident from the table 4, that majority of the soils (89.36 %) were moderately calcareous followed by non-calcareous class (10.64 %). High proportion of CaCO₃ is indicative of insufficient leaching of salts from host rock basalt. Similar findings were also reported by Challa *et al.* (2000).

Available Nitrogen, Phosphorus, Potassium and Sulphur : The results of study presented in Table 5, indicated that. The available N was found low to moderate (125.39 to 282.05 kg ha⁻¹) in soils of Manjri Farm, Pune. It may be due difference in organic matter content of soil (Waiker *et al.*, 2014). The soils of Manjri Farm, Pune were found low to medium in available P₂O₅ content (6.84 to 18.17 kg ha⁻¹). The variation in the availability of phosphorus might be due to variation in CaCO₃ content in the soil, different soil properties and agronomic practices (Singh *et al.*, 2006). In case of available K₂O in the soil was found high (239.39 to 622.87 kg ha⁻¹). This may be due to occurrence of potash rich minerals like mica and

feldspar the available K_2O was high (Malewar, 1995). The available S was found low to medium in soils of Manjri Farm, Pune (6.69 to 12.49 mg kg^{-1}). This could be attributed due to high amount of clay content in soils which can adsorbed varying amounts of S. This might be expected due to presence of Fe and Al oxides in surface soils (Singh *et al.*, 2006).

DTPA extractable micronutrients (mg kg^{-1}) : The DTPA extractable micronutrients iron (0.62-3.53 mg kg^{-1}), manganese (0.75-18.39 mg kg^{-1}), zinc (0.53-7.77 mg kg^{-1}) and copper (2.51 to 11.53 mg kg^{-1}) in the soils of Manjri Farm, Pune. The soils of Manjri Farm, Pune were deficient in iron and sufficient in manganese, zinc and copper. The similar observations were also reported by Hundal *et al.* (2006) and Meena *et al.* (2006).

Conclusions

Summarizing the results, it can be concluded that the soils of Agriculture Technical School, Manjri Farm, Pune, were neutral to alkaline in nature, normal in EC, low to medium in organic carbon, low to moderately in $CaCO_3$, low in available N, medium in available P_2O_5 , high in available K_2O , deficient in available sulphur and iron sufficient in manganese, zinc and copper. From the total samples eighty seven (92.55 %) samples show normal soils, while seven (7.45 %) samples show pH greater than 8.5, EC was normal suitable for all type crops and the majority of the soils (89.36 %) were moderately calcareous followed by non-calcareous class (10.64 %). On the basis of classification, the soils of Agriculture Technical School, Manjri Farm, Pune, were suitable for all types of field and fruit crop.

References

- Alletto, L., Coquet, Y. and Roger-Estrade, J. (2010). Two-dimensional spatial variation of soil physical properties in two tillage systems. *Soil use and management* 26, 432-444.
- Brady, N.C., Weil, R.R. and Weil, R.R. (2008). *The nature and properties of soils* (Vol. 13, pp. 662-710). Upper Saddle River, NJ: Prentice Hall.
- Challa, O., Bhaskar, B.P., Anantwar, S.G. and Gaikawad, M.S. (2000). Characterization and classification of some problematic Vertisols in semi-arid ecosystem of Maharashtra Plateau. *Journal of the Indian Society of Soil Science* 48, 139-145.
- Chesnin, L. and Yein, C.H. (1951). Turbidimetric determination of available sulphates. *Soil Science Society of America Proceedings* 15, 149-157.
- Deb, D.L., Sakal, L.R., and Datta, S.P. (2012). Micronutrients: In: *Fundamental of Soil Science*. *Indian Society of Soil Science* 56, 461-490.
- Green, T.R., Ahuja, L.R. and Benjamin, J.G. (2003). Advances and challenges in predicting agricultural management effects on soil hydraulic properties. *Geoderma* 116, 3-27.
- Griffiths, B.S., Ball, B.C., Daniell, T.J., Hallett, P.D., Neilson, R., Wheatley, R.E., Osler, G. and Bohanec, M. (2010). Integrating soil quality changes to arable agricultural systems following organic matter addition, or adoption of a ley-arable rotation. *Applied Soil Ecology* 46, 43-53.
- Hausenbuiller, R.L. (1976). *Soil Science: Principles and practices*, Washington state University, Pullman, 247.
- Hundal, H.S., Rajkumar, Dhanwinder Singh and Machandra, J.S. (2006). Available nutrient and heavy metal status of soils of Punjab, North-west India. *J. Indian Soc. Soil Sci.* 54, 50-56.
- Jackson, M.L. (1973). *Soil Chemical Analysis* Prentice Hall of India Private Limited, New Delhi.
- Jagtap, M., Chaudhari, R., Thakare, R. and Patil, T. (2018). Mapping of soil micronutrient status based on GPS-GIS and biological properties of Ajang village of Dhule tehsil of Dhule district Maharashtra. *Journal of Pharmacognosy and Phytochemistry* 7, 3270-3275.
- Knudsen, D. and G.A. Peterson. (1982). Methods of Soil Analysis. *Soil Science Society of America Journal* 9, 225-246.
- Kumar, P., Rajakumar, R., Kumar, S. and Kumar, K. (2019). Assessment of chemical properties of soils from different ecosystems located in Hyderabad. *Journal of Pharmacognosy and Phytochemistry* 8, 1909-1912.
- Lindsay, W.L. and Norwell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* 42, 421-428.
- Malewar, G.U. (1995). Micronutrient availability as influenced by cropping pattern in Marathwada region of Maharashtra. *J. Maharashtra Agric. Univ.* 20, 330-333.
- 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.
- More, S.D., Shinde, J.S. and Malewar, G.U. (1988). Characterization of some salt-affected soils of Purna Command Area of Maharashtra. *Journal of the Indian Society of Soil Science* 36, 146-150.
- N.A.A.S. (2018). *Soil Health: New Policy Initiative for Farmer's Welfare*. Policy Brief No. 3, National Academy of Agricultural Sciences, New Delhi. 4p.
- Nelson, D.W. and Sommers, L.E. (1982). Total carbon, organic carbon and organic matter. In *Methods of Soil Analysis*. *Soil Science Society of American Journal* 7, 539-577.
- Olsen, S.R., Col, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorous in soils by estimation with sodium bicarbonate. *USDA Circular* No. 939. United State Department of Agriculture, USA.
- Orlov, D.S. (1992). *Soil Chemistry*, Oxford and IBH publishers, New Delhi.
- Piper, C.S. (1966). *Soil and plant analysis*, Hans. Publication Bombay.
- Priyanka, A.V., Guldekar, V.D. and Ghabane, V.V. (2018). Assessment of available soil nutrient status in black soils of Akola district, Maharashtra. *Journal of Pharmacognosy and Phytochemistry* 7, 1124-1129.
- Rodrigues, P.M.S., Schaefer, C.E.G.R., de Oliveira Silva, J., Ferreira Júnior, W.G., dos Santos, R.M. and Neri, A.V. (2018) The influence of soil on vegetation structure and

- plant diversity in different tropical savannic and forest habitats. *Journal of Plant Ecology* 11, 226-236.
25. Sagclan, M., Oztur, H.S., Ersahin, K.S. and Ozkan, A.I. (2011). Spatial variation of soil physical properties in adjacent alluvial and colluvial soils under Ustic moisture regime. *Hydrol. Earth Syst. Sci. Discuss.* 8, 4261-4280
 26. Sauer, T.J., Cambardella, C.A. and Meek, D.W. (2006). Spatial variation of soil properties relating to vegetation changes. *Plant and soil* 280, 1-5.
 27. Singh, A.H., Kumarjit, Singh, L.N., N. Gopimohan Singh, Nandini Chongtham, and Kumar S. (2006). Status and forms of sulphur in acidic soils of Manipur. *J. Indian Soc. Soil Sci.* 54, 351-353.
 28. Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science* 25, 259-260.
 29. Tale, K.S. and Ingole, S. (2015). A review on role of physico-chemical properties in soil quality. *Chemical Science Review and Letters* 4, 57-66.
 30. U.S. Salinity Laboratory Staff. (1954). Diagnosis and improvement of saline and alkali soils. *Agriculture Handbook* 60, 83-100.
 31. Waikar, S.L., Patil, V.D. and Dhamak, A.L. (2014). Status of macro nutrients in some soils of Central Farm of MKV, Parbhani (Maharashtra). *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)* 7, 54-57.



Evaluation of Salt Combinations on the Basis of Soluble Cations and Anions in the Soil

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Abstracts

The aim of this study was to evaluate to salt combinations on the basis of soluble cations and anions. The present study mainly focused on testing of soil samples at Agriculture Technical School, Manjri Farm, Pune to determine salt combinations, during year 2018-2019. GPS based forty seven surface soil samples (0-22.5 cm depth) were collected. The salt combinations viz., CaHCO_3 , CaCl_2 , MgCl_2 , MgSO_4 , Na_2SO_4 , K_2SO_4 and CaSO_4 , were 0.21, 0.54, 0.18, 0.53, 0.11, 0.05 and 0.19 me L^{-1} , respectively. The soluble cations, calcium, magnesium, sodium, potassium and soluble anions, bicarbonate, chloride and sulphate, were 1.07, 0.71, 0.14, 0.08, 0.32, 0.70 and 0.93 me L^{-1} , respectively and sodium adsorption ratio (SAR) was 1.15. The dominant salt combinations in soil were $\text{CaCl}_2 > \text{MgSO}_4 > \text{CaHCO}_3 > \text{MgCl}_2 > \text{CaSO}_4 > \text{Na}_2\text{SO}_4 > \text{K}_2\text{SO}_4$ and dominant soluble ions were $\text{SO}_4^{2-} > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{Cl}^- > \text{HCO}_3^- > \text{Na}^+ > \text{K}^+$. On the basis of evaluation of salt combinations and sodium adsorption ratio (SAR) in soil, the soil contained less amount of salts, suitable for all types of field and fruit crop.

Key words : Forty seven, salts, cations, anions and SAR.

Introduction

The overall productivity and sustainability of a given agricultural sector is highly dependent up on the fertility and physico-chemical characteristics of soil resources (Priyanka *et al.*, 2018). Chemical characteristics of different soils vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities and several other biotic and abiotic variables (Tale *et al.*, 2015). The physical and chemical (physico-chemical) properties of the soil vary drastically in time and space, depending on the texture, climate, organic matter content, soil biological activity and tillage practices (Alletto *et al.*, 2010). Tillage is one of the main causes of spatial and temporal variability in soil physical properties, but its effects have not always been consistent depending on the location and soil type (Green *et al.*, 2003). Soil plays an important role in the formation and heterogeneity of habitats that may result into changes in vegetation structure and plant diversity (Rodrigues *et al.*, 2018). Therefore, the structure and diversity of vegetation are determined by the discontinuous distribution of biotic and abiotic factors in the habitat. Spatial variation in soil physico-chemical properties occurs as the result of soil forming factors, including time, nature of parent material, topography, climate and organisms (Saglam *et al.*, 2011). Soil physico-chemical properties have effects on plant growth and consequently plant morphology. Evaluation of soil spatial variation is important in agricultural and environmental researches, since the information on soil

properties has agronomic applications (Sauer *et al.*, 2006).

A lack of consciousness in the society towards soil quality has been to the extent that soil is used as a disposal site of hazardous waste as well as pathways of many contaminants and other applied hazardous chemicals which pose serious risk to human health. Soil quality indicators that directly monitor the soil are grouped into physical, chemical and biological indicators. Some soil chemical properties such as pH, EC, nutrient availability, ESP, SAR and CEC are the indicators of soil quality (Chnadra and Singh, 2009).

The aqueous components of a soil at different water contents in the field determine the abiotic stress experienced by plants during their growth, consequently affecting the crop yield (Rengasamy, 2010). In salt-affected soils, the total concentration of dissolved salts in soil solutions, generally measured as the electrical conductivity (EC) of the soil solutions, is considered as the primary criterion affecting the yield (Maas, 1990). Thus, most of the research on crop salinity tolerance has focused on EC of soil solutions inducing osmotic pressure affecting water uptake by plants and the accumulation of specific ions in the plant over a period of time leading to ion toxicity or ion imbalance (Munns and Tester, 2008). Because of the common opinion that sodium chloride (NaCl) is the predominant salt in saline soils, ionic effects of sodium (Na^+) and chloride (Cl^-) have received more attention. However, the composition of electrolytes, in addition to the total concentration, determines the

multi-phase equilibria involving: (1) the solid phase comprising clay minerals and other inorganic and organic materials, (2) the liquid phase comprising soil water, (3) the gaseous phase comprising mainly oxygen and carbon dioxide, and (4) the complex exchange phase (Jurinak, 1996; Läuchli and Lüttge, 2002). During crop growth in the field soil water fluctuates from high to very low levels and the chemical equilibria become more complex. Exchange reactions are determined by the nature of cations and anions, and as a result soil physical conditions are altered leading to the limitations to crop growth caused by increased soil strength and reduced water and air movement. Plant roots need a well-hydrated and well aerated soil environment of low osmotic pressure, with adequate nutrients and low toxicity. Soil pH, which depends on the composition of cations and anions and its relation with pE (electron activity related to redox potential), is changed by soil water regime, control solubility, and precipitation reactions. These processes result in the toxicity and deficiency of macro and micro-nutrient elements (Rengasamy, 2010).

Materials and Methods

Agriculture Technical School, Manjri Farm, Pune, comes under plain zone of Maharashtra and is located at 18°29' to 18°30' N latitude and 73°58' to 73°59' E longitude. The elevation from mean sea level is 562 m. The climate is usually hot and is classified as semi-arid tropical the annual rainfall 545 mm. The mean maximum temperature ranged between 34°C to 42°C while annual mean minimum temperature varies from 8°C to 20°C. The mean humidity percentage ranged between 78-95 percent. The area under cultivation is 43.04 ha out of which 27.84 ha area under lift farm and 15.20 ha under central farm (Fig. 1). GPS based forty seven surface soil samples (0-22.5 cm) were collected in cloth bags as per the standard procedure recommended by United States Department of Agricultural Sciences (USDA, 1954). Quartering technique was used for preparation of soil samples. The samples were dried in air and passed through 2 mm sieve. The soluble cations and anions were determined from the saturation extract (1: 5 soil water ratio) of soils (Richards, 1954). Chlorides (Mohr's method), carbonates and bicarbonates (double indicator method), sulphates (turbidity method), calcium and magnesium (versenate method), sodium and potassium in soil samples were determined by using flame photometer were determined by adopting the procedures given by Richards (1954). Sodium adsorption ratio (Ayers and Westcot, 1976) was calculated using following formula given by Richards (1954).

$$SAR = Na^{++} / \sqrt{Ca^{++} + Mg^{++} / 2}$$

where all the cations are expressed in me L⁻¹.

Data were input by Microsoft office Excel 2007 and salt combinations calculation done by using Statistical Package for Social Science (SPSS) software (Levesque, 2007).



Fig-1: Map and location of Agriculture Technical School, Manjri Farm, Pune.

Result and Discussion

Soluble cations : The concentration of soluble cations was in the following order $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$, in the soils from study area (Table-1). The concentration of calcium, magnesium, sodium and potassium were ranges from 0.75 to 1.40, 0.35 to 1.05, 0.07 to 0.23 and 0.02 to 0.16 me L⁻¹, respectively. Similar observation was also reported by Dubey and Sharma, (1990); Taweil and Ahmed, (1989).

Soluble anions : Among the anions (Table-1), sulphate was predominant anion followed by chloride and bicarbonate in the soils. The sulphate content ranged from 0.65 to 1.04 me L⁻¹. The chloride and bicarbonate content ranged between 0.21 to 0.81 me L⁻¹ and 0.12 to 0.45 me L⁻¹, respectively. The carbonate ions are almost in soil samples. This is due to precipitation of calcium and magnesium as carbonates. It is also observed that sulphate ion concentration increases markedly with increasing EC values of soils. Similar observation was also reported by Dubey and Sharma, (1990); Taweil and Ahmed (1989).

Salt combinations : Among the salt combinations (Table-2), $CaCl_2$ was predominant salt combination followed by $MgSO_4$, $CaHCO_3$, $MgCl_2$, $CaSO_4$, Na_2SO_4 and

Table-1 : Status of soluble cations and anions in soils of Manjri Farm, Pune.

Farm Name	Sample No.	Plot No.	Soluble cations and anions (me L ⁻¹)						
			Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
Central farm	1.	23	1.20	0.80	0.20	0.09	0.30	0.69	0.65
	2.	45-48	1.10	0.70	0.18	0.04	0.40	0.80	1.02
	3.	45-48	1.30	0.60	0.16	0.03	0.44	0.79	1.03
	4.	10-12	1.10	0.70	0.15	0.04	0.20	0.80	0.96
	5.	10-12	1.00	0.70	0.13	0.03	0.20	0.77	1.00
	6.	1-5	1.30	0.60	0.21	0.03	0.30	0.64	0.94
	7.	61-65	1.30	0.90	0.19	0.06	0.40	0.68	0.91
	8.	61-65	1.20	1.00	0.21	0.05	0.20	0.80	0.86
	9.	GTC (58)	1.10	1.00	0.23	0.04	0.20	0.68	1.01
	10.	82-86	0.75	0.70	0.16	0.09	0.30	0.70	0.77
	11.	95	1.40	0.70	0.15	0.09	0.40	0.80	1.01
	12.	24-27	1.40	0.90	0.15	0.03	0.44	0.78	0.90
	13.	49-52	1.20	0.60	0.13	0.05	0.45	0.80	0.94
	14.	59-60	0.80	0.90	0.17	0.04	0.40	0.80	0.82
	15.	66-69	1.00	0.70	0.13	0.03	0.30	0.21	0.97
	16.	66-69	1.30	0.60	0.12	0.02	0.30	0.80	0.90
	17.	6-9	0.80	0.35	0.11	0.05	0.30	0.80	0.86
	18.	6-9	0.90	0.70	0.13	0.03	0.30	0.40	0.87
	19.	40-44	1.10	0.60	0.12	0.04	0.20	0.80	0.77
	20.	70-73	1.00	0.90	0.09	0.06	0.20	0.70	1.00
Lift farm	21.	28/29	0.90	0.90	0.10	0.08	0.40	0.80	0.89
	22.	4/6 (1)	1.10	0.90	0.13	0.09	0.40	0.70	1.01
	23.	4/6 (2)	1.20	0.80	0.13	0.09	0.40	0.60	1.00
	24.	17/27	1.00	1.00	0.13	0.11	0.20	0.80	0.96
	25.	17/27	1.20	0.60	0.14	0.09	0.40	0.40	0.84
	26.	10	0.90	0.80	0.14	0.08	0.30	0.68	0.83
	27.	11-12	0.90	0.90	0.13	0.09	0.20	0.40	0.87
	28.	37	1.00	0.60	0.13	0.03	0.30	0.68	0.89
	29.	19/20/21	1.20	0.80	0.12	0.03	0.40	0.80	0.89
	30.	19/20/21	1.10	0.80	0.12	0.04	0.30	0.80	0.92
	31.	13-14	0.90	0.90	0.10	0.06	0.20	0.60	0.84
	32.	13-14	1.20	0.70	0.10	0.08	0.20	0.80	1.02
	33.	4/5	1.30	1.00	0.10	0.08	0.30	0.78	0.91
	34.	1/2 (3)	1.20	1.00	0.09	0.08	0.20	0.70	0.98
	35.	9	1.10	0.80	0.09	0.09	0.12	0.80	0.76
	36.	11-12	0.90	0.90	0.07	0.08	0.20	0.80	0.87
	37.	4/7	1.00	0.70	0.09	0.07	0.30	0.60	1.03
	38.	1/2 (1)	1.30	0.70	0.12	0.06	0.30	0.60	0.90
	39.	38	1.30	0.70	0.12	0.08	0.20	0.80	0.92
	40.	39	1.20	1.05	0.13	0.09	0.20	0.68	1.01
	41.	8/1	1.10	0.90	0.14	0.16	0.12	0.81	0.89
	42.	8/2	1.20	0.80	0.14	0.09	0.20	0.80	0.79
	43.	8/3-8/4	1.40	0.80	0.15	0.06	0.30	0.78	0.85
	44.	3	1.20	0.60	0.09	0.07	0.40	0.80	0.93
	45.	15	1.30	0.50	0.08	0.05	0.45	0.40	0.95
	46.	1/2 (2)	1.10	0.70	0.10	0.07	0.40	0.60	1.04
	47.	1/2 (4)	1.30	0.70	0.09	0.08	0.30	0.40	0.73
		Minimum	0.75	0.35	0.07	0.02	0.12	0.21	0.65
		Maximum	1.40	1.05	0.23	0.16	0.45	0.81	1.04
		Average	1.07	0.71	0.14	0.08	0.32	0.70	0.93
		S.D.	0.16	0.05	0.05	0.01	0.11	0.19	0.13

Table-2 : Status of salt combinations in soils of Manjri Farm, Pune.

Farm Name	Sample No.	Plot No.	Salt combinations (me L ⁻¹)							
			CaHCO ₃	CaCl ₂	MgCl ₂	MgSO ₄	Na ₂ SO ₄	K ₂ SO ₄	CaSO ₄	
Central farm	1.	23	0.20	0.80	Nil	0.70	0.04	Nil	Nil	
	2.	45-48	0.20	0.60	Nil	0.60	0.16	0.02	0.10	
	3.	45-48	0.40	0.70	0.11	0.40	0.15	0.02	Nil	
	4.	10-12	0.12	0.60	Nil	0.50	0.14	0.03	0.20	
	5.	10-12	0.14	0.60	Nil	0.60	0.11	0.02	0.10	
	6.	1-5	0.20	0.40	Nil	0.40	0.20	0.02	0.20	
	7.	61-65	0.30	0.60	Nil	0.70	0.10	0.02	Nil	
	8.	61-65	0.12	0.60	Nil	0.60	0.10	0.04	Nil	
	9.	GTC (58)	0.12	0.80	Nil	0.87	0.21	Nil	Nil	
	10.	82-86	0.20	0.50	0.36	0.30	0.15	0.08	Nil	
	11.	95	0.20	0.60	Nil	0.50	Nil	Nil	0.22	
	12.	24-27	0.40	0.40	Nil	0.70	Nil	Nil	Nil	
	13.	49-52	0.51	0.60	Nil	0.50	0.12	0.04	Nil	
	14.	59-60	0.30	0.40	0.20	0.24	0.09	0.03	Nil	
	15.	66-69	0.20	0.19	Nil	0.60	0.10	0.05	0.10	
	16.	66-69	0.09	0.80	Nil	0.40	0.11	0.02	0.20	
	17.	6-9	0.20	0.50	0.11	0.30	0.10	0.04	Nil	
	18.	6-9	0.12	0.20	Nil	0.50	0.07	0.03	0.20	
	19.	40-44	0.16	0.60	Nil	0.40	0.05	0.03	0.20	
	Lift farm	20.	70-73	0.14	0.80	Nil	0.70	0.08	0.05	Nil
21.		28/29	0.30	0.40	0.20	0.40	0.09	0.07	Nil	
22.		4/6 (1)	0.20	0.40	Nil	0.80	0.07	0.02	Nil	
23.		4/6 (2)	0.30	0.40	Nil	0.80	0.04	0.02	Nil	
24.		17/27	0.14	0.60	Nil	0.60	0.05	0.02	0.10	
25.		17/27	0.30	0.20	Nil	0.40	0.07	0.02	0.10	
26.		10	0.20	0.60	0.20	0.50	0.11	0.07	Nil	
27.		11-12	0.14	0.20	Nil	0.30	0.12	0.08	0.12	
28.		37	0.20	0.60	Nil	0.40	0.12	0.02	0.10	
29.		19/20/21	0.30	0.40	Nil	0.30	0.11	0.02	0.18	
30.		19/20/21	0.12	0.60	Nil	0.40	0.08	0.02	Nil	
31.		13-14	0.12	0.70	0.11	0.60	0.09	0.05	Nil	
32.		13-14	0.12	0.60	Nil	0.50	0.08	0.06	0.13	
33.		4/5	0.12	0.80	Nil	0.60	0.08	0.07	0.10	
34.		1/2 (3)	0.20	0.80	Nil	0.80	0.07	0.07	Nil	
35.		9	0.12	0.60	Nil	0.50	0.04	0.03	0.09	
36.		11-12	Nil	0.40	Nil	0.40	0.06	0.07	0.14	
37.		4/7	0.20	0.40	Nil	0.40	0.08	0.06	0.20	
38.		1/2 (1)	0.20	0.40	Nil	0.50	0.07	0.03	0.13	
39.		38	0.14	0.60	Nil	0.40	0.10	0.07	0.20	
40.		39	0.12	0.80	Nil	0.70	0.11	0.08	0.11	
41.		8/1	0.12	0.93	0.11	0.70	0.08	0.03	Nil	
42.		8/2	0.14	0.60	Nil	0.50	0.12	0.10	Nil	
43.		8/3-8/4	0.20	0.80	Nil	0.60	0.10	0.05	0.14	
44.		3	0.30	0.60	Nil	0.50	0.08	0.06	0.10	
45.		15	0.40	0.20	Nil	0.30	0.06	0.04	0.27	
46.		1/2 (2)	0.20	0.40	Nil	0.60	0.09	0.05	0.20	
47.		1/2 (4)	0.12	0.20	Nil	0.30	0.08	0.07	0.12	
		Minimum		0.12	0.19	0.11	0.24	0.04	0.02	0.09
		Maximum		0.51	0.93	0.36	0.87	0.21	0.10	0.27
	Average		0.21	0.54	0.18	0.53	0.11	0.05	0.19	
	S.D.		0.11	0.17	0.08	0.18	0.05	0.01	0.07	

Table-3 : Status of sodium adsorption ratio in soils of Manjri Farm, Pune.

Sodium adsorption ratio (SAR)	
Range	0.09-0.21
Average	1.15
S.D.	0.19

K₂SO₄ in the soils. The concentration of CaCl₂, MgSO₄, CaHCO₃, MgCl₂, CaSO₄, Na₂SO₄ and K₂SO₄, were 0.19 to 0.93, 0.24 to 0.87, 0.12 to 0.51, 0.11 to 0.36, 0.09 to 0.27, 0.04 to 0.21 and 0.02 to 0.10 me L⁻¹, respectively. The concentration of calcium chloride is higher due to precipitation of calcium and chloride in soil solution. Similar observation was also reported by Dubey and Sharma, (1990); Taweil and Ahmed (1989).

Sodium absorption ratio (SAR) : The sodium absorption ratio (SAR) is used to estimate exchangeable sodium percentage (ESP) of soil. The SAR is used in the soil studies because of its good correlation with ESP besides its easy estimation and calculation than ESP. However, it is also found that estimation of ESP from SAR values may be more accurate than ESP analysis (Donahue *et al.*, 1993). SAR indicates the equilibrium relation between soluble and exchangeable cations. The SAR values below 13 categorize into normal soils whereas above 13 are indicating salt affected soils. This is to say that SAR above 13 implies that exchangeable sodium has greatest effect on plant growth by dispersing the soil. The SAR of soil extracts from study area was calculated from the values of sodium, calcium and magnesium presented in Table 3. It is observed that SAR values ranges from 0.09 to 0.21 in the soil extracts. Further, all soil samples from Manjri Farm, Pune, have SAR values less than 13. Similar observation was also reported by Donahue *et al.* (1993).

Conclusions

Summarizing the results, it can be concluded that the soils of Agriculture Technical School, Manjri Farm, Pune, were contain following order of salt combinations, CaCl₂ > MgSO₄ > CaHCO₃ > MgCl₂ > CaSO₄ > Na₂SO₄ > K₂SO₄ and dominant soluble ions were SO₄²⁻ > Ca²⁺ > Mg²⁺ > Cl⁻ > HCO₃⁻ > Na⁺ > K⁺. On the basis of evaluation of salt combinations and sodium adsorption ratio (SAR) in soil, the soils were contained less amount of salts, suitable for all types of field and fruit crop.

References

- Alletto, L., Coquet, Y. and Roger-Estrade, J. (2010). Two-dimensional spatial variation of soil physical properties in two tillage systems. *Soil use and management* 26, 432-444.
- Ayers, R.S. and Westcot, D.W. (1976). Water quality for agriculture. *FAO Irrigation and Drainage Paper* 29, Rome.
- Chandra, R. and Singh, S.K. (2009). *Fundamentals and management of soil quality*. Westville Publishing House.
- Donahue, R.L., Miller, R.W. and Shickluna, J.C. (1983). *Soils. An introduction to soils and plant growth*. Prentice-Hall, Inc.
- Dubey, D.D. and Sharma, O.P. (1990). Salt affected soils in flood plain area of Gujarat. *Journal of the Indian Society of Soil Science* 38, 122-125.
- Green, T.R., Ahuja, L.R. and Benjamin, J.G. (2003). Advances and challenges in predicting agricultural management effects on soil hydraulic properties. *Geoderma* 116, 3-27.
- Jurinak, J.J. (1996). The chemistry of salt-affected soil and waters. *Agricultural Salinity Assessment and Management; ASCE Manuals and Reports on Engineering Practice* 71, 42-63.
- Läuchli, A. and Lüttge, U. (2002). *Salinity: Environment-plants-molecules* (pp. 229-248). The Netherlands: Kluwer Academic Publishers.
- Levesque, R. (2007). *SPSS Programming and Data Management: A Guide for SPSS and SAS Users*. 4th Edition, SPSS Inc., Chicago.
- Maas, E.V. (1990). Crop salt tolerance. In *Agricultural salinity assessment and management*, KK Tanji. *ASCE Manuals and Reports on Engineering practice* (71).
- Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol.* 59, 651-681.
- Priyanka, A.V., Guldekar, V.D. and Ghabane, V.V. (2018). Assessment of available soil nutrient status in black soils of Akola district, Maharashtra. *Journal of Pharmacognosy and Phytochemistry* 7, 1124-1129.
- Rengasamy, P. (2010). Soil processes affecting crop production in salt-affected soils. *Functional Plant Biology* 37, 613-620.
- Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils. *USDA Handbook No. 60* Washington pp. 69-82.
- Rodrigues, P.M.S., Schaefer, C.E.G.R., de Oliveira Silva, J., Ferreira Júnior, W.G., dos Santos, R.M. and Neri, A.V. (2018). The influence of soil on vegetation structure and plant diversity in different tropical savannic and forest habitats. *Journal of Plant Ecology* 11, 226-236.
- Sagçlam, M., Oztur, H.S., Ersahin, K.S. and Ozkan, A.I. (2011). Spatial variation of soil physical properties in adjacent alluvial and colluvial soils under Ustic moisture regime. *Hydrol. Earth Syst. Sci. Discuss.* 8, 4261-4280
- Sauer, T.J., Cambardella, C.A. and Meek, D.W., 2006. Spatial variation of soil properties relating to vegetation changes. *Plant and soil* 280, 1-5.
- Tale, K.S. and Ingole, S. (2015). A review on role of physico-chemical properties in soil quality. *Chemical Science Review and Letters* 4, 57-66.
- Taweil, B. and Ahmed, S.H.H. (1989) Status of boron and exchangeable magnesium in the salt-affected soils of the recent reclamation project, El-Zawia, at Northern Delta, Egypt. *Egyptian Journal of Soil Science (Egypt)*.
- U.S. Salinity Laboratory Staff. (1954). Diagnosis and improvement of saline and alkali soils. *Agriculture Handbook* 60, 83-100.



Delineation of Nitrogen Fractions of North Gujarat and its Relationship with Different Properties of Soil

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Abstract

A study was undertaken to delineate the status of available nutrients and chemical properties in soils of seven districts of North Gujarat. Total 305 representative surface soil samples collected from farmer's fields using multistage stratified random sampling. The soil available nitrogen and different forms of nitrogen was correlated. The ammonical nitrogen and organic carbon were highly correlated in Banaskantha district ($r = 0.350^{**}$ and $r = 0.724^{**}$, respectively). Organic carbon showed positive and significant relationship with available nitrogen in Mehsana district ($r = 0.298^*$). In Aravalli district, all nitrogen fractions were correlated with available nitrogen whereas ammonical nitrogen had positive and highly significant correlation ($r = 0.515^{**}$) whereas the rest fractions were significantly positively correlated viz; nitrate nitrogen ($r = 0.401^*$), total nitrogen ($r = 0.376^*$) and organic carbon ($r = 0.408^*$). In Sabarkantha district, ammonical nitrogen was significantly positively correlated with available nitrogen ($r = 0.397^*$) while, organic carbon showed highly positive significant correlation with available nitrogen ($r = 0.687^{**}$). In Kachchh district, nitrate nitrogen and total nitrogen were significantly correlated with available nitrogen ($r = 0.291^*$ and $r = 0.289^*$, respectively), while organic carbon was highly correlated with available nitrogen ($r = 0.864^{**}$). In Gandhinagar district, ammonium nitrogen and total nitrogen were correlated with available nitrogen ($r = 0.553^*$) and ($r = 0.557^*$), respectively. The soil available nitrogen were significantly positively correlated only with organic carbon in Patan districts ($r = 0.651^{**}$).

Key words : Correlation, nitrogen fractions, north gujarat, physico-chemical properties.

Introduction

In the soil, the nutrient elements are distributed in the different discrete chemical forms, which often exist in a state of dynamic equilibrium and constitute the pool from which plants draw it. Soil available form of nutrient is that fraction whose variation in amount is responsible for significant change in yield and response (Bray, 1948). The availability of these soil forms, however, involves not only their chemical and physical nature, but also the ability of plant to "Forage" them with its root system. Available nutrient constitutes only a small portion of the total nutrient present in soil.

Soil nitrogen is primarily in the organic fraction of the soil. The atmosphere above the soil contains 79 per cent N, but this nitrogen can only be used directly by leguminous plants, which have symbiotic nitrogen-fixing microorganisms such as *Rhizobium* in nodules on their roots. In the lithosphere, igneous rocks are the main source of soil nitrogen (Stevenson, 1986). Only a small proportion of total N is present in the available forms (NH_4^+ and NO_3^-) in the soil. The average Indian soils contain about 0.05 per cent nitrogen (NH_4^+ and NO_3^-). Nitrogen occurs in soil as inorganic and organic compounds. Nitrate and nitrites of calcium, potassium etc. are the main inorganic forms of nitrogen. The mineral N of

the soil exists as NH_4^+ , NO_3^- and sometimes NO_2^- either in soil solution, on exchange sites of soil particles or as NH_4^+ held by clay minerals. Some gaseous nitrogen may also be found in the soils, atmosphere and dissolved in soil solution.

In most of the soils, the bulk of nitrogen is in organic form and usually near the surface. The inorganic forms of nitrogen include nitrite which is usually a transitional stage between nitrate and ammonium and is easily removed. Nitrogen also occurs as exchangeable ions, fixed forms and traces of gaseous forms such as di-nitrogen, nitrogen monoxide and elemental nitrogen.

The total nitrogen in soils generally varies from 0.02 to 0.44 per cent. Due to tropical climate, the Indian soils are poor in total N, which varies from 0.04 to 0.12 per cent. Nitrogen in soil exists in two major forms: (i) organic and (ii) inorganic nitrogen. The inorganic forms of nitrogen (NH_4^+ , NO_3^- and NO_2^-) are very important from the crop nutrient point of view, because plant root takes-up nitrogen from the soil mostly as NO_3^- and to some extent as NH_4^+ -N. The NO_2^- form is unstable toxic and is usually present in soil in lesser extent.

Materials and Methods

Three hundred five soil samples were collected from

Table-1 : Standard analytical methods for Physical and chemical properties.

Sr. No.	Physical parameters	Methodology	Reference(s)
1.	Texture	International pipette method	Piper (1966).
Chemical Parameters Properties			
1.	pH 2.5	Potentiometry	Jackson (1973).
2.	EC 2.5	Conductometry	Jackson (1973).
3.	Organic carbon (g kg ⁻¹)	Wet oxidation	Walkley and Black (1934).
4.	CaCO ₃ (g kg ⁻¹)	Rapid titration method	Piper (1966).
5.	Available N (kg ha ⁻¹)	Alkaline permanganate method	Subbiah and Asija (1956).
6.	Available P ₂ O ₅ (kg ha ⁻¹)	Colorimetry	Olsen et al. (1954).
7.	Available K ₂ O (kg ha ⁻¹)	Flame Photometry Neutral normal ammonium acetate	Jackson (1973).
8.	Total nitrogen	Kjeldahl method	Jackson (1973)
9.	Ammonical nitrogen	Richardson's method	Richardson (1938)
10.	Nitrate nitrogen	Olsens extraction for ammonia	Olsen (1929)

farmer's fields of seven district of North Gujarat during 2016. One representative surface sample was collected from field upto a depth of 0 to 15 cm by zig-zag method. The soil samples were air dried in shade. The soil samples, after air drying were ground with wooden mortar and pestle and passed through 2.0 mm sieve. The prepared samples were stored in polyethylene lined cloth bags with proper labels. The soil samples were brought to laboratory for further analysis.

Sample correlation were worked out between nitrogen fractions and physico-chemical properties of the soil by standard statistical method (Panse and Sukhatme, 1967).

Results and Discussion

Soil Reaction (pH_{2.5}) : Soils under studies were slightly acidic to alkaline in reaction with pH varied from 6.30 to 9.15 with a mean value of 7.86 (Table-2). The lowest mean pH value of 7.48 was recorded in a soil samples collected from Sabarkantha district and the highest mean value of 8.23 was recorded in the soil samples collected from Patan district. Similar results were obtained for soils of Tonk district of Rajasthan (Meena *et al.*, 2006).

Electrical Conductivity (EC_{2.5}) : Overall, EC ranged from 0.05 to 2.50 dS m⁻¹ with an average value of 0.49 dS m⁻¹ (Table-2). The lowest and highest (0.05- 2.50 dS/m) EC value was recorded in the soil sample collected from Patan district. Meena *et al.* (2006) also reported almost similar range of EC in soils of Tonk district of Rajasthan, Savalia and Gundalia (2009) in soils of southern Saurashtra region of Gujarat.

Organic carbon : In general, soils of North Gujarat are low to very high in organic carbon status. The organic carbon content varied from 0.25 to 13.80 g kg⁻¹ with a mean value of 3.87 g kg⁻¹ (Table-3). Maximum range and mean value of organic carbon were observed in Aravalli district (2.10-6.50 g kg⁻¹ and 4.43 g kg⁻¹) and Mehsana

district (2.40-13.96 g kg⁻¹ and 4.39 g kg⁻¹). While, minimum range and mean value of organic carbon were observed in Banaskantha district (0.25-13.96 g kg⁻¹ and 3.09 g kg⁻¹). Saha *et al.* (2000) studied on organic carbon content (7.5 g kg⁻¹), in surface soil samples, all the pedons under tea gardens and forest area were rated high and among the 12 pedons six as medium (5.0-7.5 g kg⁻¹), three as high and three as low. Sahrawat (1982) found that organic carbon ranged from 0.64 to 12.8 per cent in Philippine rice soils.

Available Nitrogen : The overall range and a mean value of available nitrogen were 27.93-209.44 mg kg⁻¹ and 95.43 mg kg⁻¹, respectively in North Gujarat (Table-2). Maximum range and a mean value of available nitrogen were observed in Aravalli district (62.83-146.61 mg kg⁻¹ and 104.49 mg kg⁻¹) and minimum a mean value of available nitrogen was observed in Gandhinagar district (48.87-118.70 mg kg⁻¹ and 85.18 mg kg⁻¹). Saha *et al.* (2000) found that available nitrogen content in the surface soils ranged from 52 to 220 mg kg⁻¹. Singh *et al.* (1992) studied surface soil samples of Haryana state, where available nitrogen ranged between 38 to 272 ppm. Singh *et al.* (2017) studied the soil fertility status in different villages of Chandel district of Manipur.

Total Nitrogen : The overall range and a mean value of total nitrogen at North Gujarat were observed 0.0086-0.0767 per cent and 0.0317 per cent, respectively (Table-3). Maximum range and a mean value of total nitrogen were observed in Aravalli district (0.0181-0.0560 per cent and 0.0382 per cent). While, minimum a mean value of total nitrogen was observed in Banaskantha district (0.0086-0.0716 per cent and 0.0246 per cent). Saha *et al.* (2000) found that total nitrogen to be 0.087 per cent. Sahrawat (1982) also reported that total nitrogen content to be between 0.070 to 0.560 per cent in paddy growing soils of Philippine. Total nitrogen status ranged from 0.01 to 0.08 per cent predominant from of nitrogen

Table-2 : Range and mean of different soil physico-chemical properties of North Gujarat.

Districts	pH	EC (dS m ⁻¹)	°C (g kg ⁻¹)	CaCO ₃ (g kg ⁻¹)	Av.N (mg kg ⁻¹)	Av. P ₂ O ₅ (mg kg ⁻¹)	Av. K ₂ O (mg kg ⁻¹)	Sand (%)	Silt (%)	Clay (%)
Banaskantha	7.07-8.50	0.06-1.11	0.25-13.36	2.5-32.5	34.91-167.54	9.08-45.99	47.86-335.08	77.5-95.0	2.5-15.0	2.5-15.0
Mean	7.77	0.31	3.09	12.39	96.74	22.31	137.61	87.68	5.21	7.26
Mehsana	6.89-8.49	0.09-1.67	2.40-6.90	2.5-32.5	55.85-132.64	6.61-44.45	90.04-430.85	67.5-95.0	2.5-15.0	2.5-12.5
Mean	7.73	0.41	4.39	12.35	97.04	21.08	183.88	86.68	6.06	7.16
Aravalli	6.82-8.16	0.15-1.56	2.10-6.50	7.5-37.5	62.83-146.61	9.15-43.87	59.84-269.28	72.5-90.0	2.5-17.5	2.5-15.0
Mean	7.67	0.55	4.43	21.25	104.49	23.76	146.46	85.47	7.11	7.42
Sabarkantha	6.30-8.90	0.08-1.29	0.60-8.70	7.5-35.0	27.93-209.44	8.99-52.93	71.81-406.91	70.0-95.0	2.5-17.5	2.5-12.5
Mean	7.48	0.42	3.96	17.75	95.12	22.29	182.56	86.79	6.49	6.73
Kachchh	7.20-9.10	0.07-1.58	1.30-8.90	17.5-182.5	34.91-174.53	9.33-42.22	53.86-287.23	80.0-95.0	2.5-15.0	2.5-12.5
Mean	8.09	0.53	3.58	66.65	88.68	18.00	134.81	87.31	5.91	6.92
Gandhinagar	6.82-8.74	0.28-1.10	1.30-7.70	7.5-32.5	48.87-118.70	6.75-40.03	65.82-242.95	80.0-92.5	2.5-12.5	2.5-10.0
Mean	7.92	0.71	4.23	13.25	85.18	20.04	143.88	86.82	6.93	6.25
Patan	7.20-9.15	0.05-2.50	0.80-13.80	12.5-145.0	41.89-174.53	6.75-43.15	62.83-397.93	75.0-95.0	2.5-15.0	2.5-12.5
Mean	8.23	0.53	3.38	37.89	97.89	24.49	180.96	85.48	7.71	6.86
Overall	6.30-9.15	0.05-2.50	0.25-13.80	2.50-182.5	27.93-209.44	6.61-52.93	47.86-430.85	50.0-95.0	2.5-17.5	2.5-15.0
Mean	7.86	0.49	3.87	25.93	95.32	21.71	158.89	86.27	6.67	7.14

was NH₃-N, which constitution 1.34 per cent of total nitrogen followed by nitrate described by Vekaria *et al.*(2015).

Ammonical nitrogen (NH₄-N) : The NH₄-N value of soil for the entire North Gujarat range from and a mean value were observed 2.80-35.00mg kg⁻¹ and 12.75 mg kg⁻¹, respectively (Table-3). Maximum a mean value of ammonical nitrogen was observed in Gandhinagar district (15.40mg kg⁻¹) and minimum mean of ammonical nitrogen was observed in Mehsana district (10.75 mg kg⁻¹). Singh and Dixit (1972) found that NH₄ -N varied from 7 to 22.5 ppm in typical saline-alkali soils of Punjab and Haryana, while Aulakh and Dev (1976) found the range of NH₄ -N between 0 to 16.8 ppm.

Nitrate Nitrogen (NO₃-N) : The overall range and mean value of nitrate nitrogen at North Gujarat (Table 3) was observed 1.40-33.60 mg kg⁻¹ and 18.28 mg kg⁻¹, respectively. Maximum a mean value of NO₃-N was observed in Mehsana district (20.27 mg kg⁻¹) and minimum a mean value of NO₃-N was observed in Gandhinagar district (15.47 mg kg⁻¹). Aulakh and Dev (1976) reported that NO₃-N varied from 0.5 to 30 ppm in different soil series of Punjab state.

Correlation coefficient ('r') between available nitrogen and different forms of nitrogen in soils of North Gujarat :

The soil available N and different forms of nitrogen were correlated (Table-4), the ammonical nitrogen and organic carbon were highly correlated in Banaskantha district ('r' = 0.350** and 'r' = 0.724**, respectively), however, nitrate nitrogen and total nitrogen were not correlated in Banaskantha district. Organic carbon showed positive and significant positive relationship with available nitrogen in Patan district ('r' = 0.651**) and Mehsana district ('r' = 0.298*), while remaining fractions were not correlated with available N in both districts. In Aravalli district all nitrogen fractions were correlated with available nitrogen where as ammonium nitrogen had positive and highly significant positive correlation ('r' = 0.515**) whereas, the rest fraction were significantly positively correlated viz., nitrate nitrogen ('r' = 0.401*), total nitrogen ('r' = 0.376*) and organic carbon ('r' = 0.408*). In Sabarkantha district, ammonical nitrogen was significantly positively correlated with available nitrogen ('r' = 0.397*) while, organic carbon showed positive and highly significant correlation with available nitrogen ('r' = 0.687**). In Kachchh, nitrate nitrogen and total nitrogen were significantly correlated with available nitrogen ('r' = 0.291* and 'r' = 0.289*, respectively) while organic carbon was highly correlated with available nitrogen ('r' = 0.864**). In Gandhinagar, district ammonium nitrogen and total nitrogen were correlated

Table-3 : Range and mean of different forms of nitrogen in soils of North Gujarat.

Districts	Total nitrogen (%)	Ammonical nitrogen (mg kg ⁻¹)	Nitrate nitrogen (mg kg ⁻¹)	Organic carbon (g kg ⁻¹)
Banaskantha	0.0086-0.0716 (0.0246)	2.80-29.40 (11.14)	1.40-33.60 (19.46)	0.25-13.36 (3.09)
Mehsana	0.0207-0.0595 (0.0379)	2.80-22.40 (10.75)	5.60-33.60 (20.27)	2.40-6.90 (4.39)
Aravalli	0.0181-0.0560 (0.0382)	8.40-21.00 (14.61)	9.80-32.20 (17.78)	2.10-6.50 (4.43)
Sabarkantha	0.0089-0.0750 (0.0339)	5.60-25.20 (14.91)	7.00-33.60 (18.97)	0.60-8.70 (3.96)
Kachchh	0.0112-0.0767 (0.0309)	4.20-30.80 (14.20)	5.60-30.80 (15.51)	1.30-8.90 (3.58)
Gandhinagar	0.0112-0.0664 (0.0364)	5.60-26.60 (15.40)	7.00-29.40 (15.47)	1.30-7.70 (4.23)
Patan	0.0097-0.0690 (0.0270)	2.80-35.00 (11.54)	4.20-33.60 (18.26)	0.80-13.80 (3.38)
Overall	0.0086-0.0767 (0.0317)	2.80-35.00 (12.75)	1.40-33.60 (18.28)	0.25-13.80 (3.70)

Figures in parenthesis indicates mean value.

Table-4 : Correlation coefficient ('r') between available nitrogen and different forms of nitrogen in soils of North Gujarat.

District	Ammonical nitrogen	Nitrate nitrogen	Total nitrogen	Organic carbon
Banaskantha	0.350**	0.159	0.164	0.724**
Mehsana	0.117	-0.085	-0.056	0.298*
Aravalli	0.515**	0.401*	0.376*	0.408*
Sabarkantha	0.397*	-0.245	0.260	0.687**
Kachchh	-0.230	0.291*	0.289*	0.864**
Gandhinagar	0.553*	0.102	0.557*	-0.040
Patan	0.024	0.020	0.047	0.651**

*Significant at 5 per cent level of significance **Significant at 1 per cent level of significance.

with available nitrogen ('r' = 0.553*) and ('r' = 0.557*), respectively.

The highly significant correlation exhibited between the organic carbon content and the total nitrogen content in soil (Minhas and Bora, 1982; Narain *et al.*, 1989 and Vekaria *et al.*, 2015). The significant positive correlation between organic carbon and available nitrogen could be because of release of mineralizable nitrogen from soil organic matter in proportionate amounts (Vanilarasu and Balakrishnamurthy, 2014) and adsorption of NH₄-N by humus complex in soil.

Correlation coefficient ('r') among different forms of nitrogen and physico-chemical properties of soils of North Gujarat : Different forms of nitrogen and physico-chemical properties of soil of North Gujarat were correlated (Table-5). In Banaskantha district, the ammonical nitrogen was correlated with available nitrogen and organic carbon ('r' = 0.350** and 'r' = 0.285**, respectively). The organic carbon was correlated with available nitrogen, available phosphorus and pH ('r' = 0.725**, 'r' = 0.246* and 'r' = -0.344**, respectively).

In soil of Mehsana district, ammonical nitrogen was highly correlated with sand and silt ('r' = 0.383** and 'r' = -0.441**, respectively). The nitrate nitrogen was

correlated with available phosphorus and available potassium ('r' = 0.356* and 'r' = -0.285*, respectively). The total nitrogen was negatively correlated with available phosphorus, organic carbon and calcium carbonate ('r' = -0.292*, 'r' = 0.338*, 'r' = -0.398**, respectively). Organic carbon was positively correlated with available nitrogen ('r' = 0.297*).

In Aravalli district, ammonical nitrogen was highly correlated with available nitrogen and silt ('r' = 0.515** and 'r' = 0.397**, respectively). The nitrate nitrogen was highly correlated with available nitrogen, electric conductivity and organic carbon ('r' = 0.401**, 'r' = 0.376** and 'r' = 0.404**, respectively). Total nitrogen was highly correlated with available nitrogen ('r' = 0.377**). Organic carbon showed positive correlation with available nitrogen ('r' = 0.408**).

In Sabarkantha district, ammonical nitrogen and organic carbon showed positively correlation with available nitrogen ('r' = 0.397* and 'r' = 0.687**, respectively). Total nitrogen was positively correlated with available phosphorus, available potassium and organic carbon ('r' = 0.360*, 'r' = 0.364* and 'r' = 0.352* and 0.401*, respectively).

Kachchh district, nitrate nitrogen, organic carbon

Table-5 : Correlation coefficient ('r') among different forms of nitrogen and physico-chemical properties of soils of North Gujarat.

Sr. No.	District	Different forms of nitrogen v/s soil physico-chemical properties	
1.	Banaskantha	Ammo.-N v/s Available nitrogen	0.350**
		Ammo.-N v/s Organic carbon	0.285*
		Organic carbon v/s Available nitrogen	0.725**
		Organic carbon v/s Available phosphorus	0.246*
		Organic carbon v/s pH	-0.344**
2.	Mehsana	Ammo.-N v/s Sand	0.383**
		Ammo. -N v/s Silt	-0.441**
		Nitrate-N v/s Available phosphorus	-0.356*
		Nitrate-N v/s Available potassium	-0.285*
		Total-N v/s Available phosphorus	-0.292*
		Total-N v/s Organic carbon	0.338*
		Total-N v/s Calcium carbonate	-0.398**
		Organic carbon v/s Available nitrogen	0.297*
		Ammo. -N v/s Available nitrogen	0.515**
3.	Aravalli	Ammo.-N v/s Silt	0.397**
		Nitrate-N v/s Available nitrogen	0.401**
		Nitrate-N v/s EC	0.376**
		Nitrate-N v/s Organic carbon	0.404**
		Total-N v/s Available nitrogen	0.377**
		Organic carbon v/s Available nitrogen	0.408**
		Ammo. -N v/s Available nitrogen	0.397*
4.	Sabarkantha	Total-N v/s Available phosphorus	0.360*
		Total-N v/s Available potassium	0.364*
		Total-N v/s Organic carbon	0.401*
		Organic carbon v/s Available nitrogen	0.687**
		Nitrate-N v/s Available nitrogen	0.291*
5.	Kachchh	Total-N v/s Available nitrogen	0.289*
		Organic carbon v/s Available nitrogen	0.864**
		Ammonical-N v/s Available nitrogen	0.553*
6.	Gandhinagar	Total-N v/s Available nitrogen	0.557*
		Organic carbon v/s Silt	-0.446*
		Nitrate-N v/s pH	-0.378*
7.	Patan	Organic carbon v/s Available nitrogen	0.651**
		Organic carbon v/s Available phosphorus	-0.328*
		Organic carbon v/s pH	-0.312*

*Significant at 5 per cent level of significance, **Significant at 1 per cent level of significance.

and total nitrogen were correlated with available nitrogen ('r' = 0.291*, 'r' = 0.289* and 'r' = 0.864**, respectively).

In Gandhinagar district, ammonical nitrogen was correlated with available nitrogen ('r' = 0.553*). Total nitrogen was positively correlated with available nitrogen ('r' = 0.557*). Organic carbon showed negative correlation with silt ('r' = - 0.446*).

In Patan district, nitrate nitrogen and organic carbon were negatively correlated with pH ('r' = -0.378* and 'r' = -0.312*, respectively), while organic carbon was significantly correlated with available nitrogen and available phosphorus ('r' = 0.651** and 'r' = -0.328*, respectively).

Similar results were obtained for soils Saurashtra region of Gujarat (Misal, 2015).

References

1. Aulakh, M.S. and Dev, G. (1976). Profile distribution of total and mineral forms of nitrogen in soils of the multiple-cropping project area, Sangrini, (Punjab). *Journal of Research*, 13 : 332-336.
2. Bray, R.H. (1948). In : Diagnostic Techniques for Soil and Crops (Kitchen, H.B. Ed). American Potash Institute, Washington-6, D.C. pp. 53-66.
3. Dhamak, A.L.; Meshram, N.A. and Waikar, S.L. (2014). *Journal of Agricultural and Veterinary Sciences*, 7 (12): 81-85.
4. Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice-Hall of India Private Limited, New Delhi.
5. Mahajan, V.P. and Kanwar, J.S. (1974). Distribution of forms of nitrogen in saline alkali soils of Punjab and Haryana. *Journal of the Indian Society of Soil Science*, 22: 47-51.

6. 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(4): 508-512.
7. Minhas, R.S. and Bora, N. C. (1982). Distribution of organic carbon and the forms of nitrogen in a topographic sequence of soils. *Journal of the Indian Society of Soil Science*, 30 : 135-139.
8. Misal, N.B. (2015). Dynamics of nitrogen, phosphorus, potassium and sulphur fractions in the calcareous soils of Saurashtra region of Gujarat. Ph.D. Thesis, submitted to Gujarat Agricultural University, Junagadh Campus, Junagadh.
9. Narain, P.; Singh, R. and Singh, R. (1989). Distribution of nitrogen fractions under different land uses. *Annals of Agricultural Research*, 10 : 351-360.
10. Olsen, C. (1929). Nitrate nitrogen was determined after extraction for ammonia *Comptes Rendus des Travaux du Laboratoire Carlsberg*, 17 : 1-20.
11. Olsen, S.R.; Cole, C.V.; Watanable, J.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA circular No. 939.
12. Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for agricultural workers, ICAR, New Delhi.
13. Piper, C.S. (1966). Soil and Plant Analysis. Inter Science Publishers Inc., New York. pp. 47-48.
14. Richardson, H.L. (1938). The determination of ammonical nitrogen. *Journal of Agricultural Science*, 28 : 73-121.
15. Saha, A.K.; Saha, N. and Pal, S.K. (2000). Distribution of organic carbon and nitrogen in some Tarai soils of West Bengal. *Agropedology*, 10 : 132-138.
16. Sahrawat, K.L. (1982). Mineralization of soil organic nitrogen under water logged conditions in relation to pH, organic carbon and total nitrogen content of soils. *Oryza*, 19: 43-46.
17. Sahrawat, K.L. (1983). The relationships between ammonification of organic nitrogen and soil properties. *Oryza*, 20: 13-16.
18. Savalia, S.G. and Gundalia, J.D. (2009): Soil-site suitability evaluation for soybean in southern Saurashtra region of Gujarat. *Legume Res.*, 31(1): 1-7.
19. Singh, K.S.; Athokpam, H. and Singh, S.A. (2017). Soil macro and micro-nutrient status of Chandel district, Manipur, India. *International Journal of Agriculture Sciences*, 9(15): 4107-4109.
20. Singh, J.P.; Dahiya, D.J.; Kumar, V. and Singh, M (1992). Distribution and status of Different Forms of Nitrogen in Soils of Haryana. *Journal of the Indian Society of Soil Science*, 40 : 698-704.
21. Singh, S.B. and Dixit, V.K. (1972). Native fixed ammonium in a few soils of Uttar Pradesh. *Journal of the Indian Society of Soil Science*, 20 : 189-191.
22. Subbaih, B.V. and Asija, G.L. (1956). Available rapid procedure for the estimation of available nitrogen in soils. *Current Science*, 25: 259-260.
23. Stevenson, F.W. (1986). Cycles of soil C, N, P, S and micronutrients. John Wiley, New York. p. 380.
24. Vanilarasu, K. and Balakrishnamurthy, G. (2014). Influences of organic manures and amendments in soil physiochemical properties and their impact on growth, yield and nutrient uptake of banana. *The Bioscan*, 9 (2): 525-529.
25. Vekaria, L.C.; Parmar, K.B.; Ponkia, H.P. and Polara, K.B. (2015). Forms of nitrogen in the soils of Saurashtra. *Trends of Bio-sciences*, 8 (18) : 5007-5010.



Genetic Variability, Heritability and Genetic Advance in Pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract

Study was carried out for genetic variability, heritability and genetic advance for nine characters in forty eight genotypes of pigeonpea. The experiment was laid in RBD with three replication at Pulses Research Station, JAU, Junagadh. The analysis of variance revealed that mean squares due to genotypes were highly significant for all the nine characters indicating the presence of sufficient amount of variability in the experimental material used. The estimates of genotypic and phenotypic coefficient of variation indicated that the values of phenotypic coefficient of variation (PCV) were slightly higher than that of genotypic coefficient of variation (GCV) for all the traits studied, indicated a very little influence of environmental variation for their expression. The highest GCV was observed for number of pods per plant, while highest PCV was observed for number of pods per plant and seed yield per plant. High heritability (broad sense) estimates were observed for number of pods per plant followed by seed yield per plant, 100-seeds weight, plant height, number of seeds per pod, days to 50 % flowering, days to maturity and number of primary branches per plant. High estimates of genetic advance as per cent of mean were found for number of pods per plant followed by seed yield per plant and 100 seed weight. High heritability coupled with high genetic advance expressed as per cent of mean were observed for number of pods per plant, seed yield per plant and 100-seeds weight suggesting the role of additive gene action in inheritance of these character and selection will be effective.

Key words : Pigeonpea, genetic variability, heritability and genetic advance

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] belongs to the Genus *Cajanus*, Species *cajan*, Tribe *Phaseoleae*, Subtribe *Cajaninae*, order *Fabales*, family *Fabaceae* and Sub-family *Faboideae*, is an often cross pollinated (20-70%) crop with diploid species having chromosome ($2n=2x=22$). The term 'Pigeonpea' was coined in Barbados, where its seeds were considered an important pigeon-feed. Pigeonpea is the fourth most important pulse crop in the world where in India alone accounts for 85 percent of the world supply. In India, it is cultivated on 4.54 million hectares area with an annual production of 3.31 million tonnes with productivity around 729 kg per ha. In Gujarat, it is cultivated on 0.215 million hectares area with an annual production of 0.285 million tonnes with productivity around 1324 kg per ha (Anon., 2020). Pigeonpea is a short-lived perennial shrub, which plays a major role in improving soil nutrition by nourishing soil with atmospheric nitrogen fixation through biological nitrogen fixation up to 40 kg per ha (Rao *et al*, 1983), which is useful in maintaining soil health through increasing nitrogen availability and microbial activities. The stems are used as domestic fuel wood and for making huts; leaves are used as fodder, dry seeds as snacks after boiling in water, green seeds as a vegetable, while seeds are as primary source of protein for the poor vegetarian populations. Pigeonpea grain is an important source of protein (21%), carbohydrates (67%) and lipids (2.3%). It is

a good source of water-soluble vitamins (thiamine, riboflavin, niacin) and minerals (Ca, Mg, Cu, Fe and Zn) (Talari *et al*. 2018)^[18]. At the end of this year 2020 Pandemic of COVID- 19 falls all over the world and this pandemic is growing very fast in India. For cope up of hunger during such pandemic conditions and to increase pulses production, one has to exploit maximum yield potential of crops. To overcome such situation, genetically stable genotypes having high yield potential are required straightaway. It is therefore, necessary to estimate relative amounts of genetic and non-genetic variability exhibited by different characters using suitable selection parameters like genetic coefficient of variability (GCV), heritability estimates (H) and genetic advance (GA).

Materials and Methods

The study was conducted during *kharif* 2020 at the Pulses Research Station, Junagadh Agricultural University, Junagadh. Forty-Eight genotypes of pigeonpea were sown in a Randomized Block Design (RBD) with three replications during *kharif* 2020 at Pulses Research Station, Junagadh Agricultural University, Junagadh. Each genotype was accommodated in a single row of 4 m length with a spacing of 90 cm × 20 cm. The observations were recorded for nine characters *viz.*, days to 50 % flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, length of pod (cm), 100-seeds weight (g) and seed yield per plant (g). The mean values

for each character over three replications were subjected to statistical analysis: Analysis for randomized block design (RBD) was carried out as per Panse and Sukhatme (1985). Phenotypic co-efficient of variation and genotypic co-efficient of variation were calculated as per the formula suggested by Burton (1952). Heritability and genetic advance were estimated using the formula suggested by Allard (1960). All the statistical analysis was carried with help of INDOSTAT Statistical software.

Results and Discussion

Analysis of variance revealed that mean square due to all the traits exhibited highly significant difference among genotypes which indicated adequate genetic variability among the genotype which provide ample scope for identifying genotypes with desirable character to improve yield, provided the material be subjected to sensible pressure. It reveals that the selection of superior cultivars for development of new varieties may be helpful. (Table-1).

Genetic variability is basic tool for crop improvement due to its wider scope for selection. Therefore, the effectiveness of selection depends upon the nature and magnitude of genetic variability present in the experiment material and the extent of its heritability. The only phenotypic variation is not the precise criterion to estimate the amount of genetic variability present in breeding population and is not comparable among various traits. The other parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance as expressed as percentage of mean are important to study the extent genetic variability parameter more precisely. The magnitude of PCV was slightly greater than GCV revealed a very little influence of environmental variation for their expression. This indicated that phenotypic variability may be considered as reliable measure of genotypic variability. The range of GCV observed was 3.19% to 30.40% whereas, it was 3.73 to 31.00% for phenotypic coefficient of variation indicating extent of GCV and PCV in the material studied. These findings are in agreement with earlier findings of Sharma *et al.* (2021 b)

The high genotypic coefficient of variation and phenotypic coefficient of variation was observed for number of pods per plant followed by seed yield per plant. High value of genotypic and phenotypic coefficient of variation for number of pods per plant and seed yield per plant was also reported by Sharma *et al.* (2021a) Moderate value for phenotypic coefficient of variation (PCV) was observed for 100-seeds weight and number of primary branches per plant. Low value for phenotypic and genotypic coefficient of variation was observed for number of seeds per pod, length of pod (cm), plant

height(cm), days to 50 % flowering and days to maturity. In addition to this, the characters number of primary branches also exhibited low value for genotypic coefficient of variation only. This findings are in accordance with Baldaniya *et al.* (2018).

High heritability in broad sense estimates (Table 2) were observed for number of pods per plant followed by seed yield per plant, 100-seeds weight, plant height, number of seeds per pod, days to 50 % flowering, days to maturity, number of primary branches per plant , days to maturity and days to 50 % flowering. Moderate heritability in broad sense estimates was observed for length of pod, similar results were observed by Sarkar *et al.* (2020). Moderate heritability indicated that this trait is more affected by environment and under the control of non-additive gene action.

The genetic advance expressed as per cent of mean was highest for number of pods per plant (61.43 %) followed by seed yield per plant (37.66 %) and 100-seeds weight (21.32 %). Similar finding also reported by Rathore *et al.* (2020). The highest values of genetic advance expressed as per cent of mean have been reported in pigeonpea for number of pods per plant by Sarkar *et al.* (2020). The moderate estimate of genetic advance as per cent of mean was observed for the number of primary branches per plant, number of seeds per pod and plant height. Result are in conformity of Sarkar *et al.* (2020) for number of seeds per pod, Sharma (2020) for ^[15] number of seeds per pod, Sharma *et al.* (2014) for number of seeds per pod and primary branches per plant. The lower genetic advance as per cent of mean was observed for the length of pod, days to 50% flowering and days to maturity. The similar finding was also obtained by Gendley *et al.* (2015).

Heritability estimates reported here was based on broad sense only and hence the total genetic variance may include dominance and epistatic components which are not available for selection. Heritability being a single numerical expression on the ratio of two variances, may not lead to success if selection is based on heritability estimates alone. Shift in gene frequency under selection pressure towards desirable side is also termed as genetic advance. Therefore, high heritability coupled with high genetic advance expressed as per cent of mean is more valuable in predicting the effect of selection.

The estimates of high heritability coupled with high genetic advance expressed as per cent of mean was observed for number of pods per plant, seed yield per plant and 100-seeds weight. These characters may have contributed to preponderance of additive gene action and selection pressure could profitably be applied on these characters for their rationale improvement. Similar result

Table-1 : Analysis of variance for nine characters in 48 genotypes of pigeonpea.

Source of variation	d.f	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches per plant	Number of pods per plant	Number of seeds per pod	Length of pod (cm)	100-seeds weight (g)	Seed yield per plant (g)
Replication	2	8.52	63.19	81.52	3.58	282.67	0.12	0.48	2.41	51.13
Genotype	47	72.07**	130.11**	314.25**	5.40**	3263.39**	0.31**	0.38**	5.45**	262.54**
Error	94	19.91	36.95	66.77	1.61	124.34	0.07	0.16	0.81	35.52

*, ** Significant at 5 and 1% levels, respectively.

Table-2 : Phenotypic range, mean, range coefficient (%), phenotypic coefficient of variation (%), genotypic coefficient of variation (%), heritability, genetic advance and genetic advance as per cent of mean for nine characters of pigeonpea.

Characters	Phenotypic range	Mean	Range coefficient (%)	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability in broad sense (%)	Genetic advance	Genetic Advance expresses as % of mean
Days to 50% flowering	117.33-137.33	127.13	7.85	3.28	3.86	72.36	7.31	5.75
Days to maturity	166-186.67	174.78	5.86	3.19	3.77	71.60	9.71	5.56
Plant height (cm)	100.67-161.67	129.69	23.25	7.00	7.89	78.75	16.60	12.80
Number of primary branches per plant	9-14.40	11.87	23.08	9.47	11.30	70.21	1.94	16.34
Number of pods per plant	43.73-208.60	106.39	65.34	30.41	31.00	96.19	65.35	61.43
Number of seeds per pod	3.17-4.70	3.67	19.49	7.66	8.73	76.98	0.51	13.85
Length of pod (cm)	3.83-5.67	4.50	15.75	6.05	7.91	58.44	0.43	9.53
100-seeds weight (g)	8.23-14.50	11.08	27.57	11.22	12.15	85.13	2.36	21.32
Seed yield per plant (g)	25.67-70.33	44.24	46.53	19.66	21.14	86.47	16.66	37.66

are reported by Rathore *et al.* (2020). The high heritability coupled with moderate genetic advance expressed as per cent of mean was observed for number of primary branches, number of seeds per pod and plant height. These results are in agreement of Sharma *et al.* (2014) for number of seeds per pod and primary branches per plant. The high heritability coupled with low genetic advance as per cent of mean was found for days to 50 % flowering and days to maturity. Moderate estimates of heritability coupled with low genetic advance as per cent of mean was expressed by length of pod. Similar result reported by Gendley *et al.* (2015) for length of pod.

References

- Allard, R.W. (1960). *Principles of Plant Breeding*. John Wiley and Sons, New York.
- Anonymous (2020). Annual Report 2019-20; AICRP on Pigeonpea, IIPR, Kanpur.
- Baldaniya, J.D.; Kale, B.H.; Mungra, K.S.; Patel, H.N.; Lad, M.D. and Chauhan, D.A. (2018). Genetic variability, correlation and path analysis for morphological and quality traits in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Int. J. Curr. Microbiol. App. Sci.*, 11(5): 3297-3308.
- Burton, G.W. (1952). Quantitative inheritance in grasses. *Proc. 6th Int. Grassland Cong.*, held at Pennsylvania State College, 1: 277-283.
- Gendley, T.K.; Sharma, R.N.; Thakur, D.; Paikra, S. and Yadav, S. (2015). Genetic variability for yield traits in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Progressive Res., Int. J.* 10(2): 190-192.
- Panse, V. G. and Sukhatme, P. V. (1985). *Statistical Methods for Agricultural Workers*. (3rd Revised eds.), I.C.A.R., New Delhi.
- Rao, J.V.D.K.; Dart, P.J. and Sastry P.V.S.S. (1983). Residual effect of pigeonpea (*Cajanus cajan* (L.) Millsp.) on yield and nitrogen of maize. *Experimental Agriculture*, 19(2): 131-141.
- Rathore, T.; Srivastava, A.K.; Kushwaha, C. and Kumar, B. (2020). Genetic variability and character association for yield and its contributing characters in pigeonpea [*Cajanus cajan* (L.) Millsp.] in central plain agroclimatic region of uttarpradesh (India). *Int. J. Curr. Microbiol. App. Sci.*, 11(5): 3297-3308.
- Sarkar, S.; Mishra, S.P.; Tripathi, D.; Patidar, B.; Soni, M. and Mishra, S. (2020). Studies on genetic variability, heritability and genetic advance in pigeonpea (*Cajanus cajan* (L.) millsp.). *Int. J. Curr. Microbiol. App. Sci.*, 9(10): 2570-2578.
- Sharma, P.; Singh, I.; Khosla, G. and Singh, G. (2021a). Variability and association studies for yield and yield related traits in pigeonpea [*Cajanus cajan*(L.) Millsp.]. *Legume Research-An Int. J.* DOI: 10.18805/ LR-4374, 1-6.
- Sharma, R.; Gangwar, R.K. and Yadav, V. (2014). A Study on genetic variability and correlation in pigeonpea [*Cajanus cajan*(L) Millsp.]. *Int. J. Sci. and Res.*, 3(9): 826-828.
- Sharma, S.C.; Kumar, R. and Aarif, M. (2020). Association studies in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *J. of Pharmacognosy and Phytochem.*, 9(3): 1176-1178.
- Sharma, S.C.; Kumar, R.; Gautam, C. and Aarif, M. (2021b). Studies on direct selection parameters for seed yield and its component traits in pigeonpea [*Cajanus cajan* (L.) Millsp.]. *Int. J. Curr. Microbiol. App. Sci.*, 10(03): 1943-1947.



Effect of Malting Process on Nutritional and Physical Characteristics of Quinoa

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Abstract

Quinoa provides a nutritional, economical, easy-to-prepare, flavorful food source. Moreover, quinoa is a suitable source of protein for vegetarians and vegans and, because it is gluten-free, so it is also an alternative cereal for people suffering from celiac disease and gluten-allergy problems. Thus, the use of quinoa is not only important in developing countries but also in affluent countries where there is a need to introduce new and more nutritious food products that could substitute refined carbohydrate rich grains such as white rice and wheat. To increase its popularity among all masses, certain processing techniques such as malting can be easily adopted at household and even at cottage level. An investigation was undertaken to study the nutritional composition of raw and malted quinoa. The raw quinoa contains bitterness which was reduced by primary processing such as soaking and washing in tape water. The results showed that acceptable processed product could be produced from quinoa by optimization of malting method. Based on the optimization of processing methods, the malted quinoa which was soaked for 24 hrs with 144 hrs germination was found to be most acceptable product. Malted quinoa which was soaked for 24 hrs and germinated for 144 hrs at $27\pm 2^{\circ}\text{C}$ gives best results in terms of malting yield. All malted products from quinoa were nutritionally superior in terms of *in-vitro* protein and starch digestibility. The results stated the maximum (83.70 %) *In-vitro* protein digestibility was reported in malted quinoa which was soaked for 36 hrs with 144 hrs germination period. All the processed products showed improvement in bulk density which was useful for further formulation and product development. The carbohydrate content of all the malted quinoa were higher as compared to the raw quinoa seeds. Hence, the present study was planned to investigate the nutritional value and sensorial acceptability of malted quinoa for nutritional security.

Key words : Quinoa, celiac disease, malting, *in-vitro* protein and starch digestibility.

Introduction

Quinoa is known as a complete food (James, 2009). Quinoa (*Chenopodium quinoa* willd) is a gluten-free pseudo-cereal that contains a high amount of fibre, high biological-value proteins, essential fatty acids (-3 and -6), vitamins, and minerals (Stikic *et al.*, 2012 and James, 2009). Quinoa considered as a food of low social status and remained only as a staple food of Andean population for several years restricting its usage among European community (Galvez *et al.*, 2010). So, it has the potential in India to become a staple food as cereals for balanced diet. Due to its rich protein content and incredible balance of essential amino acids, it has been consumed by people as a holy plant (Jancurova, 2009 and Maradini Filho *et al.*, 2015). The seed composition was reviewed by Wu *et al.* (2014). In sum, the high nutritional value of quinoa arises from its high protein content, complete and balanced essential amino acids, high proportion of unsaturated fatty acids, high concentrations of vitamin B complex, vitamin E, and minerals, and high phenolic and betalain content. Due to absence of gluten, it is tolerable and acceptable to celiac patients. It has been selected by FAO as one of the crops destined to offer food security in this century (FAO, 1998). Due to the high nutritional value, good agro-ecological adaptability and low water requirements, quinoa has lately received a lot of attention, and several

projects on a sustainable production are ongoing, to improve nutrition and to increase food security and farmer income (Giuliani *et al.*, 2012).

Malting involves the limited germination of grains, under controlled conditions. Germination is mainly a catabolic process that supplies important nutrients to the growing plant through hydrolysis of reserved nutrients (Hough *et al.*, 1982). Sharma *et al.* (2015) reported that quinoa (*Chenopodium quinoa* willd), which is considered a pseudo-cereal or pseudo-grain; it is highly nutritious due to its outstanding protein quality and wide range of minerals and vitamins. It has been recognized as a complete food due to its protein quality. Germination can be used to improve the palatability of grains (Kaukovirta-Norja *et al.*, 2004). In addition, the enzyme activities that arise during germination of seeds can have desired functionalities cereal and pseudo-cereal based foods. During malting the grains are soaked, germinated and subjected to a heat treatment to end the metabolic processes and to develop aroma and flavour. Bitterness is present in higher concentrations in the outer layer of the grain. It is necessary to wash out these undesired compounds before quinoa consumption. Since bitterness interfere with quinoa's palatability and digestibility, they must be remove before consumption. The objective of the

Table-1 : Physical characteristics of raw and malted quinoa.

Samples	Soaking Time (hrs)	Germination Time (hrs)	Bulk Density (g/ml)	Water Absorption Capacity (%)
Raw Quinoa	-	-	0.68	147
Malted Quinoa	12	48	0.38	160
		72	0.38	170
		96	0.39	175
		120	0.39	180
		144	0.40	195
	24	48	0.41	197
		72	0.42	200
		96	0.43	202
		120	0.43	205
		144	0.45	210
	36	48	0.45	202
		72	0.46	200
		96	0.46	200
		120	0.47	195
		144	0.47	190

Table-2 : Hunter color analysis of malted quinoa.

Samples	Soaking Time (hrs)	Germination Time (hrs)	L* (Lightness)	a* (Redness)	b* (Yellowness)
Raw Quinoa	-	-	78.65	2.70	23.60
Malted Quinoa	12	48	77.56	2.22	21.68
		72	76.50	2.22	21.68
		96	77.45	2.17	21.65
		120	75.39	2.27	21.63
		144	77.23	2.05	21.63
	24	48	76.20	2.12	21.61
		72	77.10	2.01	21.65
		96	72.94	1.59	21.56
		120	76.70	1.59	21.53
		144	77.79	1.56	21.55
	36	48	75.60	1.56	21.50
		72	77.50	1.55	21.59
		96	74.75	1.54	21.47
		120	73.90	1.54	21.47
		144	73.90	1.53	21.45
SEM			0.163	0.001	0.010
CD@ 5%			1.065	0.006	0.064

study was investigate the effect of malting process on functional and nutritional properties of quinoa.

Materials and Methods

Good quality of quinoa were collected and cleaned properly. Preliminary studies were performed for the purpose of identifying the appropriate method of malting, sample preparation was done by removal of bitterness and accordingly percentage of processed quinoa was established through sensory evaluation.

Optimization : Malting of raw materials were tried to arrive at the desired processing method with optimum percentage yield as recommended by acceptability studies. All experimental samples were prepared using the method given by Amal *et al.*, 2014 with slight modification. Different processing methods of malting were prepared by removal of bitter content of quinoa (Overnight running tape water method). Only the most preferable of those processing methods was selected through sensory evaluation. Different properties of raw material and processed products were evaluated as given following methodology:

Bulk density : The bulk density was calculated as weight of grain (g) divided by volume of grain (ml) and was expressed as g per ml which was reported by Vilche *et al.* 2003.

Water absorption Capacity : Absorption capacity is expressed in grams of water absorbed per gram of sample (Onwuka 2005).

Colour measurement : Colour quality of the samples was estimated by using Hunter lab colorimeter (Colour Quest XE Hunter Lab, USA).1.061.06

Proximate analysis : Moisture, protein, carbohydrate, fat, crude fiber, ash were measured according methods describing by AOAC 2000.

Determination of minerals : Minerals content like calcium, magnesium, iron and zinc were determined by using titration and spectrophotometric method respectively.

Determination of *In vitro* Protein Digestibility and *In vitro* Starch Digestibility : IVPD and IVSD was determined by the method given by the Singh *et al.*, 1982.

Statistical Analysis : For comparison of nutrient content of raw and parched products of quinoa two way analysis of variance test was applied on the means of three replications for different combinations. The analysis of variance revealed at significance at $P < 0.05$ level. The standard error (SE) and critical difference (CD) at 5 percent level were mentioned where required.

Results and Discussion

On the basis of triplicate analysis, data is obtained and presented as result which in line with various previous research and trails. Physical properties of raw grains and processed products of quinoa are presented in Table-1.

Bulk density of all malted quinoa was ranged between 0.38 to 0.47 g/ml whereas raw quinoa exhibited as 0.68 g/ml. Similarly, bulk density ranges from 0.66 g/mL to 0.75 g/mL in most varieties (Wu *et al.* 2014). The decrease in bulk density of the germinated millet flours

Table-3 : Proximate composition of malted quinoa.

Sample	ST (hrs)	Germination Time (hrs)	Moisture (g/100 g)	Fat (g/100 g)	Protein (g/100g)	Carbohydrate (g/100g)	Crude Fiber (g/100g)	Ash (g/100g)
Raw		-	11.30	5.17	12.61	65.11	2.62	3.19
Malted Quinoa	12	48	7.05	5.10	12.45	70.65	2.50	2.25
		72	7.10	5.05	12.43	70.84	2.43	2.15
		96	7.11	5.01	12.40	71.00	2.35	2.13
		120	7.18	4.97	12.39	71.08	2.28	2.10
		144	7.26	4.95	12.38	71.11	2.21	2.09
	24	48	7.13	5.08	12.41	70.73	2.45	2.20
		72	7.20	5.03	12.39	70.87	2.38	2.13
		96	7.27	4.96	12.39	71.06	2.31	2.01
		120	7.36	4.93	12.37	71.12	2.24	1.98
		144	7.40	4.92	12.33	71.20	2.18	1.97
	36	48	7.15	5.07	12.40	70.76	2.43	2.19
		72	7.20	5.02	12.38	70.89	2.38	2.13
		96	7.28	4.96	12.36	71.10	2.30	2.00
		120	7.36	4.92	12.35	71.18	2.22	1.97
		144	7.45	4.90	12.32	71.23	2.15	1.95
	SEM		0.015	0.007	0.017	0.081	0.004	0.005
	CD@5%		0.061	0.028	0.049	0.239	0.016	0.021

ST- Soaking time

Table-4 : Mineral content of malted quinoa.

Samples	Soaking Time (hrs)	Germination Time (hrs)	Iron (mg/100g)	Zinc (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
Raw		-	5.21	6.60	85.30	182.40
Malted Quinoa	12	48	5.75	5.30	83.52	173.59
		72	5.71	5.26	83.11	172.96
		96	5.68	5.21	82.65	172.13
		120	5.64	5.18	81.69	171.36
		144	5.61	5.15	80.73	170.25
	24	48	5.73	5.28	83.18	173.00
		72	5.70	5.25	83.01	171.49
		96	5.65	5.18	82.35	170.10
		120	5.61	5.16	81.50	169.56
		144	5.58	5.13	80.00	169.02
	36	48	5.70	5.23	82.76	172.03
		72	5.67	5.20	82.49	170.87
		96	5.64	5.17	81.10	169.75
		120	5.60	5.15	80.20	169.30
		144	5.55	5.10	79.26	168.90
	SEM		0.003	0.022	0.043	0.994
	CD@ 5%		0.010	0.065	0.175	2.920

would be an advantage in the preparation of supplementary foods (Akubor and Obiegbona, 1999). Similarly, a study conducted by Balasubramanian and Viswanathan (2010) reported that, at higher moisture levels, bulk density will be higher.

Raw quinoa sample showed 147 % water absorption capacity where as range found in all malted quinoa samples (160-210 %). Minimum water absorption capacity was observed as 160 % in malted quinoa of 12

hrs soaking with 48 hrs germination. Water absorption capacity of the sample depends on the protein, starch and fiber with starch showing the superior contribution (Farooq and Boye, 2011). Higher water absorption capacity due to decrease in particle size of malt may be because of larger surface area of smaller particle.

The effects of malting on the grain colour of quinoa shown in table-2 where the raw quinoa samples observed the highest (78.65) lightness (L^* value) as compared to

Table-5 : *In-vitro* protein digestibility (IVPD) and *In-vitro* starch digestibility (IVSD) of malted quinoa.

Samples	Soaking time (hrs)	Germination Time (hrs)	IVPD (%)	IVSD (%)
Raw		-	75.35	67.75
Malted Quinoa	12	48	76.91	68.05
		72	77.64	68.30
		96	78.35	68.45
		120	79.67	68.56
		144	80.10	68.70
	24	48	78.70	68.18
		72	79.13	68.92
		96	80.48	69.00
		120	82.05	69.20
		144	83.30	69.26
	36	48	80.10	68.23
		72	81.00	69.09
		96	82.79	69.15
		120	83.60	69.30
		144	83.70	69.40
SEM			0.081	0.056
CD@ 5%			0.327	0.226

malted quinoa samples with different soaking and germination period while lowest (73.90) found at malted quinoa of 36 hrs soaking with 144 hrs germination period.

It was reported that the highest (2.70) redness value (a^* value) was observed in raw quinoa whereas lowest (1.53) was showed by malted quinoa of 36 hrs soaked with 144 hrs germination. Chrome or colour intensity decreased significantly due to coating and processing compared to raw material.

The maximum (23.60) yellowness (b^* values) observed in raw quinoa while minimum (21.45) was found in malted quinoa of 36 hrs soaking with 144 hrs germination period. The results in table-3 shows L^* , a^* and b^* values significantly decrease on malting.

Raw quinoa were reported to have 11.30 g/100g of moisture content whereas malted samples of quinoa contains 7.05 to 7.45 g/100g. Lower moisture content is indicator of longer product shelf life (Sanni *et al.*, 2006). Thus, the results suggest better shelf life of malted products.

Among all the samples, maximum (5.17 g/100g) fat showed in raw quinoa samples whereas minimum (4.90 g/100g) reported in malted quinoa of 36 hrs soaked with 144 hrs germination period which falls within the range of fat content for various quinoa varieties reported by Miranda *et al.*, 2013.

The hydrolysed products do not accumulate in the seed, but the glycerol becomes a part of carbohydrate

pool and the fatty acids are oxidised through and oxidation, resulting in decrease in fat on malting (Choudhury *et al.*, 2011).

Raw quinoa seed was reported to have 12.61 g/100g protein content whereas malted quinoa contains 12.32 to 12.45 g/100g. Minimum (12.32 g/100g) was reported in samples which was soaked for 36 hrs with 144 hrs germination. A protein range of 12 % to 17 % in quinoa has been reported by most studies (Rojas and Pinto. 2015). The decrease in protein content after malting may be due to hydrolysis of native protein to low molecular weight proteins or peptides and increase in enzyme activity (Shayo *et al.*, 2001).

Carbohydrate content of raw quinoa seeds observed to have 65.11 g/100g. Malted quinoa exhibited 70.65 to 71.23 g/100g carbohydrate which was more than raw quinoa seed. The results reveals the maximum (71.23 g/100g) carbohydrate content was found in malted quinoa of 36 hrs soaked with 144 hrs germination whereas minimum (65.11 g/100g) was observed in raw quinoa. The reason may be during germination, there would be partial degradation of amylopectin and increase in amylose content which contributes to the total carbohydrate of malted quinoa. The findings are in agreement with the findings of finger millet (Gokavi and Malleshi, 2000).

Raw quinoa seeds reported to have crude fiber content of 2.62 g/100g whereas malted samples of quinoa contains 2.15 to 2.50 g/100g crude fibre. Reduction in crude fibre content during malting might be due to the type of grain and degree of removal of seed coat and also due to decrease in neutral detergent fibre on malting which occurs because of cell wall degradation during sprouting process and also the exclusion of rootlets and shoots of sprouts (Kumari and Srivastava, 2000 and Choudhury *et al.*, 2011). Malted samples of quinoa contains 1.95 to 2.25 g/100g ash content which was lesser than raw quinoa seed as 3.19 g/100g. The apparent reason behind decreased ash content can be removal of hulls which accounts for 8.5% of total ash content in quinoa seeds (Chauhan *et al.*, 1992).

The iron content of quinoa seeds was observed 5.77 mg/100g, zinc 6.60 mg/100g, calcium 85.30 mg/100g and magnesium 182.40 mg/100g. In general, all malted quinoa samples iron content was ranged from 5.55 to 5.75 mg/100g, zinc between 5.10 to 5.30 mg/100g, calcium from 79.26 to 83.52 mg/100g and magnesium was exhibited from 168.90 to 173.59 mg/100g. The results obtained from table-4 showed that mineral content slightly decreased in malting. Similarly, significant decrease in minerals content of malted samples reported by Choudhury *et al.*, 2011. There was removal of seed

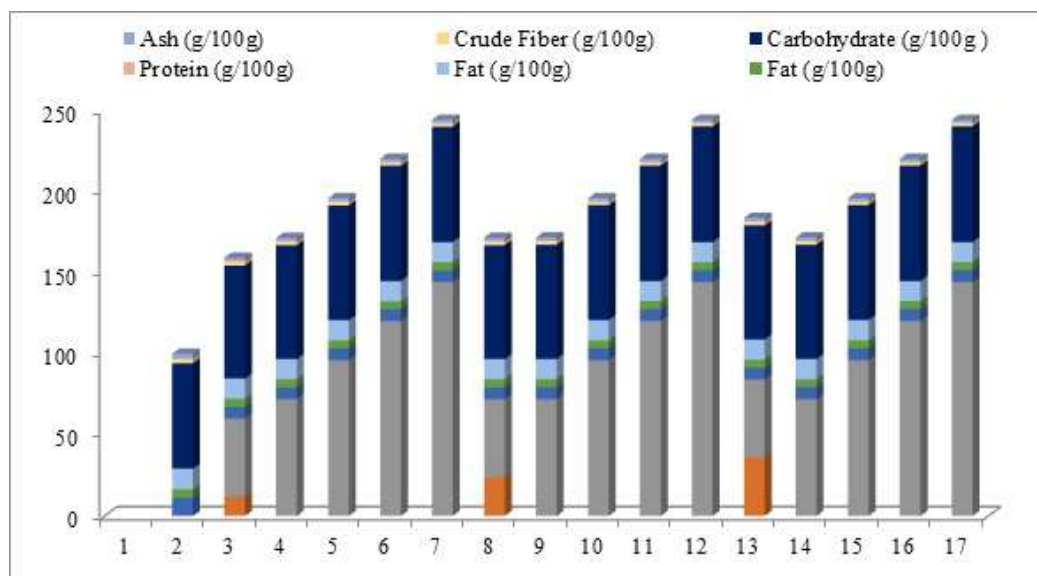


Fig.-1 : Proximate composition of malted quinoa.

coat during malting, which contributes towards the reduction in the total mineral content of malted samples (Mac Masters *et al.*, 1971).

Malted quinoa samples showed from 76.91 to 83.70 % of IVPD which was higher than raw quinoa seed. Makokha *et al.*, 2002 also reported that malting significantly increased (5.8%) protein digestibility.

It was reported that the effect of malting on sorghum was attributed to the fact that the corneous protein matrix of the endosperm is more effectively digested by the phyto-enzyme liberated during malting than by the enzymes of the gastro-intestinal tract.

The results obtained from the table-5 that the IVSD of raw quinoa seeds was 67.75 % whereas malted quinoa reported to have the range from 68.05 to 69.40 % of IVSD. Bhise *et al.*, 1988 and Chau and Cheung (1997) also reported that germination which is a primary step of malting significantly improved in vitro starch digestibility in sorghum.

Conclusions

Pseudo-cereals have considerable scope to be utilized as health food, because it has better nutritional quality as compared to some other cereals in many respects and studies on this line are progressing. However, locally available quinoa is underutilized because of lack of suitable processing technology. The processed quinoa obtained as the outcome of the present study will be useful in developing low cost health foods for children as well as geriatrics. In this study an attempt have been made to develop a quinoa based processed food with higher nutritive value. The optimized quinoa showed good sensory acceptability revealing their potential for

consumption by all type of population. Thus in the light of the scientific data it may be concluded that nutritional bioavailability and digestibility of quinoa could be improved by reducing its bitter content and in this regards the processing method contribute to enhancing utilization of quinoa based products. The addition of these products in the daily food could help to alleviate the deficit in protein and carbohydrate in the malnourished population. During recent years, the grain has started receiving popularity and attention in many countries like Europe, Australia, Japan and India *etc.* due to its health, functional and nutritional benefits.

References

1. Akubor, P.I. and Obiegbona, J.E. (1999). Certain chemical and functional properties of ungerminated and germinated millet flour. *Journal of Food Science and Technology* 36(3): 241-243.
2. Amal, M.H.; Abdel-Haleem, Azza, A. and Omran, A. (2014). Preparation of Dried Vegetarian Soup Supplemented with Some Legumes. *Food and Nutrition Sciences* (5): 2274-2285.
3. AOAC. (2000). Association of Official Analytical Chemists. *Official Methods of Analysis of the AOAC*: Washington DC.
4. Balasubramanian, S. and Vishwanathan, R. (2010). Influence of moisture content on physical properties of minor millets. *Journal of Food Science and Technology* 47(3): 279-284.
5. Bhise, V.J.; Chanan, J.K. and Kadam, S.S. (1988). Effect of malting on proximate composition and *in vitro* protein and starch digestibility of grain sorghum. *Journal of Food Science and Technology* 25: 327-329.
6. Chau, C.F. and Cheung, P.C.K. (1997). Effect of various processing methods on anti-nutrients and *in vitro* digestibility of protein and starch of two Chinese

- indigenous legume seeds. *Journal of Agriculture and Food Chemistry* 45(1): 4773-4776.
7. Chauhan, G.S.; Eskin, N. and Tkachuk, R. (1992). Nutrients and anti-nutrients in quinoa seed. *Journal of Cereal Chemistry* 69(1): 85-89.
 8. Choudhury, M.; Das, P. and Baroova, B. (2011). Nutritional evaluation of popped and malted indigenous millet of Assam. *Journal of Food Science and Technology* 48(6): 706-711.
 9. CIE. (1976). Commission International de l'Éclairage. <http://www.cie.co.at>.
 10. FAO. (1998). The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome, Italy. p 112.
 11. Farooq, Z. and Boye, J.I. (2011). Novel food and industrial applications of pulse flours and fractions. *Journal of Pulse Foods: Processing, Quality and Nutraceutical Applications*, 283-323.
 12. Galvez, A.; Miranda, M.; Vergara, J.; Uribe, E. and Puente, L. (2010). Nutrition facts and functional potential of quinoa (*Chenopodium quinoa*), evaluation of the malts as gluten free baking ingredients. *Journal of Plant Foods and Human Nutrition* 68: 90-95.
 13. Giuliani, A.; Hintermann, F.; Rojas, W. and Padulosi, S. (2012). *Biodiversity of Andean grains: Balancing market potential and sustainable livelihoods*. Rome, Italy: Biodiversity International. ISBN 13: 978-92-9043-932-5.
 14. Gokavi, S.S. and Malleshi, N.G. (2000). Malting characteristics of a few Indian wheat and chickpea varieties. *Journal of Food Science and Technology* 37: 586-591.
 15. Hough, J.S., Briggs, D.E.; Stevens, R. and Young, T.W. (1982). *Beer Flavour and Beer Quality Malting and Brewing Science: Volume II Hopped Wort and Beer* Springer, Boston
 16. James, L.A.E. (2009). Quinoa (*Chenopodium quinoa* Willd): Composition, chemistry, nutritional and functional properties. *Advances in Food Nutrition Research* 58(1): 1-31.
 17. Jancurova, M. (2009). Quinoa-a review. *Czech Journal of Food Science* 27(2): 71-79.
 18. Kaukovirta-Norja, A.; Wilhelmson, A. and Poutanen, K. (2004). Germination: a means to improve the functionality of oat. *Journal of Agriculture and Food Science* 13(1): 100-112.
 19. Kumari, S. and Srivastava, S. (2000). Nutritive value of malted flours of finger millet genotypes and their use in the preparation of burfi. *Journal of Food Science and Technology* 37(4): 419-422.
 20. Mac Masters, M.M.; Hinton, J.J.C. and Bradbury, D. (1971). Microscopic structure and composition of the wheat kernel, In: Pomeroy Y (ed) *Wheat: Chemistry and technology*. American Association of Cereal Chemists 2nd edition 51-113.
 21. Makokha, A.O.; Oniang'o, R.K.; Njoroge, S.M. and Kinyanjui, P.K. (2002). Effects of malting on protein digestibility of some sorghum (*Sorghum bicolor*) varieties grown in Kenya. www.affand.net/issuelfiles/Issuelfresearch.htm (accession date: 5th Feb'2005).
 22. Maradini-Filho, A.M.; Pirozi, M.R.; Brges, J.T.D.S.; Pinheiro, Sant'Ana, H.M.; Chaves, J.B.P. and Coimbra, J.S.D.R. (2015). Quinoa: Nutritional, functional and antinutritional aspects. *Critical Reviews in Food Science and Nutrition* 57(8): 1618-1630.
 23. Miranda, M.; Vega-galvez, A.; Martinez, E.; Lopez, J.; Marin, R.; Aranda, M. and Fuentes, F. (2013). Influence of contrasting environments on seed composition of two quinoa genotypes?: nutritional and functional properties. *Chilean Journal of Agriculture and Research* 73(2): 108-116.
 24. Onwuka, G.I. (2005). *Food Analysis and Instrumentation. Theory and practice*. Naphtali prints. surulere lagos Nigeria 133-137.
 25. Rojas, W. and Pinto, M. (2015). Chapter 8: *Ex situ* conservation of quinoa: the bolivian experience. In: Murphy KM, Matanguihan J, editors. *Quinoa: Improvement and Sustainable Production*. Hoboken, NJ: John Wiley & Sons, Inc. p 128-30.
 26. Sanni, L.O.; Adebawale, A.A.; Filani, T.A.; Oyewole, O.B. and Westby, A. (2006). Quality of flash and rotary dryer dried fufu flour. *Journal of Food Agriculture and Environment* 4: 74-78.
 27. Sharma, V.; Chandra, S.; Dwividi, P. and Parturkar, M. (2015). Quinoa (*Chenopodium quinoa* Willd) a nutritional healthy grain. *International Journal of Advanced Research* 3(9): 725-736.
 28. Shayo, N.B.; Tiisekwa, B.P.M.; Laswai, H.S. and Kimaro, J.R. (2001). Malting characteristics of Tanzania finger millet varieties. *Food and Nutrition Journal of Tanzania*, 10: 1-4.
 29. Singh, U.; Kherdekar, M.S. and Jambunathan, R. (1982). Studies on the desi and kabuli chickpea (*Cicer arietinum* L.) cultivars, the level of amylase inhibitors, levels of oligosaccharides and in vitro starch digestibility. *Journal Food Science* 49: 1228-1229.
 30. Stikic, R.; Glamoclija, D.; Demin, M.; Vucelic Radovic, B.; Jovanovic, Z.; Milojkovic, Opsenica, D.; Jacobsen, S.E. and Milovanovic, M. (2012). Agronomical and nutritional evaluation of quinoa seeds (*Chenopodium quinoa* Willd.) as an ingredient in bread formulations. *Journal of Cereal Science* (55): 132-138.
 31. Vilche, C.; Gely, M. and Santalla, E. (2003). Physical properties of quinoa seeds. *Biosystem Engineering* 86: 59-65.
 32. Wu, G.; Morris, C.F. and Murphy, K.M. (2014). Evaluation of texture differences among varieties of cooked quinoa. *Journal of Food Science* 79(11): 2337-45.



Production of Lactic Acid from Wheat Bran Using *Lactobacillus* Strains

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Abstract

Biotechnological process is valuable over chemical one as abundantly available raw material such as agro-industrial byproduct can be used as carbon source and to produce the pure lactic acid in a very economic way. Wheat bran is one of the significant portions of waste produced in the flour mills. It forms the outer portion of the wheat seed. The highest lactic acid formation compared to all the strains under different levels of glucose treatments, co-culture showed the maximum lactic acid production 52.15 g/L at pH 3.66. Hence development of production strains which can directly ferment starch to lactic acid in single step pretreatment is necessary.

Key words : Wheat bran, *Lactobacillus* sp., lactic acid, fermentation, agricultural waste.

Introduction

Lactic acid is an organic acid with a wide variety of industrial applications. The most important application is as a preservative and acidulant in foods, as a prosthetic device, controlled delivery of drugs in pharmaceutical agents and cosmetic applications and formulations in topical ointments, lotions, anti acne solutions, humectants, parenteral solutions and dialysis applications for anti carries agent (Ghasemi *et al.*, 2009; Panesar *et al.*, 2010). Recent information indicates approximately 90% of all lactic acid is produced by bacterial fermentation. Microbial fermentation by lactic acid bacteria (LAB) has the advantage of producing only one of the isomers (John *et al.*, 2006; Lunt 1998). Lactic acid molecule has two optical active isomers, D(-) and L(+) forms. The L(+) form of lactic acid is used for food and drug industry, because human body is only adapted to assimilate this form and only produced L-Lactate dehydrogenase (Datta *et al.* 1995). Recently, the demand of lactic acid has been increased gradually. In particularly, the demand was estimated to be 130,000–150,000 tons per year worldwide.

Man has long observed the souring of milk, but it was only in 1780 that Carl Wilhem Scheele discovered lactic acid, the chemical that causes this phenomenon. Although others had demonstrated the microbiological nature of souring, later Louis Pasteur, in 1857 reinvestigated Scheele's finding, and described the causative organism of the fermentation (Abdel-Rahman *et al.*, 2013). *Lactobacillus* species are well-known and widely employed lactic acid producing bacteria. *Lactobacilli* are gram-positive, non-sporing, catalase-

negative and anaerobe facultative bacteria. The optimum growth pH and temperature are normally 5.5-6.2 and 30C- 40°C respectively (Naveena *et al.*, 2003). The global production of wheat was 772.64 million metric tons (2020-2021) to which India contributed 12.3%. Wheat bran consists of approximately about 19% starch, 18% crude protein, 58% non starch carbohydrates with 24% cellulose, 70% arabinoxylans and 6% glucans as major non starch polysaccharides and lignin (Trivedi, 2008; Akerbeg. *et al.*, 2000).

Materials and Methods

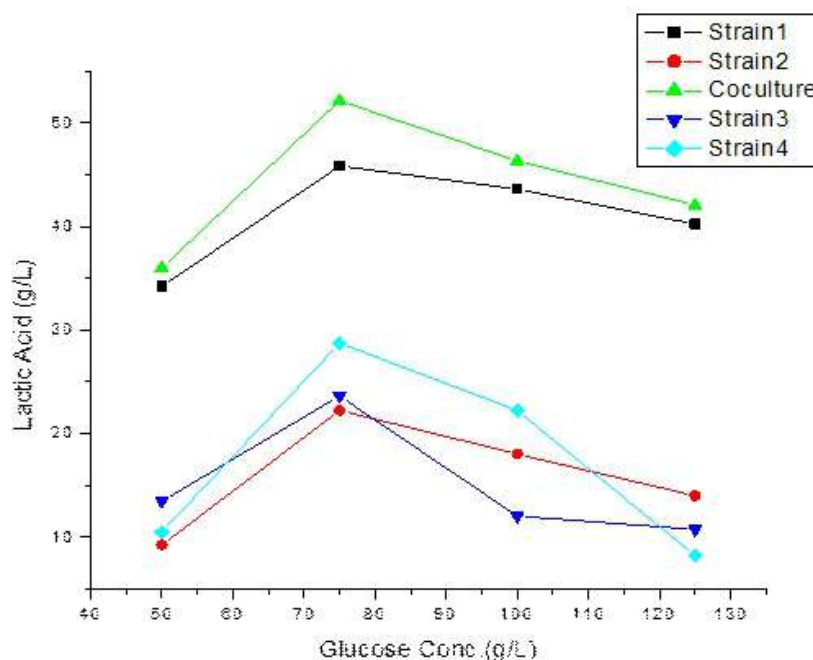
In this study, the production of lactic acid from agro-waste using *Lactobacillus* strain and their co-culture by solid state fermentation was carried out in the Biotechnology laboratory Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna MP. In experimental studies on anaerobic batch fermentation with *Lactobacillus delbrueckii* (NCIM 2025), *Lactobacillus pentosus* (NCIM 2912) *Lactobacillus* sp, (NCIM-2084) and (NCIM-2734) and their co-culture have been carried out using glucose based synthetic media at 37°C, 180 rpm, and initial pH 6.5.

Preparation of Inoculum

Lactobacillus strains were procured from National Collection of Industrial Microorganisms (NCIM), Pune, India. They are well preserved in the laboratory. The strain used in this work was *Lactobacillus* strain. The stock cultures were maintained at 4°C in 250 mL MRS broth (de Man Sharpe and Rogosa Broth). The bacterial culture was grown in 50 mL of MRS medium in 250 mL Erlenmeyer flask. After sterilization, the medium was inoculated with a loopful of cells from agar stab and incubated at 37°C for

Table-1 : Effects of pure glucose on wheat bran bed material.

Bacterial strains	Glucose 50 g/L		Glucose 75 g/L		Glucose 100 g/L		Glucose 125 g/L	
	pH	LA (g/L)*	pH	LA (g/L)*	pH	LA (g/L)*	pH	LA (g/L)*
Strain-1	4.22	34.24	3.58	45.85	3.80	43.61	3.78	40.25
Strain-2	5.08	9.25	4.58	22.25	4.54	18.05	5.84	14.01
Coculture of strain-1 and 2	4.18	36.01	3.66	52.15	3.72	46.35	4.06	42.10
Strain-3	5.14	13.50	4.52	23.65	5.36	12.04	5.34	10.75
Strain-4	5.26	10.50	4.11	28.75	3.82	22.26	5.78	8.02

Fig-1 : Lactic acid production by the *Lactobacillus* strains at different concentration of glucose.

24 h under stationary conditions. The 16 h old bacterial culture having 2 g/L was used as the inoculum (Goncalves *et al.*, 1991).

Sample Collection : Wheat bran was collected from Sindhi camp flour mills Satna M.P., India. The collected agro waste materials are powered by chipping, grinding and milling (vibratory ball milling) to reduce cellulose crystallinity. The rinsing with water is continued until the wash water is clear and fractions passing through 40 mesh screens but retained on 80 mesh screens was collected.

Pretreatment of wheat bran : The powdered wheat bran was mixed with aqueous solution of NaOH (10%) at a liquid to solid ratio of 1:10 (w/v) at a temperature of 37°C for 4h and autoclaved at 121°C for 30 min. The residues were collected and washed extensively with tap water until neutral pH reached. Then the residues was filtered and dried at 65°C for two days. The optimum acid-pretreatment (80°C for 20 h by H₂SO₄) conditions of

wheat bran were 10?min of pretreatment time, 2% (v/v) dilute-acid ratio, and 10:1 of liquid-to-solid ratio (v/w) at a fixed temperature (121°C). (Kumar *et al.*, 2010).

Bacterial cell biomass : Bacterial cell concentration was determined at 610 nm and calibrated into colony forming units (CFU) by colony count method and the bacterial biomass was expressed as cell dry weight in gram per liter (g/L).

Extraction and estimation of lactic acid : Lactic acid present in the fermentation broths in liquid state fermentation or extracts from fermented bed materials in case of solid state fermentation, were quantitatively assayed by Kimberly Taylor method (Taylor *et al.*, 1996). The absorbance for lactic acid was measured in a UV-VIS double beam spectrophotometer of (Systronics, India) at 570 nm.

Estimation of sugars DNS method : The content of sugar was determined by dinitrosalicylic acid (DNS)

assay has been available since 1955 and is still useful for the quantitative determination of reducing sugar. The absorbance was measured at 570 nm in UV-VIS double beam spectrophotometer (Systronics, India) (Miller, 1959).

Results and Discussion

The chemical composition of the bed material influences the growth of bacteria and production of lactic acid. The wheat bran contained Holocellulose 44.06%, Pentosan 31.02%, Lignin 4.85% and starch 32.24%. Lactic acid production was done by solid state fermentation with the different strains of Lactobacilli on 8g bed of wheat bran and the production medium containing various doses of Glucose. LA-Lactic acid in extract*(g/L); conditions I ml 2% NaOH neutral inoculum dose of 2g/L, production medium per flask 60 mL at 37 °C, initial pH 6.5, and six days incubation period. The results reveal that maximum acid production was attained by all the *Lactobacillus* strains including co-culture of the first two strains, at 75 g/L dose of pure glucose containing, synthetic production media (Table-1). The maximum lactic acid production under different levels of glucose treatments and co-culture showed 52.15 g/L at pH 3.66 (at a glucose level of 75 g/L) closely followed by strain-1, 45.85 g/L at pH 3.58. Co-culture showed better acid production (lower pH and higher lactic acid concentration) Strain-2, *L. pentosus* has lowest concentration 22.25g/L (pH 4.58) of lactic acid since it is primarily pentose sugar utilize but the supply of glucose as a carbon source reduced the lactic acid production.

Conclusions

The present study provides a novel approach for the

production of lactic acid by lactobacilli through solid state fermentation using wheat bran. The wheat bran, an inexpensive agro industrial waste, is available from the flour mills in large quantities. Use of 75 g/L pure glucose provides maximum lactic acid production in coculture. The coculture proved to be better than its strains-1 and 2. The higher concentration of pure glucose treatment (125 g/L) in production media indicated that, the acid synthesizing ability of strain-1 and co-culture were reduced due to inhibition at high sugar concentration.

References

1. Abdel-Rahman M.A., Tashiro Y. and Sonomoto K. (2013). *Biotechnology Advances*, 31: 877–02.
2. Akerbeg, C. and Zacchi, G. (2000). *J. of Bioresources Technology*. 75: 119-126
3. Datta R., Tsai S.P., Bonsignor P., Moon S. and Frank J. (1995) *FEMS Microbiology Reviews*, 16: 221-31.
4. Ghasemi M., Ghasem N., Rahimnejad M., Beigi P.A., Sedighi M. and Hashemiyeh B., (2009). *African J. of Biotech.*, 8(1) : 81-84.
5. Goncalves, L.M.D., Xavier, A.M.R.B. and Almeida, J.S. (1991). *J. of Enzyme Microb. Technology*. 13(4) : 314-319.
6. John R.P., Nampoothiri K.M. and Pandey A., (2006) *Biotech. Lett.*, 28(22) :1823-1826.
7. Kimberley A.C. and Taylor C. (1996). *Applied Biochemistry and Biotechnology*, 56: 49-58.
8. Kumar S., Negi Y.S. and Upadhyaya J.S. (2010). *Advanced Materials Letters*, 1(3) : 246-253.
9. Lunt J. (1998). *Polymer Degradation and Stability*, 59: 145-52.
10. Naveena B.J., Vishnu C., Mohammed A. and Reddy G., (2003). *J. of Scientific and Ind. Res.*, 62(5) : 453-456.
11. Panesar, P.S., Kennedy, J.F., Knill, C.J. and Kosseva, M., (2010). *Braz. Arch. Biol. Technol.*, 53 : 219-226.
12. Trivedi T.P., (2008). *Handbook of Agriculture, Wheat*, 5th edition, 845-857.



Estimation of Combining Ability using Line $\times$ Tester Analysis in Paddy

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Abstract

An experiment was conducted to evaluate the performance of 21 crosses developed by crossing of 7 lines with 3 testers. Analysis of variance revealed highly significant differences in treatment, parent, crosses, parent vs. crosses and line for all the traits studied which indicated the considerable amount of variability among the treatments, parents, crosses and lines for all of the traits. The mean squares due to tester and line $\times$ tester was significant for most of the traits except 1000 grain weight, kernel length and elongation ratio. The lines (P-1592, P-1121 and P-1612), tester P-2511 and the crosses viz., (P-1592 $\times$ P-2511, P-1121 $\times$ Mahi Sugandha, P-1121 $\times$ P-2511, Pratap-1 $\times$ P-2511, P-1612 $\times$ P-2511 and Basmati-370 $\times$ P-2511) were identified as best combiners for yield attributing and quality traits on the basis of *per se* performance and combining ability effects. The crosses having best specific combination for grain yield per plant would have been obtained either through good $\times$ good, good $\times$ poor, poor $\times$ good and poor $\times$ poor parental combinations.

Key words : combining ability, gene action, line $\times$ tester,

Introduction

Rice *Oryza sativa* belongs to Poaceae family. it is the most important staple food crop in the world. India place second position in production and consumption of rice in the world. Most of the population of the world depends on rice as the main source of calories. It contains carbohydrate (78.2%), protein (6.8%), fat (0.5%) and minerals (0.6%). To meet the food demand of the growing population and to achieve food security in the country, the present production levels need to be increased by 2 million tones every year, which is possible through heterosis breeding. Thus, production of rice has to be improved and maintained for global food security. It was anticipated that by 2030 world should produce 60 per cent more rice than what it produced in 1995. Plateauing shift in the yield of HYVs, decreasing and degrading natural resources and acute labour shortage make the mission of increasing rice production quite challenging. Among the innovative breeding approaches available for enhancing the rice production and productivity in India and other rice growing countries, hybrid rice is one of the highly adapted and practically viable choice of breeding (Ahmed and Siddiq, 1998). The general combining ability identifies superior parental genotypes while specific combining ability helps in identification of best hybrid combinations (Saleem *et al.*, 2008). Line $\times$ Tester (Kempthorne, 1957) analysis is one of the most powerful tools for estimating the GCA of parents and SCA of crosses for the exploitation of heterosis.

Materials and Methods

The present experiment was conducted at Agriculture Research Station, Ummedganj, Kota. A line $\times$ tester set of 21 hybrids (F_1 's) were derived by crossing seven lines (female) viz., P-1592, P-1121, Pratap-1, Surabhi, P-1612, Basmati-370 and Pakistan Basmati with three testers (male) viz., Mahi Sugandha, P-2511 and P-1509 during *Kharif* 2019 and evaluated in randomized block design with three replications during *Kharif*, 2020. Crossing work was carried on more than 20 panicles in every cross combination in order to get the required number of crossed seeds. Standard agronomic practices and need based plant protection measures were followed to raise healthy crop. The data were recorded on morpho-physiological and quality traits like Days to 50% flowering, Plant height (cm), No. of effective tillers/ plant, Panicle length (cm), 1000-Grain weight (g), Kernel length (mm), Kernel breadth (mm), L/B ratio, Elongation ratio and Grain yield/ plant (g). Observations were recorded on ten randomly selected competitive plants of each genotype in each replication for all traits except for days to 50% flowering. This observation was recorded on whole plot basis. The analysis of variance for randomized complete block design was carried out by Panse and Sukhatme (1967). The combining ability analysis was carried out by line $\times$ tester mating design outlined by Kempthorne (1957) and further elaborated by Arunachalam (1974).

Results and Discussion

The analysis of variance for combining ability was carried out for grain yield and it's contributing characters and

Table-1 : Analysis of variance (mean sum of square) and other parameters for different characters in rice.

Source	d.f.	Days to 50% flowering	Plant height (cm)	No. of effective tillers/ plant	Panicle length (cm)	1000-Grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Elongation ratio	Grain yield/ plant (g)
Replications	2	4.52	32.53	0.48	1.43	0.21	0.13	0.001	0.04	0.002	5.24
Treatments	30	129.44**	504.86**	16.65**	4.25**	3.34**	1.43**	0.04**	0.52**	0.10**	49.66**
Parents	9	211.20**	819.44**	25.25**	4.92**	5.48**	0.95**	0.01**	0.41**	0.15**	50.24**
Parents vs. crosses	1	46.80**	28.32**	9.88**	7.32**	5.65*	16.59**	0.22**	1.25**	0.28**	79.53**
Crosses	20	96.78**	387.11**	13.10**	3.81**	2.25**	0.89**	0.05**	0.54**	0.08**	47.90**
Lines	6	136.42**	1073.10**	28.41**	2.96*	4.89**	2.06**	0.07**	1.42**	0.10**	83.81**
Testers	2	36.25**	139.45**	10.23**	16.65**	2.29	0.50	0.22**	0.41*	0.43**	176.12**
Lines x Testers	12	87.05**	85.40**	5.92**	2.08*	0.93	0.37**	0.009*	0.12**	0.008	8.58**
Error	60	18.50	22.04	0.92	0.54	0.32	0.10	0.003	0.03	0.02	3.15
² gca line		17.75	117.41	9.31	16.11	1.97	0.40	0.217	0.38	0.41	172.97
² gca tester		68.55	63.36	5.00	1.54	0.61	0.27	0.006	0.09	-0.01	5.43
² sca		22.85	21.12	1.66	0.51	0.20	0.09	0.002	0.03	-0.004	1.81
Contributions of lines		42.28	83.16	65.07	23.36	65.00	69.45	44.03	78.58	38.06	52.48
Contributions of testers		3.74	3.60	7.80	43.80	10.16	5.63	45.12	7.55	55.25	36.76
Contributions of LxT		53.96	13.23	27.11	32.82	24.83	24.91	10.83	13.86	6.68	10.74

*, ** Significant at 5% and 1% level of significance, respectively.

mean sum of squares are presented in Table-1. The treatments registered highly significant differences for all the traits. The parents and crosses exhibited significant differences for all the traits under study. The parents vs. crosses also showed significant differences for all the traits Singh and Kumar (2004) and Panwar (2005). The effects of hybrids were partitioned into lines, testers and their interactions. The lines were found to be significant for all the traits whereas, among testers, the differences were significant for all the traits except 1000 grain weight and kernel length. The interaction effects (lines x testers) were found to be significant for all the traits except 1000 grain weight and elongation ratio, suggesting that line x tester interaction variance contributed largely for total genetic variance and both lines and testers interacted differently in cross combinations.

An average performance of a line in a series of cross combinations termed as general combining ability. For seed yield and its contributing traits, parents with significant GCA effect in desired direction, non-significant GCA effect in desired direction, and significant GCA effect in undesired direction were classified as good, average, and poor general combiner, respectively; similarly, crosses were classified as good, average, and poor specific combiner.

GCA effects (Table-2) showed line P-1592 showed significant value in desirable direction for days to 50% flowering, plant height, number of effective tillers/ plant, kernel length, kernel breadth, L/B ratio and grain yield/ plant. Line P-1121 showed significant value in desirable direction for days to 50% flowering, plant height, number of effective tillers/ plant, panicle length, 1000-grain weight, kernel length, kernel breadth, L/B ratio and grain yield/ plant. Line Pratap-1 showed significant value in desirable direction for number of effective tillers/ plant and 1000-grain weight. Line Surabhi showed significant value in desirable direction for days to 50% flowering and plant height. Line P-1612 showed significant value in desirable direction for days to 50% flowering, plant height and grain yield/ plant. Similarly, tester Mahi Sugandha showed significant value in desirable direction for plant height and kernel breadth. Tester P-2511 showed significant value in desirable direction for plant height, number of effective tillers/plant, panicle length, 1000-grain weight, kernel breadth, L/B ratio and grain yield/ plant. Similar results were recorded by Singh *et al.* (2020), Kirubha *et al.* (2019) and Akanksha and Jaiswal (2019).

Estimation of SCA effect (Table-3) revealed that desirable number of crosses identified significant in desirable direction for different traits. For days to 50 per cent flowering, the specific combining effect varied from -9.15 to 6.54 and maximum value of significant SCA effect

Table-2 : Estimation of general combining ability effects of lines and testers for different characters in rice.

Parents	Days to 50% flowering	Plant height (cm)	No. of effective tillers/ plant	Panicle length (cm)	1000-Grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Elongation ratio	Grain yield/ plant (g)
Lines										
P-1592	-7.09**	-15.72**	1.56**	0.39	0.21	0.38**	-0.06**	0.31**	-0.08	3.71**
P-1121	-3.57*	-3.40*	2.72**	0.52*	0.92**	0.46**	-0.16**	0.62**	0.05	2.69**
Pratap-1	1.79	2.09	1.19**	-1.18**	0.47**	0.09	0.05**	-0.82**	-0.10	0.56
Surabhi	-3.76*	-3.40*	-0.79*	-0.17	-1.05**	-0.15	0.02	-0.12*	0.06	-1.66**
P-1612	-4.46**	-5.46**	0.52	0.29	0.55**	-0.01	0.09**	-0.21**	0.06	2.04**
Basmati-370	1.68	6.81**	-2.24**	0.14	-0.76**	-0.96**	0.06**	-0.62**	0.10	-3.24**
Pakistan Basmati	2.34	19.08**	-1.96**	0.00	-0.34	0.20	-0.008	0.10	-0.14	-4.12**
Testers										
Mahi Sugandha	1.49	-2.93**	-0.43*	-0.87**	-0.36**	-0.15	-0.07**	0.07	-0.10	-1.57**
P-2511	-0.50	-2.06**	0.80**	0.90**	0.27*	-0.001	-0.04**	0.08**	-0.06	3.34**
P-1509	-0.98	1.87	-0.37	-0.02	0.09	0.15	0.11**	-0.16**	0.16	-1.76**

*, ** Significant at 5% and 1% level of significance, respectively.

Table-3 : Estimation of specific combining ability effects of hybrids for different characters in rice.

S.N.	Hybrids	Days to 50% flowering	Plant height (cm)	No. of effective tillers/ plant	Panicle length (cm)	1000-Grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Elongation ratio	Grain yield/ plant (g)
1.	P-1592 x Mahi Sugandha	-2.38	-0.84	1.80**	-0.01	-0.29	-0.09	0.04	-0.13	0.006	1.18
2.	P-1592 x P-2511	3.95	-3.22	1.64*	0.81*	0.79*	-0.28	-0.08*	0.07	-0.02	2.55*
3.	P-1592 x P-1509	-1.57	-2.37	-2.44**	-0.70	-0.22	0.38*	0.04	0.05	0.01	0.37
4.	P-1121 x Mahi Sugandha	-1.61	1.48	0.58	0.86*	0.84*	-0.25	0.05	-0.22*	-0.06	1.43
5.	P-1121 x P-2511	-0.04	-1.19	-0.19	0.92*	0.86*	0.12	0.08*	-0.23*	0.09	0.58
6.	P-1121 x P-1509	-1.57	-0.28	0.78	-0.89*	-0.28	0.13	-0.09*	0.24*	-0.02	2.01*
7.	Pratap-1 x Mahi Sugandha	-1.27	5.76*	0.97	-0.08	0.39	0.14	0.01	0.05	-0.03	1.54
8.	Pratap-1 x P-2511	-5.27*	-10.31*	1.50*	0.40	0.77*	0.23	0.01	-0.14	-0.01	1.63
9.	Pratap-1 x P-1509	6.54**	4.54	-0.47	0.49	0.38	0.10	-0.02	0.09	0.04	-3.17**
10.	Surabhi x Mahi Sugandha	-2.38	-2.57	-0.08	0.44	-0.04	0.06	-0.06	0.17	0.04	-0.13
11.	Surabhi x P-2511	4.95*	3.98	0.95	-0.10	-0.33	-0.05	-0.005	-0.02	-0.03	0.39
12.	Surabhi x P-1509	-2.57	-1.41	-0.87	-0.33	0.38	-0.01	0.06	-0.14	-0.001	-0.26
13.	P-1612 x Mahi Sugandha	-4.27	-0.18	-1.13*	-0.68	-0.004	0.04	-0.01	0.04	-0.002	-1.46
14.	P-1612 x P-2511	-3.06	2.11	1.47*	0.73	0.57	0.61**	-0.01	0.30**	0.03	0.28
15.	P-1612 x P-1509	1.20	-1.92	0.65	-0.04	-0.57	-0.65**	0.02	-0.34**	-0.03	1.74
16.	Basmati-370 x Mahi Sugandha	3.50	3.48	-0.09	0.65	0.60	0.08	0.001	0.01	-0.01	-0.25
17.	Basmati-370 x P-2511	2.50	-4.46	1.79**	0.85*	-0.38	0.14	-0.07*	0.31**	0.04	1.16
18.	Basmati-370 x P-1509	-6.01*	0.97	1.89**	0.20	-0.22	-0.22	-0.01	-0.04	-0.02	-0.91
19.	Pakistan Basmati x Mahi Sugandha	5.17*	-7.12*	-0.88	-0.27	-0.38	0.02	-0.02	0.08	0.06	0.55
20.	Pakistan Basmati x P-2511	-9.15**	6.64*	0.41	-1.00*	-0.15	-0.29	0.03	-0.23*	-0.09	-0.77
21.	Pakistan Basmati x P-1509	3.98	0.48	0.46	1.27**	0.54	0.26	-0.009	0.13	0.03	0.21

*, ** Significant at 5% and 1% level of significance, respectively.

in desirable direction was recorded in cross Pakistan Basmati $\times$ P-2511. With regards to plant height, the SCA effect varied from -10.31 to 6.64 and maximum value of SCA effect in desirable direction was recorded in cross Pakistan Basmati $\times$ P-2511. For number of effective tillers/plant, the specific combining effect varied from -2.44 to 1.89 and maximum value of significant SCA effect in desirable direction was recorded in cross Basmati-370 $\times$ P-1509. With regards to panicle length, the SCA effect varied from -1.00 to 1.27 and maximum value of SCA effect in desirable direction was recorded in cross Pakistan Basmati $\times$ P-1509. For number of 1000 grain weight, the specific combining effect varied from -0.38 to 0.86 and maximum value of significant SCA effect in desirable direction was recorded in cross P-1125 $\times$ P-2511. For number of kernel length, the specific combining effect varied from -0.65 to 0.61 and maximum value of significant SCA effect in desirable direction was recorded in cross P-1612 $\times$ P-2511. For number of kernel breadth, the specific combining effect varied from -0.09 to 0.08 and maximum value of significant SCA effect in desirable direction was recorded in cross P-1121 $\times$ P-1509. For number of L/B ratio, the specific combining effect varied from -0.34 to 0.31 and maximum value of significant SCA effect in desirable direction was recorded in cross Basmati-370 $\times$ P-2511. With regards to elongation ratio, the SCA effect varied from -0.09 to 0.09. For grain yield per plant, the specific combining effect varied from -3.17 to 2.55 and maximum value of significant SCA effect in desirable direction was recorded in cross P-1592 $\times$ P-2511. The present findings are in accordance with results reported by Singh *et. al.* (2020), Sathya and Jebraj (2015) and Sarial (2014).

Conclusions

It is concluded that different parents had been identified as good general combiners for different traits. The results showed that there was close relationship between mean performance and their GCA effects. Therefore, the lines P-1592, P-1121 and P-1612 and tester P-2511 will be utilized as donor parent in future breeding programme to improve yield and quality attributes in rice. Similarly, the crosses viz., P-1592 $\times$ P-2511, P-1121 $\times$ Mahi Sugandha, P-1121 $\times$ P-2511, Pratap-1 $\times$ P-2511, P-1612 $\times$ P-2511 and Basmati-370 $\times$ P-2511 identified as promising crosses therefore, these crosses further be evaluated for superior transgressive segregants. The crosses having best specific combination for grain yield per plant would have

been obtained either through good $\times$ good, good $\times$ poor, poor $\times$ good and poor $\times$ poor parental combinations.

Acknowledgement

The authors are grateful to the Zonal Director Research, Dean, COA, Kota for providing all the facility in conducting the experiment at Agricultural Research Station, Ummedganj, Kota.

References

1. Ahmed, M.I and Siddiq, E.A. (1998). Hybrid cultivar development. *Narosa Publishing House*, New Delhi, India. pp-221-256.
2. Akanksha and Jaiswal, H.K. (2019). Combining ability studies for yield and quality parameters in basmati rice (*Oryza sativa* L.) genotypes using diallel approach. *Electronic Journal of Plant Breeding*, 10 (1): 9-17.
3. Kirubha, A. M., Gnanamalar, R.P., Thangaraj, K., Kavitha Pushpam, A. and Priyanka, A. R. (2019). Gene action and combining ability studies for protein content and grain quality traits in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 10 (1): 58-65.
4. Arunachalam, V. (1974). The fallacy behind the use of modified line $\times$ tester design. *Indian J. Genet.*, 34 (2): 200-207.
5. Kempthorne, O. (1957). An introduction to genetic statistics. *John Wiley and Sons Inc.*, New York.
6. Panse, V.G., and Sukhatme, P.V. (1967). Statistical methods for agricultural workers, *Ind Ed.*, 152-157.
7. Panwar, L.L. (2005). Line $\times$ tester analysis of combining ability in rice (*Oryza sativa* L.). *Indian Journal of Genetics*, 65 (1): 51-52.
8. Saleem, M.Y., Mirza, J.I. and Haq, M.A. (2008). Heritability, genetic advance and heterosis in line $\times$ tester crosses of Basmati rice. *Journal of Agricultural Research Lahore*, 46 (1): 15-26.
9. Singh, N.K. and Kumar, A. (2004). Combining ability analysis to identify suitable parents for heterotic rice hybrid breeding. *International Rice Research Notes*, 29 (1): 21-22.
10. Singh, V., Dwivedi, D.K., Khan, N.A., Verma, R.L., Kumar, M., Jena, D., Rout, D., Arsode, P. and Samantaray, S. (2020). Combining ability analysis for yield and contributing traits in short duration rice (*Oryza sativa* L.). *Oryza*, 57 (4): 271-276.
11. Sathya R, and Jebraj, S. (2013). Heritability and genetic advance estimates from three line rice hybrids under aerobic condition. *International Journal of Agricultural Science and Research*. 3 (3): 69-74.
12. Sarial, A.K. (2014). Heterosis and combining ability analysis for grain quality and physico-chemical traits involving fertility restorers with basmati background in Rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 5 (4): 615-625.



Long-Term Consequences of Carbon Sequestration in Micro Aggregate of Soils with Different Clay Mineralogy on Stabilization

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Abstract

The smectic clays are more potent in accumulation and sequestration of SOC in black cotton soils of India. Sorption is influenced by the chemical properties of a mineral, mainly the surface chemistry, which includes the surface structure of the mineral, and is also influenced by the physical properties, e.g. the specific surface area (SSA) and the porosity. Soil organic matter sorption seems to increase with increasing specific surface area (SSA) of soil minerals. SSA in soils can be related to the oxide content. Ligand exchange occurs mostly in acid soils and soils which are rich in oxides. Perhaps ligand exchange is more relevant in subsoils, because of the smaller surface loadings. The bonds by ligand exchange are very strong, they are able to outlast over 100 years. In neutral and alkaline soils mostly Ca^{2+} and Mg^{2+} occur, whereas in acid soils additionally Fe^{3+} and Al^{3+} form cation bridges with SOM by electrostatic bonding. The coordination complexes of the Fe^{3+} and Al^{3+} ions are considerably stronger in comparison to those with Ca^{2+} . Ligand exchange is considered to be the most efficient binding mechanism at lower pH values on porous clay minerals. As pH increases, adsorption of SOM to mineral surfaces generally decreases. The pH affects the surface charge of variable-charge minerals, e.g. Fe and Al hydroxides. On hydroxylated surfaces, the net surface charge becomes increasingly negative as pH increases. Increase in temperature will cause reduction in stabilization due to desorptive effect of greater affinity molecules from soil mineral surfaces. Mineral characteristic exerts control on top soil organic carbon pool, such information is crucial to assess the site specific potential of afforestation to mitigate global warming. So this provides scope for development of a method that can predict capacity of different soils to stabilize the SOM.

Key words : Stabilization, pyrophyllite, hydroxylated, temperature.

Introduction

In 1992, the Kyoto Protocol on climate change demanded the fundamental understanding of the stabilization of carbon in soils. The reason for this lies in the fact that one of the largest sinks of organic carbon on the global scale is the organic matter stored in soils (Kalbitz *et al.*, 2005). Changes in the size and the turnover rate of the soil carbon pools could possibly have an effect on the atmospheric CO_2 concentration and the global climate (Lützow *et al.*, 2006). Although the ability of the soil to store organic matter and to prevent it (partly) from mineralization to CO_2 has received growing interest in the last years, the mechanisms for carbon stabilization are still not entirely clear, and the potential of the soil for carbon stabilization is unknown (Kaiser and Guggenberger, 2003).

Stabilization of soil organic C (SOC) is pre-requisite for long-term C sequestration to mitigate climate change. Stabilization of SOC means the decrease in the potential loss of organic C by microbial respiration, erosion or

leaching (Sollins *et al.*, 1996). More than 45% of TOC is in the form of stabilized SOC (Lewandowski *et al.*, 2002).

Sorption to mineral surfaces is considered to be the most effective mechanism that protects SOC against microbial degradation (Mikutta *et al.*, 2007). The stabilization of SOC is not only influenced by the amount (i.e., soil texture) of but also the type of clays present. The sandy clay loam soils of Pattambi, Kerala stabilized more silt+clay protected C than sandy loam soil of Bhubaneswar, Odisha (Sukumaran *et al.*, 2016). The smectic clays are more potent in accumulation and sequestration of SOC in black cotton soils of India (Bhattacharyya *et al.*, 2005). Sorption is influenced by the chemical properties of a mineral, mainly the surface chemistry, which includes the surface structure of the mineral, and is also influenced by the physical properties, e.g. the specific surface area (SSA) and the porosity. Soil organic matter sorption seems to increase with increasing specific surface area (SSA) of soil minerals (Kahle *et al.*, 2004). SSA in soils can be related to the oxide content (Kleber *et al.*, 2005). Mikutta *et al.*, (2007) approximated the contribution of binding mechanisms between forest

floor organic matter and goethite, pyrophyllite and vermiculite at pH 4. Ligand exchange occur mostly in acid soils and soils which are rich in oxides. Perhaps ligand exchange is more relevant in subsoils, because of the smaller surface loadings. The bonds by ligand exchange are very strong, they are able to outlast over 100 years (Lützow *et al.*, 2006). In neutral and alkaline soils mostly Ca^{2+} and Mg^{2+} occur, whereas in acid soils additionally Fe^{3+} and Al^{3+} form cation bridges with SOM by electrostatic bonding. The coordination complexes of the Fe^{3+} and Al^{3+} ions are considerably stronger in comparison to those with Ca^{2+} (Lützow *et al.*, 2006).

Materials and Methods

Control on stabilization : Potential controls on stabilization and destabilization are diagrammed in Fig.-1. This figure focuses specifically on stabilization as they relate to respiration. It has been drawn with stabilization as separate circles, each divided into three parts: change in recalcitrance, change in interactions, and change in accessibility (Cheshire *et al.*, 1974; Ladd *et al.*, 1993). Recalcitrance comprises molecular-level characteristics of organic substances, including elemental composition, presence of functional groups, and molecular conformation, that influence their degradation by microbes and enzymes. Interaction of soil organic C with other substances can increase stabilization with respect to microbial respiration. Through precipitation, sorption, and complexation reactions, organics may interact with other organics or with inorganic materials, such as clay surfaces or dissolved aluminum and iron, thereby lowering their potential to be acted upon by microorganisms and their extracellular enzymes. The reactions are influenced by the chemical environment and by the surface properties of clay minerals.

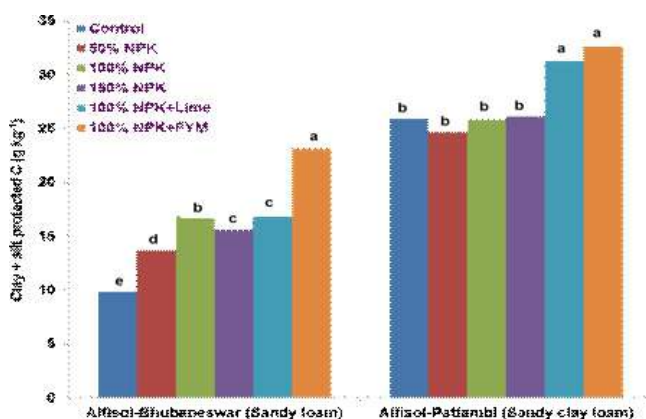


Fig.-1 : Long-term effect of manuring and fertilization on clay + silt protected C in two Alfisols with different texture.

Mechanisms of soil organic matter stabilization (Protection)

Chemical stabilization : Through chemical or physio-chemical binding between SOM and soil minerals. SOM associated with the $<20 \mu\text{m}$ is better protected against decomposition. Protection determined by extent of adsorption and nature of bonding, if bonding is strong like ligand exchange stabilization also strong. It also depends on the surface chemistry of minerals also.

Physical stabilization : Stabilization of SOM from microbial decomposition through occlusion within macro- and micro-aggregates and Inaccessibility of substrate to microbes and enzymes, 50% of organic matter is protected by this mechanism (Elliott *et al.*, 1996). It depends on the formation of micro aggregate and micro aggregate stability. It may vary with intercultural operations like tillage puddling etc.

Biochemical stabilization : Protection of SOM from microbial decomposition due to the complex chemical composition of the organic matter (e.g. recalcitrant compounds such as lignin and polyphenols), this complex chemical composition can be an inherent property of plant residue, or be acquired during decomposition.

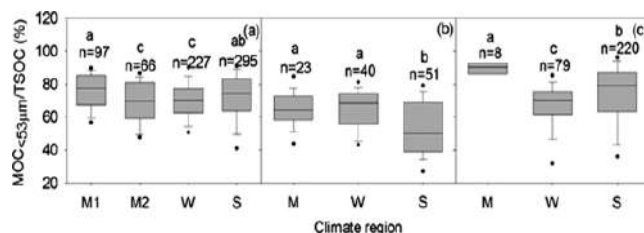


Fig.-2 : Effect of climate on MOC – stabilization.

Stabilization of OM in relation with soil texture : The capacity to protect organic carbon (C) and nitrogen (N) in fine textured soils is higher than coarse textured soils with similar addition of organic inputs (Hassink *et al.*, 1997; Jenkinson, 1988). Association with silt and clay particles can be attributed as one of the main factors responsible for the physical protection of organic carbon and nitrogen in soil (Theng, 1979). In fine soil fractions, the C and N associated is largely affected by soil texture, unlike in large fractions, where it is mainly regulated by organic inputs rather than soil texture (Christensen, 1992; Garwood *et al.*, 1972). Most of this organic matter exists in the colloidal fraction of the soil but larger particles also have organic coatings. The study done by suvana *et al.*, (2016), they found that the C and N carrying capacity in the silt+clayfraction of Alfisol was greatly influenced by soil texture. Alfisol of Pattambi having sandy clay loam in texture stabilized more amount of C and N than Alfisol of Bhubaneswar having sandy loam in texture (fig.-3).

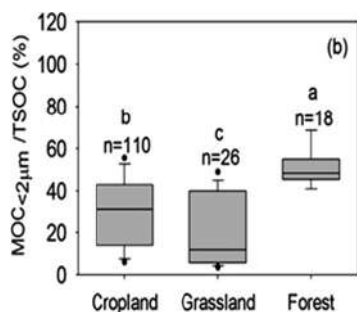


Fig-3 : Temperature effect on micropore surface area of ferrihydrite and OC sorption.

Textural differences also influence stabilization. The soil with more finer fraction stabilize more organic carbon than that of coarser soil. Chemically stabilized organic carbon mainly occurs through organo mineral interaction with clay minerals and organic matter.

Bonding mechanism in organo-mineral complex :

Different binding mechanisms can occur between soil organic matter and mineral surfaces depending on the properties of both the mineral surface and the soil organic matter.

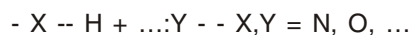
Ligand exchange : An important mechanism for the formation of strong complexes of organic matter and mineral surfaces is anion exchange between singly coordinated OH groups on mineral surfaces, carboxyl groups (COOH) and phenolic OH groups of the soil organic matter, e.g. Fe-O-C bonds (Lützw *et al.*, 2006). Anions possess one or more atoms with a lone pair of electrons and thus can act as the donor in a coordinate bond (Cornell and Schwertmann, 2003).

Bridges of polyvalent cations : Organic anions are normally pushed away from negatively charged surfaces in soils. Bindings can only occur if there are polyvalent cations, which neutralize the mineral surface by acting like a bridge and adjusting the charge of the negatively charged mineral surface as well as the charge of the acidic functional group of the organic matter (COO⁻). In neutral and alkaline soils mostly Ca²⁺ and Mg²⁺ occur, whereas in acid soils additionally Fe³⁺ and Al³⁺ form cation bridges. The coordination complexes of the Fe³⁺ and Al³⁺ ions are considerably stronger in comparison to those with Ca²⁺ (Lützw *et al.*, 2006).

Weak interactions Van der Waals forces : Van der Waals forces are electrostatic forces caused by a temporarily fluctuating dipole moment arising from a brief shift of orbital electrons to one side of an atom or molecule which creates a similar shift in adjacent atoms or molecules (Lützw *et al.*, 2006). Van der Waals forces are nonspecific interactions which can form between any kinds of molecules, no matter what chemical structure they have (Schwarzenbach *et al.*, 2003).

Hydrophobic interactions : Non-polar residues are excluded from water by entropy-related interactions to force the non-polar groups together. Hydrophobic interactions become more favourable at low pH due to the protonation of hydroxyl and carboxyl groups of OM and the suppressed ionisation of the carboxyl groups (Lützw *et al.*, 2006).

H-Bonding : A hydrogen atom with a positive partial charge interacts with partially negative charged N or O atoms (Lützw *et al.*, 2006). Hydrogen does not possess any inner electrons isolating the nucleus from the bonding electrons, it consists only of one proton. If hydrogen bonds with highly electronegative atoms, the bonding electrons are drawn to the electronegative atom, leaving the proton exposed at the outer end of the covalent bond. This proton can now attract another electron-rich center and form a hydrogen bond (Schwarzenbach *et al.*, 2003).



Weak interaction occurs in all soils, no preference was found (Lützw *et al.*, 2006).

Models of organo-mineral interaction : Decades ago, earth scientists acknowledged the ability of mineral particles to protect soil organic matter (SOM) from biological attack (Jung, 1943; Allison *et al.*, 1949). In temperate, cultivated soils, 50–75% of SOM exists within clay-sized organomineral particles (Christensen, 2001), and numerous researchers have reported positive correlations between the contents of mineral particles and carbon in soils (Körschens, 1980; Nichols, 1984; Burke *et al.*, 1989; Mayer and Xing, 2001).

Wershaw bilayer model : The soluble mixtures of organic molecules representing a significant fraction of SOM can form organized structures called micelles within aqueous solution, structures that consist of hydrophilic exterior regions that shield hydrophobic interiors from contact with water molecules (von Wandruszka, 1998). Because amphiphilic molecules are requisite to the formation of micelles, the ability of SOM components to form these structures suggests that many of these molecules are amphiphilic. Significant to this insight, Wershaw (1993) previously developed a bilayer model of organo-mineral interactions (Fig.-4.) that sharply contrasted with the traditional view of organo-mineral interactions (Stevenson 1985), which were visualized as associations of large, multifunctional polymers with mineral surfaces via a broad range of bonding mechanisms (Stevenson, 1985; Leinweber and Schulten, 1998). Further, Wershaw and Pinckney (1980) postulated that decayed organic materials are often bound to clay surfaces by amino acids or proteins, based on the observation that deamination of organo-mineral

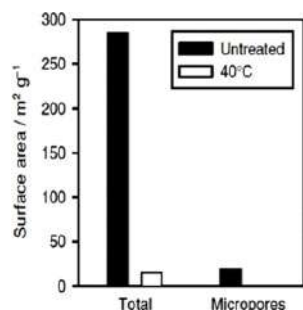


Fig.-4 : Temperature effect of Surface area.

complexes with nitrous acid released organic materials from the clay.

Zonal model : The zonal structure of organo-mineral associations (Fig.-5), based on the amphiphilicity of SOM fragments, and the intimate involvement of proteinaceous compounds in stable organo-mineral associations, as defined here, a zonal structure is formed when the organic matter attached to a mineral surface is segregated into more than one layer or zone of molecules, such that not all adsorbed molecules are in contact with the mineral surface. Assuming such a zonal structure, we are able to account simultaneously for a number of phenomena observed in soils and sediments.

Micro aggregate model : Organo-mineral interactions manifest themselves primarily as organic surface coatings on clay particles, which can be considered an aggregate when sandwiched between two clay particles (Fig.-6). From that perspective, one can ask whether the interaction with mineral surfaces or the protection by its location between minerals confers more stability to the organic matter.

A spatial distinction of organic matter forms becomes important to distinguish organic coatings that bear very different chemical characteristics than organic debris in pores (Kinyangi *et al.*, 2006). Interactions between microbial metabolites and mineral surfaces are important in initiating OM stabilization and that physical occlusion within micro aggregates is a secondary stabilization process

Mineral properties controlling stabilization Clay mineral type : From the study of (Bhattacharyya *et al.*, 1993, 1997; Shirsath *et al.*, 2001) they found that the type of clay is also important in stabilization more than the clay percentage. They have studied two soil from same order having different clay percentage. SOC content (Table. 4) and smectite content of Alfisols of Satpura (P3) and that of the Western Ghats (P6) are compared. Even under forests, the Alfisols of the Western Ghats (P6) had lesser amount of SOC due to lower amount of smectite than the Alfisols of the Satpura (P3) under agriculture.

Presence of amorphous oxide : Effects of goethite coatings on kaolinite, illite, and smectite on DOC sorption, the effect of coating illitic clay with different hydrous iron oxides (haematite, goethite, ferrihydrite) on DOC sorption was studied in another experiment. Organic matter extracted from dried medic (*Medicago truncatula* cv. Praggio) shoot residue was reacted with minerals at DOC concentrations ranging from 0 to 200 mg C L⁻¹ at pH 6.0. The maximum adsorption capacity (Q_{max}) of phyllosilicate clays, as determined from fits to the Langmuir equation, increased in the order kaolinite b illite b smectite on a mass basis and illite b smectite b kaolinite on a surface area basis.

The sorption capacity of kaolinitic clay increased significantly with goethite coating. The presence of goethite reduced desorption from kaolinitic clays but did not influence desorption from illitic and smectitic clays. The results suggest that interactions of hydrous iron oxides and phyllosilicate clays can modify DOC sorption and desorption, probably by affecting the surface charges and SSA. Study done by Kleber *et al.*, (2005) also found that amorphous iron and aluminium oxide better co relate with that crystalline oxides. Crystalline minerals exhibit smaller SSA values and hydroxyl site densities than poorly crystalline minerals (Bracewell *et al.*, 1970), and thus are less efficient in forming organo-mineral associations than poorly crystalline minerals. Consequently, crystalline Fe oxides need to be present in substantial amounts (>45 g/kg soil; Figure 8) to protect similar proportions of OM as samples containing moderate amounts of poorly crystalline minerals.

Specific surface area (SSA) : The organic carbon content of soil is positively related to the specific surface area (SSA), but large amounts of organic matter in soil result in reduced SSA as determined by applying the Brunauer–Emmett–Teller (BET) equation to the adsorption of N₂.

Results and Discussion

Factors influencing stabilization

Temperature : The response of soil organic matter (OM) decomposition to increasing temperature is a critical aspect of ecosystem responses to global change. The impacts of climate warming on decomposition dynamics have not been resolved due to apparently contradictory results from field and lab experiments, most of which has focused on labile carbon with short turnover times. But the majority of total soil carbon stocks are comprised of organic carbon with turnover times of decades to centuries. Understanding the response of these carbon pools to climate change is essential for forecasting longer-term changes in soil carbon storage.

Effect of pH : Effects of the pH variation on the complexation of humic substances by dried clay-humus systems were investigated. The amounts of FA (fulvic acid) fixed, when FA solutions at various pH values were complexed with Ca-montmorillonite, Ca-illite and Ca-kaolinite, were determined. The amounts of FA extractable at different pH values from FA@H 7.0)-clay-complexes were determined; the variation of extraction of HA (humic acid) at two different temperatures, from Ca-clay-HA complexes were also studied. Mainly electrostatic; water-bridges may exist between such links, even when the complexes are dry.

Type of organic matter added : Mineralization of DOC is decreased with increase in degree of decomposition of the parent solid material. Experiment done by Karsten *et al.*, (2005) they found that the stabilization of decomposed organic matter is more than that of fresh organic matter. They studied the mineralization rate of fresh maize solution, organic matter extracted from Oi layer of soil and organic matter extracted from Oa layer.

After adsorption of these OM to the clay mineral they found that the OM from the Oa layer is more stabilized than that of fresh maize solution. Finding the mean residence time they found that Oa adsorbed OM have a MRT of 95 year (Table-10) but the adsorbed fresh organic matter have MRT only 1.5 year.

Different land use : Study done by Zhang *et al.*, 2016 on different land use of crop land grass land and forest land. They found stabilization is vary with different land use.

SOC stabilization in grasslands is likely due primarily to physical protection by macro- and micro-aggregates. In cropland, medium and coarse soils appeared to be of equal importance in SOC stabilization as fine soil. Organic C stabilization by clay particles was more important for SOC accumulation in forest soil.

MOC-(Mineral-Grasslands differ from forests and croplands in having a larger proportion of underground biomass and fine roots, which facilitate the formation of aggregates (O'Brien and Jastrow, 2013). Thus, SOC stabilization in grasslands is likely due primarily to physical protection by macro- and microaggregates.

Effect of climate : Study done by Zhang *et al.*, 2016 in china they have found that climate have a greater influence on stabilization by improving the mineralization. When they compared MOC<53 mm/TSOC ratios across climatic regions (Fig. 13), they found evidence suggesting that climate was a major factor in regulating MOC/TSOC ratios.

Cropland soils in the humid typical-temperate zones (mainly in northern China) and the subtropical zones

(southern China), MOC<53 mm/TSOC ratios were 0.77 and 0.74, respectively.

Effect of soil type : In all six soil types across the three land uses, MOC<53 mm was positively correlated with TSOC.

The significant linear regressions indicated that MOC<53 mm/TSOC ratios were relatively stable at a given TSOC range. Because these soils were categorized based on intrinsic differences in soil mineral content, the significant partial coefficient of TSOC accumulation to MOC<53 mm (i.e., the slope of the regression) demonstrated that differing responses to organic C among soil types was likely due to their mineral content (Table 11). For example, ultisol is richer in iron and aluminum (oxy) hydroxides than the other five soil groups (Wagai *et al.*, 2013).

The large surface area and absorption capacity of iron and aluminum (oxy) hydroxides enable ultisols to exhibit more organo-mineral binding (Spielvogel *et al.*, 2008; Wiseman and Püttmann, 2006).

A relatively high MOC/TSOC ratio was also found in mollisols, which were mainly distributed in the temperate regions of northeast China. This soil type has been found to possess a higher percentage of organic C than other soils in the same area, despite having similar fine-fraction proportions (Zhao *et al.*, 2006).

Effects of management : Study found significant, positive linear correlations between MOC<53 mm and TSOC in cropland, with MOC/TSOC ratios of 0.58e0.75 (Table-12). Agricultural management can alter microenvironment conditions in soil and consequently influence SOC decomposition and stabilization, processes that are further complicated by practices such as routine fertilization and drying rewetting cycles, which strongly affect soil nutrient cycling (Jarvis *et al.*, 2007; Pan *et al.*, 2009). In this study, average MOC<53 mm/TSOC ratios were similar in the mono- and double-cropping systems (0.70 and 0.73), although more variation was observed in the double-cropping than in the monocropping soils. These results demonstrate that different cropping practices were unlikely to change the way that gross organic C inputs were partitioned into different SOC pools. Fertilization greatly affects MOC/TSOC ratios because it alters the quantity and quality of organic C inputs. We found that under mineral fertilizer applications, the average MOC<53 mm/TSOC ratios were much higher in paddy fields (0.75) than in other agricultural land uses (0.58e0.68). However, under organic fertilizer applications, the average MOC<53 mm/TSOC ratio in uplands was significantly higher than in paddy fields (Table-12). With mineral fertilizers

application, soils in both upland and paddy field were far from saturation (Zhang *et al.*, 2012, 2010). This difference may be due to the frequent drying-rewetting procedures in paddy fields, which could enhance the stabilization of organic C by soil minerals (Cosentino *et al.*, 2006; Muhr *et al.*, 2010). Moreover, the large absorption capacity of iron and aluminum (oxy) hydroxides in paddy soils likely caused more organo-mineral binding, also increasing organic C stabilization. Finally, the strong influence of fertilization on MOC/TSOC ratios is further supported by the reversal we found when organic fertilizer was used.

It is concluded that the clay mineral type instead of clay content is a more important factor in accumulation and sequestration of SOC. Presence of poly-valent cation and amorphous oxides can influence mineral associated stabilization. Quality of organic matter and nature of organic compound can be influence stabilization of organic matter on mineral surface in soil. Better understanding of stabilization mechanism is important to assess site-specific potentials of afforestation to mitigate global warming. Management of stabilization of soil organic matter through mineral interaction is very difficult.

References

- Amundson, R., and Biardeau, L. (2018). Opinion: Soil carbon sequestration is an elusive climate mitigation tool. *Proceedings of the National Academy of Sciences*, 115(46), 11652-11656.
- Angst, G., Kögel-Knabner, I., Kirfel, K., Hertel, D., and Mueller, C.W. (2016). Spatial distribution and chemical composition of soil organic matter fractions in rhizosphere and non-rhizosphere soil under European beech (*Fagus sylvatica* L.). *Geoderma*, 264, 179-187.
- Baveye, P.C., Schnee, L.S., Boivin, P., Laba, M., and Radulovich, R. (2020). Soil organic matter research and climate change: Merely re-storing carbon versus restoring soil functions. *Frontiers in Environmental Science*, 8, 161.
- Baveye, P., Berthelin, J., Tessier, D., and Lemaire, G. (2018). The "4 per 1000" initiative: a credibility issue for the soil science community? *Geoderma*, 309 (Supplement C), 118-123.
- Bhattacharyya, T., Pal, D.K., Chandran, P., and Ray, S.K. 2005. Land-use, clay mineral type and organic carbon content in two Mollisols-Alfisols-Vertisols catenary sequences of tropical India. *Clay Res.*, 24: 105-122.
- Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P. and Griscom, B.W. (2020). The role of soil carbon in natural climate solutions. *Nature Sustainability*, 3(5), 391-398.
- Cai, A., Feng, W., Zhang, W., and Xu, M. 2016. Climate, soil texture, and soil types affect the contributions of fine-fraction- stabilized carbon to total soil organic carbon in different land uses across China. *J. Environ. Manage.*, 172: 2-9.
- Chenu, C., Angers, D.A., Barré, P., Derrien, D., Arrouays, D., and Balesdent, J. (2019). Increasing organic stocks in agricultural soils: Knowledge gaps and potential innovations. *Soil and Tillage Research*, 188, 41-52.
- Conant, R.T., Ryan, M.G., Agren, G.I., Birge, Cotrufo, M.F., Ranalli, M.G., Haddix, M.L., Six, J., and Lugato, E. (2019). Soil carbon storage informed by particulate and mineral-associated organic matter. *Nature Geoscience*, 12(12), 989-994.
- Eusterhues, K., Rumpel, C., Kleber, M. and Kögel-Knabner, I. 2003. Stabilisation of soil organic matter by interactions with minerals as revealed by mineral dissolution and oxidative degradation. *Organic Geochem*, 34(12): 1591-1600.
- Fuss, S., Lamb, W.F., Callaghan, M. W., Hilaire, J., Creutzig, F., Amann, T., ... & Minx, J. C. (2018). Negative emissions—Part 2: Costs, potentials and side effects. *Environmental Research Letters*, 13(6), 063002.
- H.E., Davidson, E.A., Eliasson, P.E., and Hyvönen, R. 2011. Temperature and soil organic matter decomposition rates— synthesis of current knowledge and a way forward. *Global Change Biol.*, 17(11): 3392-3404.
- Kleber, M., and Lehmann, J. (2019). Humic substances extracted by alkali are invalid proxies for the dynamics and functions of organic matter in terrestrial and aquatic ecosystems. *Journal of environmental quality*, 48(2), 207-216.
- Kleber, M., Sollins, P., and Sutton, R. 2007. A conceptual model of organo-mineral interactions in soils: self-assembly of organic molecular fragments into zonal structures on mineral surfaces. *Biogeochem.*, 85(1): 9-24.
- L.M. 2012. Effects of clay mineralogy and hydrous iron oxides on labile organic carbon stabilisation. *Geoderma*, 173: 104-110.
- Lavallee, J. M., Soong, J. L. and Cotrufo, M. F. (2020). Conceptualizing soil organic matter into particulate and mineral-associated forms to address global change in the 21st century. *Global Change Biology*, 26(1), 261-273.
- Mikutta, R., Mikutta, C., Kalbitz, K., Scheel, T., Kaiser, K., and Jahn, R. 2007. Biodegradation of forest floor organic matter bound to minerals via different
- Oldfield, E.E., Bradford, M.A., and Wood, S.A. (2019). Global meta-analysis of the relationship between soil organic matter and crop yields. *Soil*, 5(1), 15-32.
- Pett-Ridge, J., Nuccio, E., and McFarlane, K. (2018). Deeply Rooted: Evaluating Plant Rooting Depth as a Means for Enhanced Soil Carbon Sequestration (No. LLNL-CONF-750320). Lawrence Livermore National Lab. (LLNL), Livermore, CA (United States).
- Poultou, P., Johnston, J., Macdonald, A., White, R. and Powlson, D. (2018). Major limitations to achieving "4 per 1000" increases in soil organic carbon stock in temperate regions: Evidence from long-term experiments at Rothamsted Research, United Kingdom. *Global Change Biology*, 24(6), 2563-2584.
- Robertson, A.D., Paustian, K., Ogle, S., Wallenstein, M.D., Lugato, E., and Cotrufo, M.F. (2019). Unifying soil organic matter formation and persistence frameworks: the MEMS model. *Biogeosciences*, 16(6), 1225-1248.
- Roth, V.N., Lange, M., Simon, C., Hertkorn, N., Bucher, S., Goodall, T. and Gleixner, G. (2019). Persistence of dissolved organic matter explained by molecular changes during its passage through soil. *Nature Geoscience*, 12(9), 755-761.

23. Saidy, A.R., Smernik, R.J., Baldock, J.A., Kaiser, K., Sanderman, J., & Macdonald,
24. Schmidt, R., Gravuer, K., Bossange, A. V., Mitchell, J. and Scow, K. (2018). Long-term use of cover crops and no-till shift soil microbial community life strategies in agricultural soil. *PLoS one*, 13(2), e0192953.
25. Smith, P., Soussana, J. F., Angers, D., Schipper, L., Chenu, C., Rasse, D. P., ... & Klumpp, K. (2020). How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. *Global Change Biology*, 26(1), 219-241.
26. Sokol, N.W., Kuebbing, S.E., Karlsen-Ayala, E., & Bradford, M. A. (2019). Evidence for the primacy of living root inputs, not root or shoot litter, in forming soil organic carbon. *New Phytologist*, 221(1), 233-246.
27. Wiseman, C.L.S. and Püttmann, W. 2006. Interactions between mineral phases in the preservation of soil organic matter. *Geoderma*, 134(1): 109-118.
28. Amundson, R., and Biardeau, L. (2018). Opinion: Soil carbon sequestration is an elusive climate mitigation tool. *Proceedings of the National Academy of Sciences*, 115(46), 11652-11656.
29. Angst, G., Kögel-Knabner, I., Kirfel, K., Hertel, D., and Mueller, C. W. (2016). Spatial distribution and chemical composition of soil organic matter fractions in rhizosphere and non-rhizosphere soil under European beech (*Fagus sylvatica* L.). *Geoderma*, 264, 179-187.
30. Baveye, P., Berthelin, J., Tessier, D., and Lemaire, G. (2018). The "4 per 1000" initiative: a credibility issue for the soil science community? *Geoderma*, 309 (Supplement C), 118-123.
31. Baveye, P.C., Schnee, L.S., Boivin, P., Laba, M. and Radulovich, R. (2020). Soil organic matter research and climate change: Merely re-storing carbon versus restoring soil functions. *Frontiers in Environmental Science*, 8, 161.
32. Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P. and Griscom, B.W. (2020). The role of soil carbon in natural climate solutions. *Nature Sustainability*, 3(5), 391-398.
33. Chenu, C., Angers, D.A., Barré, P., Derrien, D., Arrouays, D. and Balesdent, J. (2019). Increasing organic stocks in agricultural soils: Knowledge gaps and potential innovations. *Soil and Tillage Research*, 188, 41-52.
34. Cotrufo, M.F., Ranalli, M.G., Haddix, M.L., Six, J. and Lugato, E. (2019). Soil carbon storage informed by particulate and mineral-associated organic matter. *Nature Geoscience*, 12(12), 989-994.
35. Fuss, S., Lamb, W.F., Callaghan, M.W., Hilaire, J., Creutzig, F., Amann, T. and Minx, J.C. (2018). Negative emissions—Part 2: Costs, potentials and side effects. *Environmental Research Letters*, 13(6), 063002.
36. Kleber, M. and Lehmann, J. (2019). Humic substances extracted by alkali are invalid proxies for the dynamics and functions of organic matter in terrestrial and aquatic ecosystems. *Journal of environmental quality*, 48(2), 207-216.
37. Lavallee, J.M., Soong, J.L. and Cotrufo, M.F. (2020). Conceptualizing soil organic matter into particulate and mineral-associated forms to address global change in the 21st century. *Global Change Biology*, 26(1), 261-273.
38. Oldfield, E.E., Bradford, M.A. and Wood, S.A. (2019). Global meta-analysis of the relationship between soil organic matter and crop yields. *Soil*, 5(1), 15-32.
39. Pett-Ridge, J., Nuccio, E. and McFarlane, K. (2018). *Deeply Rooted: Evaluating Plant Rooting Depth as a Means for Enhanced Soil Carbon Sequestration* (No. LLNL-CONF-750320). Lawrence Livermore National Lab.(LLNL), Livermore, CA (United States).
40. Poulton, P., Johnston, J., Macdonald, A., White, R. and Powlson, D. (2018). Major limitations to achieving "4 per 1000" increases in soil organic carbon stock in temperate regions: Evidence from long-term experiments at Rothamsted Research, United Kingdom. *Global Change Biology*, 24(6), 2563-2584.
41. Roth, V.N., Lange, M., Simon, C., Hertkorn, N., Bucher, S., Goodall, T. and Gleixner, G. (2019). Persistence of dissolved organic matter explained by molecular changes during its passage through soil. *Nature Geoscience*, 12(9), 755-761.
42. Robertson, A.D., Paustian, K., Ogle, S., Wallenstein, M.D., Lugato, E. and Cotrufo, M.F. (2019). Unifying soil organic matter formation and persistence frameworks: the MEMS model. *Biogeosciences*, 16(6), 1225-1248.
43. Schmidt, R., Gravuer, K., Bossange, A.V., Mitchell, J. and Scow, K. (2018). Long-term use of cover crops and no-till shift soil microbial community life strategies in agricultural soil. *PLoS one*, 13(2), e0192953.
44. Smith, P., Soussana, J.F., Angers, D., Schipper, L., Chenu, C., Rasse, D.P. and Klumpp, K. (2020). How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. *Global Change Biology*, 26(1), 219-241.
45. Sokol, N.W., Kuebbing, S.E., Karlsen, Ayala, E. and Bradford, M.A. (2019). Evidence for the primacy of living root inputs, not root or shoot litter, in forming soil organic carbon. *New Phytologist*, 221(1), 233-246.



General and Specific Combining Ability Analysis for Yield and Some of its Associated Characters in Late Sown Condition in Bread Wheat (*Triticum aestivum* L. em. Thell)

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Abstract

In order to analyze combining ability for yield and some of its associated characters in late sown condition in bread wheat (*Triticum aestivum* L. em. Thell), the present experiment was carried out performing diallel analysis following Griffing (1956) Method II Model I. Ten genetically diverse parents were selected and crossed in half diallel fashion excluding reciprocals. These parents were evaluated along with their 45 F₁'s and 45 F₂'s in a randomized block design with 3 replications. Significant differences were observed among the parents, generations, F₁, F₂ and parents v/s generations for all the characters except for number of tillers per plant among the parents and grain filling period for parents v/s generations. Significant mean squares due to GCA and SCA for all the characters except GCA for number of tillers per plant in F₁ and SCA for number of tillers per plant in F₁ indicating that both additive and non-additive gene effects played an important role in the genetic control of the traits studied. The GCA / SCA variance ratio was less than unity indicated the importance of non-additive gene action for all the characters under investigation. Based on an overall evaluation of GCA effects and *per se* performance, the parent parents Raj 3765, Raj 4083 and Raj 4079 emerged as good general combiners while the crosses Raj 4238 X Raj 4238 and Raj 4120 X DBW 17 emerged as good specific cross combinations for grain yield and some other attributes. As a consequence of predominant non-additive gene action in the present study, breeding approaches such as reciprocal recurrent selection, diallel selective mating, bi-parental mating and multiple cross would be useful breeding approaches for developing new genotypes from potent breeding material identified.

Introduction

Wheat, a cereal crop which stands at prime position among cereals in terms of acreage, production and versatility in adaptation to wider range of agro-environmental situations. Wheat is the third most produced food grain in the world after maize and rice which stands second to rice as the main human feed and ahead of maize as maize is more extensively used for animal feed. It is staple food for more than one billion people of the country and also in as many as 43 countries of the world. In India even after the making the noteworthy progress in wheat production during recent years, it is necessary to further more increase the productivity level of the crop to meet the requirements and to keep pace with the burgeoning population growing at 1.2% per annum (Anonymous, 2015) and changing food habits of rural and urban population. Hence, the fundamental objective of most of the plant breeding programmes remain to evolve varieties with improved and high yield potential. Yield which is a complex character influenced by various contributing traits, sowing time, environmental stresses and so. (confirmed by various studies and Grafius (1959) even doubted the existence of genes for yielding ability) Hence. Improvement in yield requires component breeding approach. For this, a breeder needs

to identify suitable breeding methodology, which primarily depends upon the combining ability, nature and magnitude of different types of gene actions and overall inheritance pattern for yield and yield contributing characters.

Diallel mating design is widely used in plant breeding research to obtain information on genetic effects for a fixed set of parental lines or estimates of general combining ability, specific combining ability.

Therefore, using ten genetically diverse parents viz., Raj 3765, DBW 621 50, Raj 3077, Raj 4079, Raj 4120, HD 2967, Raj 4083, Raj 4238, DBW 17 and DBW 88 were subjected to diallel mating (excluding reciprocals) in the present study.

Materials and Methods

On the basis of genetic diversity and their stability for different yield traits, ten diverse wheat varieties selected as the experimental material and crossed in diallel mating fashion excluding reciprocals to obtain 45 F₁'s in *rabi* 2014-2015. In *Rabi* 2015-16 ten genotypes along with their 45 F₁'s and 45 F₂'s (obtained at IARI, regional station, Wellington, TN during *kharif* 2015) progenies were evaluated using Randomized Block in 3 replications at Agricultural Research Farm of RARI, Durgapura.

Table-1 : Analysis of variance sowing mean squares for parents F₁'s and F₂'s for yield and its contributing attributes.

	df	Days to heading	Days to maturity	Grain filling period	Plant height	Flag leaf area	Effective tiller per plant	Spike length	Grain per spike	1000 grain weight	Harvest index	Grain yield per plant
Replications	2	0.46	10.59	0.35	8.54	13.17	1.31	1.84	3.20	2.17	3.95	9.45
Genotypes	99	20.11**	48.44**	74.29**	64.22**	19.74**	2.67**	10.06**	97.38**	69.77**	46.26**	33.82**
Parents	9	6.96**	33.94**	61.36**	79.59**	23.50**	0.58	12.20**	67.52**	19.18**	34.29**	66.19**
Generations	89	21.36**	50.00**	76.42**	62.37**	19.18**	2.78**	9.67**	93.49**	70.53**	47.50**	29.64**
F ₁	44	17.57**	62.28**	70.39**	59.16**	17.59**	2.15**	8.54**	88.45**	72.35**	36.57**	20.99**
F ₂	44	18.46**	38.24**	72.76**	64.46**	20.25**	1.96**	7.97**	100.11**	67.23**	54.50**	19.34**
F ₁ vs F ₂	1	316.07**	26.70*	503.15**	111.38**	42.49*	66.61**	134.73**	23.79*	135.76**	220.75**	863.42**
Parents vs generations	1	26.78**	40.28*	1.25	90.25**	35.14*	11.24**	25.49**	712.09**	456.60**	43.34**	114.73**
Error	198	1.89	6.04	1.72	5.37	5.97	1.03	1.44	4.60	3.99	4.27	3.90

Table-2 : Analysis of variance for general and specific combining ability for yield and its contributing attributes.

	df	Days to Heading	Days to Maturity	Grain Filling Period	Plant Height cm	Flag Leaf Area cm ²	Tillers/ Plant	Spike Length	Grains/ Spike	1000 grain weight	Harvest Index (%)	Grain Yield/ Plant (g)
GCA												
F ₁	9	10.67**	32.92**	17.99**	44.20**	12.32**	0.56	5.64**	43.20**	5.66**	16.10**	35.88**
F ₂	9	11.98**	19.82**	16.64**	55.23**	13.63**	0.62*	5.33**	47.47**	5.55**	21.14**	16.43**
SCA												
F ₁	45	4.06**	16.13**	23.68**	16.86**	4.94**	0.63*	2.98**	30.06**	8.11**	11.01**	31.68**
F ₂	45	4.87**	11.19**	24.93**	15.53**	5.87**	0.79**	2.36**	31.89**	8.62**	16.68**	7.70**
F ₁	108	0.39	2.21	0.66	1.93	1.88	0.40	0.59	2.23	0.86	1.47	1.10
F ₂	108	0.86	2.11	0.48	1.60	5.87**	0.31	0.42	1.35	1.50	1.38	1.42

Observations were recorded on days to heading (Days), days to maturity (Days), grain filling period (Days), plant height (cm.), flag leaf area (cm²), number of tillers per plant, spike length (cm), number of grains per spike, 1000-seed weight (g), harvest index (%) and grain yield/plant (g). Mean values over selected plants were used for statistical analysis. The mean values of different parents, F₁s and F₂s for all characters were subjected for analysis of variance and the estimates of variance for general combining ability and specific combining ability and their effects were computed by Method 2 (Model I) as suggested by Griffing (1956).

Results and Discussion

Analysis of variance revealed significant differences among parents except for number of effective tillers per plants, significant differences were also observed among the genotypes and generations for all the characters. Further analysis revealed significant mean squares due to parents and F₁ progenies and F₂ progenies. This is also in conformity with the findings obtained by Kaukab *et al.* (2014), Samir and Ismail (2015), Bhardwaj (2017) and Yadav (2017).

Mean squares due to F₁ vs F₂ were found significant for all the characters. Similarly, the differences among parents vs generation were significant for all the traits except for grain filling period indicated the presence of heterosis in all the three environments. Yada (2017) reported similar results.

The combining ability analysis revealed significant mean squares due to GCA and SCA for all the characters in F₁ and F₂ generations except GCA for number of tillers per plant in F₁. The significant differences of GCA and SCA indicated that both additive and non-additive gene effects played an important role in the genetic control of the traits under study. These findings were in close agreement with those reported by Adel *et al.* (2013), Kalhoro *et al.* (2015). Kumar and Kerkhi (2015), Mari *et al.* (2015) and Samir and Ismail (2015), Bhardwaj (2017) and Yadav (2017).

The GCA / SCA variance ratio was less than unity indicated the importance of non-additive gene action for all the characters under investigation. The results were in conformity with findings obtained by Irshad *et al.* (2014), Kaukab *et al.* (2014), Mari *et al.* (2015), Kumar *et al.* (2015), Bhardwaj (2017) and Yadav (2017). The preponderance of non-additive genetic variance for most of the characters indicated that the best cross combinations might be selected on the basis of SCA for further tangible advancement in wheat.

Consistency for desirable GCA estimates for more

Table-3.1 : Estimates of general combining ability effects.

	Days to Heading E1F1	Days to Heading E1F2	Days to Maturity E1F1	Days to Maturity E1F2	Grain Filling Period E1F1	Grain Filling Period E1F2	Plant Height cm E1F1	Plant Height cm E1F2	Flag Leaf Area cm ² E1F1	Flag Leaf Area cm ² E1F2
Raj 3765	-0.38*	-0.28	-1.45***	-0.31	0.34	0.54**	-1.49***	-1.66***	0.29	0.56
DBW 621 50	0.57**	0.51*	1.99***	1.32**	2.13***	1.94***	2.87***	3.84***	-1.39***	-1.33**
Raj 3077	0.39*	0.39	1.25**	1.22**	-0.77***	-0.71***	3.09***	2.81***	-1.25**	-1.35***
Raj 4079	0.51**	0.64*	1.55***	1.52***	0.82***	0.78***	-0.56	0.13	-0.65	-0.65
Raj 4120	0.98**	0.78**	0.64	-0.31	-0.97***	-0.78***	0.63	0.57	-0.92*	-1.11**
HD 2967	0.42**	0.49	-0.42	-0.23	-1.15***	-1.38***	-2.26***	-2.57***	1.75***	1.84***
Raj 4083	-2.27***	-2.56***	-3.23***	-2.36***	-0.84***	-0.93***	-1.64***	-1.84***	0.51	0.66
Raj 4238	-0.56**	-0.67*	-1.59***	-0.95*	-1.27***	-1.24***	-0.37	-0.40	0.77*	0.82*
DBW 17	-0.30	0.28	1.02*	1.18**	1.73***	1.53***	-1.62***	-2.05***	0.66	0.37
DBW 88	0.64***	0.41	0.25	-1.09**	-0.02	0.25	1.36***	1.17**	0.23	0.19
CD Comparisons for GCA										
Gi 0 at 95%	0.38	0.58	0.92	0.90	0.51***	0.43	0.86	0.78	0.85	0.89
Gi 0 at 99%	0.55	0.83	1.32	1.29	0.73***	0.62	1.24	1.13	1.22	1.28
Gi—Gj at 95%	0.57	0.86	1.37	1.34	0.75***	0.64	1.28	1.17	1.27	1.33
Gi—Gj at 99%	0.82	1.23	1.97	1.93	1.08***	0.92	1.84	1.68	1.82	1.91
h ² Narrow Sense	0.30	0.28	0.24	0.21	0.11	0.10	0.29	0.37	0.26	0.25
h ² Broad Sense	0.93	0.87	0.90	0.85	0.97	0.98	0.92	0.93	0.72	0.73
GCA/SCA Ratio	0.23	0.23	0.18	0.16	0.06	0.06	0.24	0.32	0.28	0.25
Predictability Ratio	0.32	0.32	0.27	0.25	0.11	0.10	0.32	0.39	0.36	0.34

Table-3.2 : Estimates of general combining ability effects.

	Tillers/ Plant E1F1	Tillers / Plant E1F2	Spike Length E1F1	Spike Length E1F2	Grains/ Spike E1F1	Grains/ Spike E1F2	1000-grain Weight (g) E1F1	1000-grain Weight (g) E1F2	Harvest Index (%) E1F1	Harvest Index (%) E1F2	Grain Yield/ Plant (g) E1F1	Grain Yield/ Plant (g) E1F2
Raj 3765	0.24	0.31*	0.96***	0.64***	4.06**	4.29***	0.55	0.64	1.90***	1.88**	1.83***	1.35***
DBW 621 50	-0.37*	-0.35*	-1.18***	-0.98***	-1.28**	-1.43***	-1.55***	-1.73***	-1.51***	-1.92***	-2.98***	-1.72***
Raj 3077	-0.08	-0.10	-0.25	-0.24	0.92*	0.65*	-0.50	-0.65*	-1.29***	-1.33***	-0.64*	-0.94**
Raj 4079	0.25	0.28	0.718**	0.91***	0.84*	0.45	1.27***	1.27***	1.06**	0.99**	1.71***	1.55***
Raj 4120	-0.30	-0.26	-0.15	-0.19	-0.25	0.95**	-1.14***	-0.74*	-0.54	0.38	-0.86**	0.27
HD 2967	0.06	0.12	0.10	0.01	-2.37***	-3.34***	1.94**	2.13***	-0.76*	0.33	-0.29	-0.95**
Raj 4083	0.16	0.13	0.47*	0.91***	0.47	0.70*	1.12***	1.11***	1.35***	0.33	1.96***	1.15***
Raj 4238	0.04	-0.03	0.18	0.17	-0.16	-0.38	0.36	0.38	0.25	0.80*	0.71*	0.01
DBW 17	0.14	0.11	0.17	-0.41*	0.36	-0.82*	-0.62*	-0.78*	0.29	0.94**	0.90**	0.55
DBW 88	-0.14	-0.22	-1.01	-0.83***	-2.58***	-1.08***	-1.42***	-1.63***	-0.75*	-0.05	-2.33***	-1.28
CD Comparisons for GCA												
Gi 0 at 95%	0.39	0.34	0.48	0.40	0.93	0.72	0.65	0.73	0.75	0.73	0.65	0.74
Gi 0 at 99%	0.56	0.49	0.68	0.58	1.33	1.04	0.93	1.06	1.08	1.04	0.94	1.06
Gi—Gj at 95%	0.58	0.51	0.71	0.60	1.38	1.07	0.97	1.09	1.12	1.08	0.97	1.10
Gi—Gj at 99%	0.84	0.74	1.02	0.86	1.98	1.54	1.39	1.57	1.61	1.56	1.39	1.58
h ² Narrow Sense	0.04	0.06	0.22	0.26	0.19	0.19	0.23	0.25	0.18	0.16	0.15	0.25
h ² Broad Sense	0.40	0.63	0.85	0.87	0.94	0.97	0.91	0.89	0.89	0.93	0.97	0.86
GCA/SCA Ratio	0.06	0.05	0.18	0.21	0.12	0.13	0.17	0.19	0.13	0.11	0.09	0.20
Raj 3765	0.11	0.10	0.26	0.30	0.20	0.20	0.26	0.28	0.20	0.18	0.16	0.28

Table-4.1 : Estimates of specific combining ability.

	Days to Heading		Days to Maturity		Grain Filling Period		Plant Height cm		Flag Leaf Area cm ²	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
P1XP2	-0.41	-0.81	-4.33**	-2.95*	-1.90*	-1.59*	-0.27	-1.22	-2.37	-2.71*
P1XP3	-0.98	-2.03*	0.41	0.81	-0.12	0.10	1.34	1.53	1.29	1.44
P1XP4	0.48	0.06	-1.90	-1.16	-2.96***	-2.25**	-4.65***	-5.00***	4.10**	5.16***
P1XP5	-0.61	-1.24	2.02	4.01**	-4.04***	-3.17***	0.58	1.67	0.00	-0.42
P1XP6	-0.42	-0.46	-4.92***	-4.41**	-9.20***	-9.12***	-3.07*	-3.19**	0.99	1.28
P1XP7	-0.69	-0.41	0.56	0.40	7.95***	8.32***	0.29	0.20	0.88	0.45
P1XP8	-2.23***	-2.63**	-2.42	-2.35	-2.57**	-2.20**	-4.84***	-4.10**	2.11	1.45
P1XP9	3.33***	2.31**	3.96**	1.51	-1.78*	-0.79	6.69***	7.29***	-0.71	-0.37
P1XP10	0.37	0.92	-0.92	0.12	1.09	2.40***	2.90*	3.18**	-2.06	-2.30
P2XP3	-3.05***	-3.00**	-3.36*	-1.15	-1.69*	-1.53*	-2.15	-2.79*	2.85*	2.54
P2XP4	3.45***	2.14*	2.67	1.55	-5.60***	-5.26***	-7.16***	1.21	0.44	0.70
P2XP5	-1.07	-0.91	1.59	0.71	7.42***	7.85***	0.91	1.45	-0.17	-2.06
P2XP6	-1.37*	-1.59	0.64	0.93	4.17***	5.58***	2.68*	2.74*	0.07	-0.10
P2XP7	-0.32	-0.66	4.01**	4.10**	2.93***	3.98***	3.42*	4.43***	-1.57	-0.13
P2XP8	1.56**	1.57	5.81***	3.02*	3.47***	3.63***	2.89*	2.39*	-1.06	-1.30
P2XP9	-1.62**	-2.38**	-1.14	1.14	-0.71	-1.31*	-5.09***	-5.96***	0.04	-0.08
P2XP10	3.35***	2.38**	4.97***	-0.18	7.64***	8.09***	-0.34	-1.38	-4.44**	-4.15**
P3XP4	-2.92***	-3.02***	-4.59**	-4.35**	-1.33	-0.46	-0.80	-1.51	0.67	0.42
P3XP5	1.28*	0.87	2.33	-0.52	0.97	0.84	1.20	1.55	-2.36	-2.09
P3XP6	-1.15*	-1.13	-1.95	-3.93**	2.38**	2.52***	-1.94	-1.32	-1.29	-1.30
P3XP7	1.20*	0.92	1.53	1.20	1.90*	3.98***	-1.22	-1.21	1.29	1.22
P3XP8	-0.85	-1.30	-0.45	0.45	-1.58*	-1.63*	1.32	1.60	-0.26	-0.23
P3XP9	1.89**	0.60	1.94	0.32	-2.74***	-1.82**	1.61	1.91	-1.16	-0.46
P3XP10	0.87	0.84	1.38	3.26*	3.13***	3.60***	1.30	1.88	-1.13	-3.34*
P4XP5	2.16***	1.96*	5.02***	2.50	-3.68***	-3.97***	6.35***	5.55***	-3.90**	-3.40*
P4XP6	-0.39	-0.38	-0.92	0.43	0.63	1.77**	-1.55	-2.21	-1.22	-2.99*
P4XP7	-1.26*	-1.00	-7.11***	-6.10***	-7.67	-6.68***	-3.86**	-4.66***	3.23*	2.39
P4XP8	0.69	0.78	-1.09	-2.19	9.18	9.46***	-5.80***	-5.64***	-0.86	-0.93
P4XP9	4.44***	3.16***	-2.37	-0.98	2.38	1.97**	2.41	2.10	-3.77**	-3.66**
P4XP10	-1.91**	-1.96*	3.41*	2.29	0.43	1.14	2.83*	2.79*	-0.71	-1.03
P5XP6	0.88	0.82	1.66	-0.74	1.47	2.11**	4.38**	4.25***	-0.36	-0.26
P5XP7	-1.10	-1.13	-7.53***	-6.60***	0.31	0.99	-7.07***	-7.45***	1.41	1.70
P5XP8	0.22	0.64	-1.84	-0.02	5.75***	6.36***	-0.92	-0.76	2.15	2.70*
P5XP9	-1.37*	-2.97**	-8.45***	-5.48***	-9.86***	-9.14***	-5.84***	-5.83***	3.02*	1.69
P5XP10	3.57***	1.57	-2.01	-5.88***	-1.67*	0.02	1.33	2.29	-2.23	-2.35
P6XP7	0.84	-2.52**	0.87	1.65	-2.05**	-3.79***	1.47	2.44*	-1.62	-1.86
P6XP8	-0.21	-4.81***	2.85*	4.23**	2.67***	3.53***	-1.24	-0.75	-0.89	-0.89
P6XP9	-3.13***	2.94**	-2.39	-1.57	-2.42**	-2.24**	-0.98	-0.99	0.55	-0.14
P6XP10	2.92***	1.85*	6.05***	5.04***	1.35	2.18**	4.10**	3.77**	0.31	1.88
P7XP8	-1.52*	-0.69	-2.30	-2.30	-6.65***	-5.27***	-3.23*	-2.65*	2.26	2.18

Table-4.2 : Estimates of specific combining ability.

	Tillers/ Plant		Spike Length		Grains/ Spike		1000-grain Weight (g)		Harvest Index (%)		Grain Yield/ Plant (g)	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
P1XP2	-0.70	-0.28	0.19	-0.44	-1.01	-1.93	4.14**	3.52**	0.53	1.23	1.21	0.98
P1XP3	0.37	0.06	-0.40	-1.51*	-1.26	-1.50	-2.19*	-1.58	-0.81	-0.43	-1.79	-0.39
P1XP4	0.84	0.56	2.39**	1.73**	5.00**	4.27**	-0.85	-1.15	-0.27	0.47	4.98**	0.64
P1XP5	-0.56	-0.16	0.09	-0.77	0.08	0.09	1.60	1.10	-1.51	-1.52	-1.05	-1.03
P1XP6	1.20*	0.80	1.52*	2.15**	6.09**	6.43**	0.40	-0.50	4.19**	5.65**	7.51**	3.74**
P1XP7	-1.65**	-1.82***	-0.55	-1.48*	-5.82***	-6.88***	-3.43***	-3.99**	-5.63***	-7.62***	-0.61	-0.82
P1XP8	0.69	-0.21	2.40**	0.96	4.90**	4.53**	3.49**	2.73*	3.72**	3.69**	6.42***	2.39*
P1XP9	0.00	-0.16	-1.98**	-1.40*	2.66	2.89**	-4.79***	-5.16**	-3.43**	-5.43**	-4.12***	-4.34***
P1XP10	-0.50	-0.47	-1.13	-0.29	0.14	2.82*	1.29	0.94	-1.06	-3.36**	-0.36	-2.03
P2XP3	-0.65	-1.01	3.21***	1.47*	5.12***	5.31***	3.57***	2.93*	5.16***	5.65**	9.57***	2.22*
P2XP4	0.53	0.25	1.62*	1.15	7.48***	6.97***	-0.99	-2.14	-0.68	-0.36	1.27	0.69
P2XP5	-0.46	-0.71	-1.00	-1.11	0.16	-1.41	1.11	0.05	-1.81	-4.06***	-0.10	-0.95
P2XP6	0.04	-0.77	-0.13	0.63	-3.69*	-2.86*	0.88	0.10	-0.87	-0.24	0.40	0.76
P2XP7	-1.11	-1.30*	-0.29	-0.53	-2.75	-3.18**	-3.25**	-3.63**	-2.03	-2.30*	-2.55*	-1.41
P2XP8	-0.09	0.05	-1.36	0.04	-2.74	-3.17**	-5.61***	-4.99***	-3.63**	-3.85***	-3.74**	-1.09
P2XP9	0.74	1.09*	1.59*	1.33*	3.50*	4.60**	4.38**	3.63**	0.00	-6.50**	3.06**	0.94
P2XP10	0.64	0.08	0.05	-0.15	-0.98	-0.83	-2.79**	-3.26**	-1.96	0.54	-1.28	-0.45
P3XP4	0.48	0.53	-1.74*	-1.08	-3.06*	-2.32*	0.53	-0.32*	2.34*	-5.46**	1.26	-1.91
P3XP5	-1.06	-0.90	-0.96	-0.45	-9.68***	-12.45***	-5.05***	-5.21***	-3.96***	3.26**	-5.45***	-2.80*
P3XP6	1.46*	0.97	2.33**	1.51*	5.17**	6.19**	-1.97*	-2.90*	2.87*	-4.39**	6.00**	3.63**
P3XP7	-0.51	-0.95	1.07	-0.23	4.24**	4.44**	-3.85***	-4.95**	-2.85*	0.33	-1.82	-0.66
P3XP8	-0.49	-0.16	0.27	0.57	4.55**	4.06**	1.62	0.43	-1.25	-2.00	2.94**	0.89
P3XP9	0.31	0.03	-0.49	-0.19	4.87***	5.45**	3.98**	3.97***	-0.87	-1.34	1.11	-1.60
P3XP10	0.49	0.13	-0.38	0.57	-1.89	-3.20**	0.67	-0.02	-1.99	-0.09	-0.60	-0.50
P4XP5	-1.35*	-1.56**	-2.09**	-2.17**	-6.62***	-7.75***	-5.80***	-5.71***	-6.89***	-4.82***	-7.41***	-5.27***
P4XP6	-0.87	-0.63	-0.92	0.41	2.72	3.45**	-0.85	-1.64	2.40*	-5.75**	3.69**	0.90
P4XP7	1.24*	0.86	0.71	0.20	6.44**	5.95**	3.05**	2.74*	2.41*	1.83	4.78**	0.67
P4XP8	0.11	-0.27	0.92	1.06	-1.13	-0.72	2.62**	3.22**	-0.42	6.67***	2.04*	0.95
P4XP9	-1.45*	-1.45**	-1.35	-2.42***	-5.19***	-4.53***	-1.38	-2.23*	-4.18***	1.57	-6.52***	-4.09***
P4XP10	-0.17	-0.45	0.18	-0.68	-1.14	-3.33**	0.38	-0.38	-0.48	-3.13**	-1.39	-1.69
P5XP6	0.89	0.60	0.07	-0.28	-3.55*	-3.95***	0.46*	3.08**	0.08	1.35	0.13	-0.23
P5XP7	0.44	0.14	1.43*	1.74**	5.28***	7.05**	3.16**	3.16**	3.97***	-0.96	6.89***	3.28**
P5XP8	0.09	-0.25	2.21**	0.55	5.58**	3.85***	-0.79	-2.06	2.58*	7.06**	5.62***	2.42*
P5XP9	0.59	0.41	2.81***	2.60***	7.19***	6.22***	2.84**	3.54**	8.14***	1.20	8.14***	3.35**
P5XP10	-0.70	-1.16*	-0.90	-0.88	-1.36	9.27***	1.12	-0.24	-1.84	-2.07	-2.38*	-1.04
P6XP7	-0.68	-0.81	-1.88*	-1.72**	-0.98	-1.00	2.45*	2.44*	-1.48	-0.72	2.36*	-1.26
P6XP8	-0.71	-0.20	-0.83	-1.54*	-5.90**	-5.37**	2.21*	2.00	-2.32*	-0.66	-2.37*	-0.59
P6XP9	0.12	0.19	1.78*	-0.76	7.25***	0.37	0.83	0.00	3.70**	-1.41	5.91***	0.54
P6XP10	-1.01	-1.07*	-0.11	-1.26*	0.97	-0.03	-3.57***	-3.48**	-2.11	4.61**	-3.06**	-0.67
P7XP8	0.35	0.17	1.96**	2.26***	6.54***	7.98***	0.82	0.50	5.45***	-7.94***	6.66***	3.36**
P7XP9	1.23*	0.86	-2.21**	-2.33***	-8.48***	-8.36***	2.84**	1.93	-3.47**	8.06**	-4.44**	-3.18**
P7XP10	0.23	0.66	2.46**	4.23***	9.61***	8.05**	4.58**	4.30***	4.30***	2.96**	8.30***	5.20***
P8XP9	-0.26	-1.05*	-0.82	-0.32	-0.62	-0.29	-3.11**	-4.93**	-1.83	2.44*	-1.18	-0.79
P8XP10	0.69	0.43	2.76**	1.58*	8.63***	7.09**	3.45**	3.32**	4.34***	0.44	9.98**	4.87***
P9XP10	-0.01	-0.42	1.23	-0.55	-1.87	-2.71*	0.43	0.11	0.51	-0.34	0.86	-0.57
C. D. Comparisons												
Sij 0 at 95%	1.17	1.03	1.43	1.20	2.77	2.16	1.95	2.20	2.25	2.18	1.95	2.21
Sij 0 at 99%	1.56	1.38	1.91	1.60	3.70	2.89	2.61	2.94	3.00	2.91	2.61	2.96
Sij—Sik at 95%	1.72	1.52	2.10	1.77	4.08	3.18	2.87	3.23	3.30	3.20	2.87	3.25
Sij—Sik at 99%	2.30	2.03	2.80	2.36	5.45	4.24	3.83	4.32	4.41	4.28	3.83	4.34
Sij—Skl at 95%	1.64	1.45	2.00	1.68	3.89	3.03	2.73	3.08	3.15	3.05	2.73	3.10
Sij—Skl at 99%	2.19	1.93	2.67	2.25	5.19	4.05	3.65	4.12	4.21	4.08	3.65	4.14

than one specific or many characters, three parents namely; Raj 3765, Raj 4083 and Raj 4079 were good general combiners. Therefore, these parents have good potential and may be used in synthesizing a dynamic population with most of the favorable genes accumulated.

In self-pollinated crops like wheat, SCA effects have relatively less applicability as they are consequences of non-additive gene effects except those arising from complementary gene action or linkage effects and cannot be fixed in the end product i.e. pure line. Jinks and Jones (1958) emphasized that the superiority of the hybrids might not indicate their ability to yield transgressive segregants, rather SCA would provide satisfactory Maturity criteria. However, if a cross combination exhibit high SCA as well as high *per se* performance having at least one parent as good general combiner for a specific trait, it is expected that this cross combination may provide desirable transgressive segregates in later generations.

In the present study, none of the crosses showed consistently high SCA effects in desirable direction for all the characters. However, based on the relative consistent exhibition of high SCA effects in desirable direction for yield and some of its contributing characters the crosses Raj 3765 X Raj 4238 and Raj 4120 X DBW 17 appeared as good specific cross combinations for grain yield and some associated traits.

The parents Raj 3765 was good general combiners for grain yield and one or two yield contributing traits while the other parents were emerged as average or poor combiners. Further, both additive and non-additive gene action were operating for most of the characters, thus recurrent selection is an appropriate choice (Hull, 1945), but it is often not very effective with partial dominance (Moll *et. al.*, 1964). The additive gene action has been exploited more in wheat as being a self-pollinated crop, whereas the non-additive variance which is outcome of dominance and epistasis gene interaction remains to be utilized, which can be exploited for further improvement of wheat through systematic breeding programme for the targeted environment. Overall appraisal of the results in the present study, advocated that reciprocal recurrent selection (Hull, 1945) diallel selective mating, use of multiple crosses and bi-parental mating may be effective alternative approaches for tangible advancement of bread wheat yield in the coming years.

References

1. Anonymous, 2015. Population growth (annual %). World Bank. Retrieved 20 January 2015.
2. Adel, M.M. and Ali, E.A. 2013. Gene action and combining ability in a six parent diallel cross of wheat. *Asian J. Crop Sci.*, 5(1): 14-23.
3. Bhardwaj, R. Genetic Studies for Yield and its Contributing Attributes in Bread Wheat (*Triticum aestivum* L. em Thell) Over Environments. *Thesis (Unpub.) submitted to SKNAU*, Jobner.
4. Grafius, J.E. 1959. Heterosis in barley. *Agron. J.*, 51 (9): 551-554.
5. Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Aust. J. Biol. Sci.*, 9 (4): 463-493.
6. Hull, F.H. 1945. Recurrent selection for specific combining ability in corn. *J. Amer. Soc. Agron.*, 37: 134-145.
7. Irshad, M.; Khaliq, I.; Iqbal, J.; Hussain, N.; Aslam, M.; Hussain, K. and Din, N. 2014. Genetics of some polygenic traits in hexaploid bread wheat in high temperature stress. *J. Animal and pl br. Sci.*, 24 (4): 1212-1219.
8. Jinks, J.L. and Jones, R.M. 1958. Estimation of components of heterosis. *Genet.*, 43 (2): 223-234.
9. Kalhor, F.A., Rajpar, A.A., Kalhor, S.A., Mahar, A., Ali, A., Otho, S.A., Soomro, R.N., Ali, F. and Baloch, Z.A. (2015). Heterosis and combining ability in F₁ population of hexaploid wheat (*Triticum Aestivum* L.). *Am. J. Pl. Sci.*, 6: 1011-1026.
10. Kaukab, S., Saeed, M.S. and Rehman, A.U. 2014. Genetic analysis for yield and some yield traits in spring wheat. *Uni. J. Agric. Res.*, 2 (7): 272-277.
11. Kumar, D. and Kerkhi, S.A. 2015. Combining ability analysis for yield and some quality traits in spring wheat (*T. aestivum* L.). *Electronic J. of Pl. Br.*, 6 (1): 26.
12. Mari, S.N.; Ansari, B.A.; Kumbhar, M.B. and Keerio, M.I. 2015. Gene action governing inheritance of economically valued traits among F₁ hybrids of hexaploid wheat derived through diallel mating system. *Sindh Univ. Res. J.*, 47 (4): 663-668.
13. Moll, R.H., Lindsey, M.F. and Robinson, H.F. 1964. Estimates of genetic variances and level of dominance in maize. *Genet.*, 49: 411-423.
14. Samir, K.A.; Ismail. 2015. Heterosis and combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L.). *Int. J. Curr. Microbio. App. Sci.*, 4 (8): 1-9.
15. Sharma, J.K. and Singh, H.B. 1990. Combining ability in bread wheat (*Triticum aestivum* L.). *Himachal J. Agril. Res.*, 16 (1/2): 48-55.
16. Yadav, J. 2017. Genetic architecture of yield and its associated traits in bread wheat (*Triticum aestivum* L. em. Thell.) over environments. *Thesis (Unpub.) submitted to SKNAU*, Jobner.



Inbreeding Depression Analysis for Yield and Some of its Associated Characters in Late Sown Condition in Bread Wheat (*Triticum aestivum* L. em. Thell)

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Abstract

In order to study inbreeding depression for yield and some of its associated characters in bread wheat (*Triticum aestivum* L. em. Thell) over the environments, the present experiment was carried out performing diallel analysis following Griffing (1956) Method II Model I. Ten genetically diverse parents were selected and crossed in half diallel fashion excluding reciprocals. These parents were evaluated along with their 45 F₁'s and 45 F₂'s in a randomized block design with 3 replications over three environments namely, normal sown (E₁), late sown (E₂) and very late sown (E₃) environments created by using three different dates of sowing. In the present experiment significant inbreeding depression was reported for different traits in all the three environments. Even though, none of the cross displayed significant inbreeding depression in desired direction for all the characters and in all the environments but HD 2967 X DBW 88 was found as desirable cross combination in E₃ environment as it showed desirable (significant negative) inbreeding depression for grain yield per plant and some other traits.

Introduction

Wheat one of the most important food crop and cereal crop remains the third most produced food grain in world a cereal crop. There is noteworthy production in the production and productivity of wheat but still it needs much more improvement the yield and quality of wheat as it is a staple good of more than one billion people and still the population is burgeoning. The fundamental objective of most of plant breeding programmes remain to increase yield of concerned crop by developing improved varieties through heterotic expression which is expected to decline in F₂ generation due to decrease in heterozygosity and referred as inbreeding depression.

The estimates of heterosis and inbreeding depression together provide information about the type of gene action involved in the expression of various quantitative traits. The mating between more closely related individuals is known as inbreeding. The closest form of inbreeding is self-fertilization. The genetic effects of inbreeding on cross-fertilizing crops are as follows (Falconer, 1981).

1. Homozygosity is increased which results in fixation of genes. The recessive deleterious genes come to the surface due to release of hidden genetic variability from heterozygotes. These recessives are exposed to natural selection.

2. The heterozygosity is reduced rapidly because inbreeding results in elimination of hybrids from a population and replaces them with pure types. Thus, inbreeding leads to purity of types.

3. The populations mean is reduced due to decrease in the number of hybrid genotypes, which have more number of dominant genes.

4. Genetic correlation increases between close relatives due to increase in the prepotency, which increases with homozygosity.

5. The variability, which is hidden in heterozygote, is made free through inbreeding. Thus, the total variability is increased without selection. With selection the variability is reduced towards the direction of selection.

The inbreeding depression refers to decrease in fitness and vigour due to inbreeding. The degree of inbreeding is measured by the inbreeding coefficient. Inbreeding depression results are due to fixation of unfavorable recessive genes in F₂, while in case of heterosis the unfavorable recessive genes of one line or parent are covered by favorable dominant genes of other parent. The fixation of all favorable dominant genes in one homozygous line is impossible due to linkage between some unfavorable recessive and favorable dominant genes. . In the present study Inbreeding depression is studied and analysis under three environments viz. normal. Late and very late sown conditions which are indicated as E₁, E₂ and E₃ respectively.

Materials and Methods

On the basis of genetic diversity and their stability for different yield traits, ten diverse wheat varieties selected as the experimental material and crossed in diallel mating fashion excluding reciprocals to obtain 45 F₁s in *rabi*

Table-1.1 : Estimates of inbreeding depression.

	Days to Heading E1	Days to Heading E2	Days to Heading E3	Days to Maturity E1	Days to Maturity E2	Days to Maturity E3	Grain Filling Period E1	Grain Filling Period E2	Grain Filling Period E3
P1XP2	-2.331*	2.990*	1.987	-0.763	-1.246	-0.719	0.927	-6.161	-26.583**
P1XP3	-0.962	3.856*	0.852	-1.305	-0.901	-1.071	2.243	-6.738	23.428**
P1XP4	-1.095	2.724*	2.243	0.055	-1.223	-1.460	-1.442	-7.959**	-60.290***
P1XP5	1.350	3.505*	1.658	-0.524	-1.488	-1.060	2.969	-9.650**	-19.378**
P1XP6	3.084**	2.288**	1.429	-1.240	-1.282	-1.852	0.120	-7.388	-11.658*
P1XP7	1.396	2.451	1.105	-1.378	-1.250	-1.873	2.005	-5.621*	-38.045***
P1XP8	4.000	3.197*	-0.067	1.416	-1.266	-1.449	0.701	-7.609	-8.366
P1XP9	-0.457	2.851	2.281	0.545	1.458	-1.418	2.702	-7.822**	1.042
P1XP10	0.826	1.871*	2.138	0.254	-0.307	-0.719	-2.179	-9.484	-25.908***
P2XP3	2.548*	2.570	1.657	-0.992	-0.904	-0.364	-0.306	-5.583*	-50.032***
P2XP4	-1.608	3.962*	0.751	-0.775	1.994	-0.362	1.726	-6.167	-47.209***
P2XP5	-0.541	2.603***	2.139	-0.182	2.609	-2.290	-2.547	-5.379	-39.516***
P2XP6	0.172	2.767*	1.596	1.326	0.619	-1.838	0.899	-6.982*	-45.004**
P2XP7	2.416*	3.548	1.563	1.818	0.197	-1.128	3.220	-6.660	-0.307
P2XP8	-0.463	2.642	1.992*	-0.353	2.849	-1.103	3.500	-4.949	-33.201***
P2XP9	0.573	2.857	3.191*	-0.771	-1.112	-1.083	-0.879	-2.802	-12.006
P2XP10	0.000	3.996**	1.524	-0.088	6.497**	-1.465	3.842	-5.445	1.809
P3XP4	-0.728	2.510	0.541	-0.512	0.306	-1.792	3.408	-7.889	18.692**
P3XP5	0.701	3.225	2.131	0.508	3.768	-1.413	4.321	-5.860	3.596
P3XP6	1.900	2.347	2.094	0.850	2.128	-1.449	-0.736	-5.323*	-5.892
P3XP7	1.429	3.302	1.613	-1.238	0.000	-1.852	2.342	-10.406**	-2.679
P3XP8	-0.236	3.318*	2.122*	-1.028	-0.909	-2.281	0.178	-6.113*	1.364
P3XP9	0.420	3.391*	3.134**	-0.126	1.739	-2.273	4.648*	-7.692*	-2.714
P3XP10	0.126	2.780	2.162*	-4.810**	0.000	-2.239	-0.494	-7.005*	-11.901
P4XP5	1.809	2.724	0.992	-1.235	3.395**	-0.692	2.158	-5.670	15.862**
P4XP6	0.299	2.161	1.093	-0.838	-0.901	-1.034	3.593	-7.571**	-80.092***
P4XP7	-1.571	2.439	1.130	0.787	-1.307	1.767	1.338	-9.353	-67.012***
P4XP8	0.794	2.315	1.483	-0.942	0.912	-0.730	-4.430	-5.068	-15.338
P4XP9	0.823	3.070	2.247	-0.773	-0.901	-1.429	3.130	-3.487	-37.281***
P4XP10	1.317	2.729	0.939	-1.064	2.586	-0.348	3.017	-7.538	-62.695***
P5XP6	-0.261	2.666	0.532	0.549	3.254	-1.370*	4.552	-7.053	-71.734***
P5XP7	-0.704	3.330	1.124	0.552	-0.331	-1.730	-1.183	-7.662**	-8.501
P5XP8	0.885	2.315	1.656	-0.811	-0.926	-0.690	5.969*	-6.927**	-11.317**
P5XP9	0.919	4.245	1.648	-0.220	-1.603	-1.053	3.395	-9.255**	-46.530***
P5XP10	1.377	5.508***	1.053	1.429	6.079*	-0.678	2.050	-11.452**	-40.261***
P6XP7	1.396	7.583**	2.775	0.000	-1.235	-1.370	1.205	-0.471	-45.740***
P6XP8	-1.667	9.019**	1.070	-0.257	-1.526	-1.014	0.401	-7.020	2.557
P6XP9	-1.293	-7.263**	1.413	-1.282	-0.612	-1.003	9.818*	-5.065	-46.316**
P6XP10	-0.661	3.982	1.905	0.251	2.286	-0.304	-8.004*	-7.535*	-43.158**
P7XP8	-1.708	1.990	2.968	-1.676	-0.965	-0.699	17.813**	-11.110**	-3.326
P7XP9	-0.008	3.389	1.124	0.741	0.872	-1.481	9.411	-5.149	-13.444**
P7XP10	-1.716	5.136*	2.377	-1.667	-0.664	-1.429	0.784	-4.208	-23.001**
P8XP9	-0.400	2.279	1.657	0.249	0.301	-1.056	4.488	-6.765	-40.173**
P8XP10	-0.707	2.358	2.551	-0.826	-0.619	-1.515	3.119	-8.397	-26.707**
P9XP10	0.172	2.290	1.124	-1.312	2.882	-1.465	-2.458	-6.596*	-28.185***
Average	0.251	3.032***	1.666***	-0.400	0.569	-1.186*	2.078	-6.715***	-19.955***

Table-1.2 : Estimates of inbreeding depression.

	Plant Height cm E1	Plant Height cm E2	Plant Height cm E3	Flag Leaf Area cm ² E1	Flag Leaf Area cm ² E2	Flag Leaf Area cm ² E3	Tillers/ Plant E1	Tillers/ Plant E2	Tillers/ Plant E3
P1XP2	2.158	-1.176	2.101*	7.540	4.352	8.083	14.286	6.129	14.170
P1XP3	-1.534	-1.008	0.608	5.849	1.744	7.485	18.875	16.780	7.909
P1XP4	-0.676	-1.772	-1.366	13.834	-2.959	10.551	50.000	13.913	29.923
P1XP5	-1.093	-2.518	3.496*	11.292	5.509	8.667	3.138	5.950	7.742
P1XP6	-0.313	-0.658	3.646*	13.766**	0.000	9.706	12.500	14.702	-14.870
P1XP7	-1.240	-0.809	-1.587	11.300	3.258	-2.130	18.182	20.524	24.675
P1XP8	1.046	-2.308	1.112	24.968***	4.555	10.521	8.333	25.208	18.153
P1XP9	3.368*	-1.328	-1.159	20.352*	1.752	10.194	-28.571	15.067	-1.732
P1XP10	-1.417	-1.219	-2.114	14.356	3.865	1.390	-24.388	14.610*	30.720
P2XP3	6.490	-1.379	0.638	20.424	5.265	-9.583	-12.500	24.806	48.987*
P2XP4	5.002**	-15.641**	1.558	17.286	1.940	1.931	10.048	16.747	12.309
P2XP5	3.948	-3.115	0.959	13.945	16.357	10.563	24.471	21.585	24.620
P2XP6	-1.426	-2.253	-0.210	9.904**	3.470	8.073	8.056	27.654	0.645
P2XP7	-5.376***	-3.529**	-3.550	6.756	-6.125	-41.077	-12.500	22.321	22.374
P2XP8	8.172***	-1.849	1.200	17.881	4.522	5.306	7.619	13.255	24.348
P2XP9	3.266*	-1.011	-1.681	19.253**	5.525	-12.876	16.000	7.612	25.112
P2XP10	-11.358*	-1.001	-4.580	6.502	2.528	7.884	9.167	23.993	29.235
P3XP4	-1.587	-0.977	-1.139	6.218	5.699	14.776	26.435	11.614	7.720
P3XP5	-12.207***	-1.310	-0.725	8.217	4.678	-9.880	-16.667	14.556	-27.778
P3XP6	6.241***	-1.447	0.949	27.332***	3.705	-24.904	-37.619*	17.232	12.425
P3XP7	-1.698	-0.764	-1.673	13.697	3.449	8.824	-13.636	24.027	15.625
P3XP8	1.116	-1.279	1.139	21.365	3.696	8.112	4.167	10.636	29.140
P3XP9	-0.218	-0.816	1.244	26.019**	1.957	9.028	25.000	18.280	1.201
P3XP10	1.905	-1.419	1.392	5.449	18.032	2.636	-7.066	20.788	8.007
P4XP5	-0.080	-1.071	1.326	-1.791	2.506	15.219	11.111	21.504	-4.407
P4XP6	2.148	-1.093	-0.050	31.773***	12.504	9.107	8.333	9.097	28.314
P4XP7	0.133	-1.081	1.375	22.235*	6.099	10.572	-12.676	15.939	27.803
P4XP8	-1.250	-2.720	0.803	4.814	3.696	5.496	-2.857	19.786	9.082
P4XP9	2.926	-1.330	1.078	-5.815	5.525	5.523	9.524	17.097	-19.134
P4XP10	0.830	-1.911	1.926	-3.110	5.740	-10.664	0.111	19.908	13.713
P5XP6	1.919	-0.697	1.061	26.877***	3.292	-18.535	0.000	15.476	-10.819
P5XP7	-0.806	-0.606	1.983	33.148*	2.006	6.985	0.000	18.034	17.619
P5XP8	1.924	-1.492	0.789	35.971**	1.123	-3.477	9.091	20.755	32.807
P5XP9	10.432**	-0.832	-3.248	31.209***	11.376	2.282	0.000	15.647	26.667*
P5XP10	-10.161***	-2.226	-0.995	6.275	6.242	-2.674	13.995	28.054	0.486
P6XP7	-1.435	-2.074	-2.133	15.784	3.348	-18.569	-15.789	16.760	2.130
P6XP8	2.985**	-1.698	-0.412	7.000	2.482	-8.576	16.667	5.751	21.442
P6XP9	0.537	-0.447	-0.461	12.136	7.067	-12.407	10.000	11.436	-6.803
P6XP10	2.653*	-0.287	-9.301	1.729	-4.602	-14.912	14.729	18.636	-2.644
P7XP8	2.188*	-2.000	2.997	27.691*	2.390	10.256	7.407	17.032	29.243
P7XP9	3.975*	-0.293	-0.815	9.142	7.838	7.892	8.696	16.803	20.695
P7XP10	5.426**	-1.327	4.102	34.177**	2.805	13.680	-23.333	8.059	0.731
P8XP9	2.660*	-0.972	0.077	8.447	8.046	10.302	21.466	29.466**	-2.002
P8XP10	4.593*	-1.119	-1.393	28.698***	3.462	10.465*	12.500	18.919	30.901*
P9XP10	1.117	-1.492	1.052	-15.624*	6.210	10.156	16.123	22.910	-2.136
Average	0.909	-1.706*	0.099	16.627***	4.256*	2.649	4.573	17.115***	13.906***

Table-1.3 : Estimates of inbreeding depression.

	Spike Length E1	Spike Length E2	Spike Length E3	Grains/ Spike E1	Grains/ Spike E2	Grains/ Spike E3	1000-grain Weight (g) E1	1000-grain Weight (g) E2	1000-grain Weight (g) E3
P1XP2	-6.733	16.686	-21.949*	5.100	2.918	-13.777	2.030	7.383	16.086**
P1XP3	-21.846**	21.891	-19.501	1.480	1.607	-20.083*	1.736	4.909	22.558**
P1XP4	-19.412	12.519	-8.767	1.722	2.568	-9.479	4.535	6.484	19.922**
P1XP5	-5.640	19.243**	18.400	2.941	-1.994	-9.255	1.402	5.979	18.431*
P1XP6	-2.873	6.732	4.268	2.795*	1.714	-12.405	-0.094	7.189	16.424*
P1XP7	-2.083	15.968	6.859	5.729	2.554	-18.894*	2.813	7.745	14.387
P1XP8	-13.932*	19.524*	-0.811	36.808***	1.598	-7.713	2.268	7.007*	10.311*
P1XP9	-28.390	13.921	-9.971	-11.331**	2.382	-11.270**	5.391	8.384*	15.049**
P1XP10	-37.309**	4.488	4.744	-8.159*	-8.681**	-10.524	4.656	8.342	17.398**
P2XP3	-14.950	20.288*	15.671	0.041	1.476	-9.803	5.688	8.372	18.780**
P2XP4	-8.811	9.748	21.420**	-4.826	3.042	-8.296	2.440	9.998	18.298
P2XP5	-27.702	12.056	3.477	3.872**	2.385	-19.628**	5.167*	8.719	10.901
P2XP6	-28.079*	2.837	0.187	3.667	2.134	-8.912*	3.547	7.872	17.295
P2XP7	-7.447	7.309	11.830	11.440	2.090	-23.221**	7.941	8.448	22.991***
P2XP8	-31.011	-4.813	13.060	0.208	3.241	-8.347	-8.011	5.946	15.406*
P2XP9	-4.781	14.896	9.955	-1.459	1.545	-7.561	7.421	8.488	20.158*
P2XP10	-12.349	10.509	28.350*	-4.786	-2.625	-18.946***	3.436	9.921	15.321*
P3XP4	-4.647	2.856	-3.374	19.658***	0.962	-5.962	7.582	8.924	21.916*
P3XP5	1.509	6.592	-5.754	0.033	6.719	-10.034*	0.640	7.128*	15.431
P3XP6	-14.867	15.042	-7.598*	2.121	1.480	-5.519	4.429*	8.587*	16.321*
P3XP7	-17.713	15.816*	14.368	3.472	0.650	-11.316*	1.991	10.360	21.568*
P3XP8	-7.632	7.309	6.265	1.750	2.980	-9.880*	1.458	9.303	21.179*
P3XP9	1.464	13.067	13.723	2.150	2.708	-11.450	-2.076	6.444	16.011**
P3XP10	-34.179*	0.102	-14.587	1.935	1.408	-10.687**	1.894	9.222	25.023**
P4XP5	-15.793	10.842*	-6.996	3.842	2.130	-6.130	5.811	5.607	12.225**
P4XP6	10.617	-2.443	10.797	3.605*	2.472	-9.286	8.339***	7.201	18.190**
P4XP7	2.865	7.731	7.145	3.332	2.189	-9.351	1.048	6.039	15.769*
P4XP8	2.349	6.267	12.613	1.787	1.577	-9.138***	1.796	3.966	17.163
P4XP9	-21.450**	23.830**	8.798	1.998	3.519	-11.031*	3.225	8.945	18.061*
P4XP10	-47.558***	14.530	10.919*	2.088	3.841	-12.092*	2.167	8.617	17.832
P5XP6	-15.920*	14.244	11.271	2.277	1.729	-8.190*	3.986	2.580	25.689**
P5XP7	-16.183*	3.363	10.113	1.861	-5.542**	-5.024	2.552	4.639	18.972**
P5XP8	-25.321*	20.897*	23.830**	1.840	2.516	-8.682*	4.647	8.762*	12.643
P5XP9	-17.679	13.882	20.650	1.431	2.798	-8.488*	4.097	3.459	21.345**
P5XP10	-9.804	10.506	12.049	8.777**	-32.614***	-16.622*	1.024	9.598*	21.033*
P6XP7	-11.547	6.454	33.212**	1.750	3.038	-10.901*	7.230	4.866	19.159
P6XP8	11.398	18.070*	23.408*	3.960*	3.253	-5.493	3.757	5.421	18.412
P6XP9	-9.656	32.410*	21.252**	3.391	19.469**	-10.699**	0.909	7.764***	16.346
P6XP10	-7.887	21.300*	-31.840*	3.491	2.408	-17.038**	3.169	6.379*	24.097*
P7XP8	-24.727*	2.990	76.100***	2.080	-1.930	-10.720**	2.645	6.527	22.545**
P7XP9	13.282	14.262	28.045	3.708	3.637	-8.574*	6.506	8.227*	20.428**
P7XP10	3.670	-9.234	10.673*	2.207	0.620	-7.186	2.180	8.331*	16.577*
P8XP9	-48.992**	11.368*	15.776	1.763	3.584	-10.658**	2.320	12.499	17.886*
P8XP10	-6.554	16.147	6.220	1.385	1.503	-8.402	3.505	6.545*	14.090**
P9XP10	-21.177*	28.201*	21.858	2.137	2.524	-5.540	2.319	8.266	17.556**
Average	-13.015***	12.037***	10.013***	3.178*	1.332	-10.217***	3.181	7.391	17.957***

Table-1.4 : Estimates of inbreeding depression.

	Harvest Index (%) E1	Harvest Index (%) E2	Harvest Index (%) E3	Grain Yield/ Plant (g) E1	Grain Yield/ Plant (g) E2	Grain Yield/ Plant (g) E3
P1XP2	1.340	3.168	-7.945	-0.222	10.13	8.634
P1XP3	2.230	3.120	-6.937	5.994	22.07**	3.102
P1XP4	-4.229	2.055	-10.056	7.097	-7.4	-14.309
P1XP5	5.271	1.549	-6.888	1.944	13.85	10.711
P1XP6	3.994	3.067	-7.713	8.154	13.83*	10.021
P1XP7	0.849	12.906	-8.608	4.639	13.8	5.606
P1XP8	5.754	2.266	-4.317	3.052	18.34**	16.780
P1XP9	5.189	7.861	-12.067*	-1.637	30.59**	16.377
P1XP10	3.151	8.275	-8.715*	-7.004	23.09**	14.457**
P2XP3	-0.422	3.616	-11.445	17.026*	22.67**	22.737
P2XP4	4.308	4.489	-10.839*	9.540	14.55	17.089*
P2XP5	-3.397	9.599	-11.571	2.840	21.17*	14.313
P2XP6	-3.814	7.343	-7.808	12.150	22.88**	20.707
P2XP7	1.947	9.040	-11.466	10.020	20.44*	26.320*
P2XP8	-1.658	4.793	-9.037	-4.045	13.96	18.239*
P2XP9	0.094	21.385**	-11.899	14.875	28.27**	17.815
P2XP10	9.401	-3.962	-11.954	-1.704	14.86	14.032
P3XP4	0.879	23.767**	-6.989	9.944	20.62**	12.312
P3XP5	4.789	-20.958*	-8.226*	12.446	18.13	17.648**
P3XP6	7.115	26.315**	-14.448	3.371	13.12	13.624
P3XP7	-4.343	-1.841	-12.233*	-5.029	17.12*	22.134*
P3XP8	9.681	4.920	-10.087	-3.607	20.93**	17.697
P3XP9	6.735	3.755	-9.435	5.959	30.93**	16.424
P3XP10	-1.196	-3.249	-10.202*	-0.737	24.21**	16.754
P4XP5	-6.501	-4.656	-8.455	3.509	14.94	22.942
P4XP6	3.964	27.338***	-0.069	2.859	14.35*	18.374
P4XP7	1.664	7.450	-12.890*	4.176	7.3	14.300
P4XP8	-4.163	-15.907*	-11.788*	8.919	11.17	11.164
P4XP9	5.816	-14.050	-8.973	5.017	19.1*	10.532
P4XP10	11.772*	9.392	-10.309*	6.229	15.7	5.432
P5XP6	5.550	1.549	-10.704*	5.198	24.79**	12.495
P5XP7	5.386	15.453**	-11.860*	-0.632	3.73	15.199
P5XP8	8.845**	-11.261*	-17.996*	4.969	29.26**	16.388*
P5XP9	8.042*	15.126**	-10.272	4.744	17.49**	15.357*
P5XP10	3.623	0.273	-9.086	0.441	11.79	28.010*
P6XP7	3.742	8.259	-10.465	0.000	18.15*	18.599
P6XP8	1.500	1.544	-3.695	10.920	16.46	22.946
P6XP9	5.092	17.733**	-8.223	6.623	18.34*	17.441
P6XP10	8.035	-13.836	-6.613*	9.998	16.1	-25.012*
P7XP8	3.966	34.541**	-4.532	2.094	9.72	47.290**
P7XP9	-0.740	-27.234*	-14.127**	8.511	17.82*	-8.964
P7XP10	7.639	7.444	-16.321	8.633	5.97	18.600*
P8XP9	-5.438	-11.047*	-9.722	-0.559	11.49	18.387
P8XP10	3.055	10.022*	-11.511*	-2.837	9.97	18.199
P9XP10	3.540	2.601	-15.499*	-3.023	20.99**	19.118*
Average	3.175	4.847***	-9.924***	4.243*	17.978***	14.967***

2014-2015. In *Rabi* 2015-16 ten genotypes along with their 45 F₁'s and 45 F₂'s (obtained at IARI, regional station, Wellington, TN during *kharif* 2015) progenies were evaluated using Randomized Block in 3 replications over three environments created by three different dates of sowing viz. 15 Nov., 5 Dec. and 25 Dec. at Agricultural Research Farm of RARI, Durgapura.

Observations were recorded on days to heading (Days), days to maturity (Days), grain filling period (Days), plant height (cm.), flag leaf area (cm²), number of tillers per plant, spike length (cm), number of grains per spike, 1000-seed weight (g), harvest index (%) and grain yield/plant (g). Mean values over selected plants were used for statistical analysis. The mean values of different

F₁s and F₂s for all characters were subjected for analysis of inbreeding depression as per cent increase or decrease in the mean value of F₂ over F₁.

Results and Discussion

The heterotic expression normally decreases in F₂ generation as the dominance or dominance interaction effects dissipate in this generation due to reduced heterozygosity, resulting into inbreeding depression. In present experiment, significant inbreeding depression was reported for different traits in all the three environments. Each cross exhibited significant inbreeding depression for atleast one or more traits in one or more traits, however none of the cross exhibited consistency for each character over each environment. For example the cross Raj 3765 X HD 2967 for days to heading in E₁ and E₂ environments and plant height in E₃ environment showed desirable significant inbreeding depression but in other cases it showed inbreeding depression either in desirable direction but non-significant or in undesirable direction. Cross Raj 3765 X DBW 621-50 for days to heading in E₂ environment, plant height in E₃ environment and spike length in E₃ environment showed desirable significant inbreeding depression but in other cases it also showed inbreeding depression either in desirable direction but non-significant or in undesirable direction. The same pattern was displayed by other crosses also for exhibition of inbreeding depression. Such results were also reported for different crosses and characters. However the cross HD 2967 X DBW 88 displayed desirable (significant negative) inbreeding depression for grain yield per plant and some other traits viz. spike length (cm) and number of grains per spike. Similar findings were also reported by Sharma and Menon (1996), Joshi *et al.* (2003b), Prakash Ved and Joshi (2003), Singh *et al.* (2004), Singh *et al.*, (2012), Kumar and Kerkhi (2014), Kumar *et al.*, (2015), Bhardwaj (2017) and Yadav 2017).

The negative inbreeding depression may result from the advantage of population buffering, which may occur in F₂ generation due to the segregation of genes or sometimes because of formation of superior gene

combinations, such a situation is valuable in conventional breeding programme.

References

1. Anonymous, 2015. Population growth (annual %). World Bank. Retrieved 20 January 2015.
2. Bhardwaj, R Genetic Studies for Yield and its Contributing Attributes in Bread Wheat (*Triticum aestivum* L. em Thell) Over Environments. *Thesis (Unpub.) submitted to SKNAU*, Jobner.
3. Falconer, D.S. 1981. Introduction to quantitative genetics, 2nd ed. Longman, New York.
4. Grafius, J.E. 1959. Heterosis in barley. *Agron. J.*, 51 (9): 551-554.
5. Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Aust. J. Biol. Sci.*, 9 (4): 463-493.
6. Joshi, S.K., Sharma, S.N., Singhania, D.L. and Sain, R.S. 2003b. Hybrid vigour over environments in a ten parent diallel cross in common wheat. *SABRAO. J. Br. Genet.*, 35: 81-91.
7. Kumar, A.; Harshwardhan; Kumar, A. and Prasad, B. (2015). Heterotic performance of diallel F₁ crosses over parents for yield and its contributing traits in bread wheat. *J. Hill Agri.*, 6 (1): 237-245.
8. Kumar, D. and Kerkhi, S.A. 2014. Heterosis studies for yield component traits and quality in spring wheat (*Triticum aestivum* L.). *Supplement Genet. and Pl. Br.*, 9 (4): 1725-1731.
9. Prakash, V. and Joshi, P. 2003. Genetics of metric traits in spring wheat under normal and late sown environments. *Crop Improv.*, 30 : 177-187.
10. Singh, H.; Sharma, S.N. and Sain, R.S. 2004. Heterosis studies for yield and its components in bread wheat over environments. *Hereditas.* 141: 106-114.
11. Singh, V.; Krishna, R.; Singh, S. and Vikram, P. 2012. Combining ability and heterosis analysis for yield traits in bread wheat (*T. aestivum* L.). *Indian J. Agric. Sci.*, 82: 11.
12. Sharma, S.N. and Menon, U. 1996. Heterosis over environments in bread wheat. *Crop Improv.*, 23: 225-228.
13. Yadav, J. 2017. Genetic architecture of yield and its associated traits in bread wheat (*Triticum aestivum* L. em. Thell.) over environments. *Thesis (Unpub.) submitted to SKNAU*, Jobner.



Sustainable Utilization of Bullock Power through Rotary Mode Power Transmission System in Operation of Flour Mill

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Abstract

Livestock have been used in agriculture for thousands of years supplying energy for crop production in terms of draught power and organic manure. Use of draught animals as source of energy is very dominant and will continue to be so for many more years (Srivastava, 2000). Draught animals are known to be widely used for selected crop production operation during cropping season and left idle for the rest of period. The idle period of draught animal can be very well utilized by other means. This is possible through employing animal in the rotary mode of power to operate different agro processing machines (Srivastava, 2000). One of the potential areas of draught animal power could be application to operate low horse power post-harvest machines such machines are chaff cutter, grain cleaner-cum-grader, water lifting, generation of electricity. This study attempts to operate a Flour mill machine through animal operated rotary power transmission unit to produce grain flour. The Power generated by the bullock pair in a developed rotary transmission system and Output of flour milling operation were varies significantly with speed of local bullock pair during all operations. The draft exerted by bullocks, speed of bullocks, power generated and output of flour Mill during work rest cycle were varied from 46 to 52 kg, 4.69 to 3.21 kmph, 0.585 to 0.527 kW and 7.5 to 6.0 kg/hr respectively. The output of flour mill by using animal driven rotary power transmission system was lower than that of in electrical operation. The total cost of operation of bullock operated flour mill were Rs. 72.91 per hour. Due to fluctuation of speed in rotary mode, the performance of the flour milling was lower in a rotary power transmission system than that of in the electrically operations.

Key words : *Rotary power transmission, flour mill, dynamometer, draft, fatigue score.*

Introduction

In rural areas electricity is either unavailable or available for limited time period. So performing many activities with the help of animal driven rotary mode power can be a good alternative. Draught animal are used for a limited time period for agricultural work 40 to 50 days and rest of the time they stand idle. The farmer has to feed them throughout the year despite no work output during off season, leading to high maintenance cost as compared to power output. But this idle period can be utilized and converted to work through rotary mode operation. The bullocks can be used in rotary mode power transmission system, post-harvest operations like mini rice mill, chaff cutting, dal milling, groundnut decortications, flour milling, oil extraction, threshing and other stationery operations. Development of matching agro processing machines to be used in rotary mode power transmission system is helpful to the farmers to use their animals in idle time and save electricity and other fuels and may earn more by lending this facility to others.

Materials and Methods

The rotary gear unit was installed in the premises of College of Agricultural Engineering and Technology, at the site of the AICRP on UAE, CAET, V.N.M.K.V, and

Parbhani. India. The experiment was conducted during 2013-14 in the College of Agricultural Engineering and Technology, V.N.M.K.V., Parbhani, Maharashtra. The bullock operated rotary power transmission system was evaluated for its performance for flour milling operation. During the test, bullocks were hitched at a distance of 5.5 m from the Centre of vertical input shaft. The bullocks walked in circular motion that resulted on an average 2.0 RPM at vertical input shaft 710 RPM at pulleys of Flour Mill. Flour mill is a machine of 1 hp capacity which is operated by Rotary Power Transmission system. The bullock operated rotary transmission system was designed for 1 hp power output. The work rest schedule of 1 h work + 0.5 h rest + 1 h work + 0.5 h rest + 1 h work was followed. The speed (kmph), Draft (kg), Output (kg/hour), Power developed (W), Physiological responses and Fatigue score of local bullocks flour milling operations were recorded.

Rotary gear Unit

Box : In the gear box different part are assembled it is made up of 6mm thick cast iron plate frame shape of box is rectangular having dimension 860mm X 750mm X 75mm

Spur gear : A set of spur gear of power transmission between two parallel shafts. The spur gear are made up of



Animal driven rotary power transmission unit

heat treated alloy steel having module 3.0 mm the spur gear has 96 T Teeth while the spur pinion has 23T teeth. The speed ratio is 1: 4.1 speed step-up obtained.

Bevel gears : A set of bevel gear transmitted the power of 900 they are spiral tooth. The material of the bevel gear is heat treated alloy steel .The speed ratio is 1:4. Combination of bevel and spur gear can produce the speed ratio of 1 : 4.

Shafts : The first shaft of spur gear is held in vertical position having diameter of 500mm at bottom side and top side respectively. The second shaft of the spur 94T teeth link with third shaft of idler gear 22T has 250 mm with ratio 1: 4 speed step-up and idler gear 110T teeth link with pinion 31T teeth has dia 250 mm. The fourth shaft of pinion fixed by belt-pulley transmission system dia 18" Drive pulley transmit the power to dia 10" pulley of bevel gear which is transmit vertical motion to horizontal 900 motion to the underground shaft of rotary mode system.

Bearings : One ball bearing 90 x 50 x 24 mm size is fitted on the 50mm shaft and another ball bearing of 72 x 30 x 20 mm size are fitted at the top of the same. One thrust bearing 60 x 38 x 20 mm size is fitted at outer end of pinion shaft. For underground shaft four pedestal bearings 300 x 80 x 50 mm size is fitted.

Belt pulley transmission unit : The two transmission shaft are mounted in this rotary mode system first shaft is underground shaft which is connected to output of gear box that first drive shaft was coupled with another 16 feet size shaft for increasing length. One pulley of 12" was mounted on the first drive shaft and counter shaft has pulley of 16" and other pulleys of various sizes .The pulley of 12" was connected to 16" size pulley in counter shaft with the help of v belt thereby stepping down in the ratio 1:0.75

For Flour mill operation another 45.72 cm pulley mounted on the counter shaft was connected through v-belt with the shaft of flour mill unit having 20 cm pulley

stepping up ratio 1:2.25. so final input to output speed ratio for flour mill is 1: 1.6

Yoke : Harnessing system plays a very important role in utilizing the available animal power efficiently. It consisted of a yoke and strong rope. The yoke was supported by the withers and provided the necessary tractive force. A rope was used to hitch the horizontal beam with yoke.

Measuring instruments : Measuring instruments which were used during the testing of rotary power transmission system. The drawbar power required to pull the shaft was measured by using digital dynamometer. It is usually placed between the animal yoke and the shaft to be pulled through the rope. The tachometer was used to measure rpm of output shaft. A measuring tape was used for measuring the dimensions of the set-up for the proper installation of machineries. Vernier caliper was used for measuring the smaller dimensions of the system component. A stop watch was used to measure the travelling speed of bullock. It was also used for measuring respiration & pulse rate count in one minute. The stopwatch used has the precision to measure the time up to 1 micro second. A digital thermometer was used for measurement of body temperature of bullocks. The physiological observations were recorded according to the method given by Miller and Robertson (1959). Pulse rate was measured by placing the index or second finger on the coccygeal artery beneath the tail of bullocks and the number of beats per minute was counted. The pulse rate was measured at the start of work and at hourly interval in both the sessions. The respiration rate was measured by counting the number of hot gushes exhaled per minute by placing the palm of hand near the nostrils of the bullocks. The respiration rate was measured at the start of work in both the session and thereafter every hour of work. The body temperature of the bullocks was measured by inserting the clinical thermometer 40 to 50 mm inside of the rectum of bullocks for two minute duration. The body temperature was measured at the start of work in both the session and thereafter every half hour of work.

Experimental Procedure : Experiments were conducted at AICRP on UAE, CAET Parbhani site. The procedure followed is described below:

Evaluation of power transmission system : The developed power transmission system was evaluated by computing the power, draft and output. The load was applied only after the bullocks attained the desired working speed. The dynamometer was mounted between yoke and beam, such that the pull exerted by the bullocks was applied to the beam through the dynamometer and which showed the instantaneous pull acting at the beam. The recorded draught was used to calculate input power.

Test bullocks were hitched and allowed to move on a circular track. The system was tested at no load and loads. The resulted draft was measured using dynamometer. The input power was calculated using the following relations :

$$\text{Input Power (kW)} = \frac{(\text{Draft(N)} \times \text{Speed(m / s)})}{1000}$$

Selected Flour Mill Machines RPM Record : For flour mill operation Electrical rpm was 700 measured by Tachometer and the Rated rpm with Bullock operating Power Transmission unit rpm 710 was measured. For obtaining same rpm, the 45.72 cm pulley mounted on the counter shaft was connected through v- belt with the shaft of flour mill unit having 20 cm pulley. The stepping up ratio 1:2.25 so final input to output speed ratio for flour mill is 1: 1.6

Mechanism of rotary power transmission system :

The rotary power transmission system was evaluated by computing the power, draft and power output. Test bullocks were hitched and allowed to move on a circular track. The load was applied only after the bullocks attained the desired working speed. The dynamometer was mounted between yoke and beam, such that the pull exerted by the bullocks was applied to the beam through the dynamometer and which showed the instantaneous pull acting at the beam. The recorded draught was used to calculate input power. The system was tested at loads condition. The resulted draft was measured using dynamometer.

Physiological Responses of Bullocks : The trials were conducted using yoke. Tests were conducted during summer (March-April) season. Trials were conducted using following work-rest schedule. 1 h work + 0.5 h rest + 1 h work+ 0.5 h rest + 1 h work during the rest period animals were kept in shed and also given feed and water. The environmental temperature started declining in the evening session and animals work up till the natural light was available. Hence, on an average the animals worked for 3-4 hour per day. The physiological responses such as respiration rate, pulse rate and body temperature were recorded at the start of work in both the sessions termed as initial values. Then, after every hour of work the observation were recorded for physiological responses and physical symptoms for both the bullocks separately. The bullock moving in the outer circle was termed as outer bullock and the one moving inside was called inner bullock. The average speed was also calculated.

Performance evaluation of Flour Mill : A commercially available Flour Mill of capacity 1 hp manufactured by Vijay Engineering, Narayangoan, Pune was used (Plate). It was modified for using it in rotary transmission unit. The Flour

Mill of capacity 1 hp was evaluated for its performance in developed animal driven rotary transmission system. Jowar grains were grinded in it. An output capacity in Kg per hour was measured in respect of animal and electric operated. The output capacity of selected Flour Mill operated by animal driven rotary transmission system was also compared with an electric operated Flour Mill of capacity 1 Hp respectively. Offered machines are used for grinding of all kind of grains. These are extensively used for grinding of wheat, grains, pulses and many more.

Table-1 : Technical Specification of Flour Mill.

Sr. No.	Overall Dimensions	
1.	Length (mm)	800
2.	Width (mm)	550
3.	Height (mm)	660
4.	Weight (kg)	85
5.	Number of stones :	2
6.	Grinding efficiency (per cent)	89.4-94.3
7.	Power requirement (kW) :	4.3 -5.7
8.	Capacity (kg/h) : (depending upon the grain)	8-10



Plate-1, 2 : Using flour mill jowar flour were obtained from bullock operated power transmission system.

Results and Discussion

Bullock operated rotary power transmission system was evaluated for its performances in Flour milling operation in continuous working of 1.5 hours at load conditions. The comparative physiological behavior of inner and outer bullock (B1 and B2) in a developed rotary mode system for Flour milling operation were observed for obtaining maximum work efficiency without undue fatigue. The tests were carried out on the test track for continuous three effective hours of work duration. The various physiological parameters and physical symptoms of individual bullock were recorded during experiment. The level of fatigue was assessed using fatigue score card developed by Upadhyay and Madan (1985).

Table-2 demonstrate that at load condition an average speed of local bullock pair was decreased from 4.55 to 3.21 kmph during 1.5 hours of work. Draft exerted by the bullock pair was varies from 46 to 52 kg. Speed available at flour mill was also observed to be decreased

Table-2 : Performance evaluation of bullock operated rotary power transmission system under an operation of Flour Mill at load condition.

Parameters	Duration, h								Mean	
	In		0.5		1.0		1.5			
	B1	B2	B1	B2	B1	B2	B1	B2	B1	B2
Respiration rate, bpm	15	16	28	30	38	39	40	42	30.25	31.75
pulse rate, bpm	48	43	53	51	59	56	64	66	56	55
Body temp, °C	37.7	37.8	37.9	38.0	38.2	38.3	38.5	38.6	38.07	38.17
Draft, kg	—		52		46		48		48.6	
Percentage body weight	—		5.90		5.22		5.45		5.52	
Draft, N	—		509.6		450.8		470.4		476.9	
rpm of bullocks/0.5h	—		66		63		61		63	
Speed, m/s	—		1.26		1.30		1.17		1.24	
Speed, km/h	—		4.55		4.69		3.21		4.48	
rpm at machine shaft	—		700		730		710		713	
Power output of Bullock (kW)	—		0.585		0.527		0.540		0.550	
Output (Kg/h)	—		6.0		7.5		7		6.8	
Fatigue score			15		17		17		16.33	

from 730 to 700 RPM. Similarly, Power generated was also decreased from 0.585 to 0.527 kW at the same condition. The output of flour mill was varies from 7.5 to 6.0 kg/hr. The respective average values of Draft, Percentage of draft to body weight of bullock pair, Average speed of bullock pair, Speed available at flour mill, Power output and Output of flour mill were 48.6 kg, 5.52 %, 4.48 kmph, 713 RPM, 0.550 kW and 6.8 kg/hr respectively at load condition.

Determination of work rest schedule for bullock for rotary power transmission system in operation of Flour mill : A pair of bullock was used to operate flour mill having 1 hp capacity. The work rest schedule of 1 h work + 0.5 h rest + 1 h work+ 0.5 h rest + 1 h work was followed for flour milling operation. This work rest cycle was adopted to get maximum performance from the selected local bullocks. It is due to the fact that, the bullocks gives better performance in continuous 1 hour of work. During the experiment period, fatigue score of bullock noted according to Madan and Upadhyay (1985) by observing behavioural changes as well as by recording physiological responses after half an hour.

Comparison of outputs of animal drawn rotary power transmission system and Electrical operated flour mill : The comparison between outputs of bullock operated, and electrical operated flour mill shows that output of bullock operated flour mill is 7.5 to 6.0 kg/hr. of flour. Output of an electrically operated flour mill was 8 to 9 kg /hr of flour. It is clear that, an output of bullock operated flour mill is lower than that of output of an electrically operated.

Cost economics of animal driven rotary transmission system for operating flour mill : The total cost of rotary power transmission unit for operating Flour Mill with pair of bullock is Rs. 72.91 per hour Cost.

Conclusions

The Power generated by the bullock pair in a developed rotary transmission system and Output of flour milling operation were varies significantly with speed of local bullock pair during all operations.

The output of flour mill by using animal driven rotary power transmission system was lower than that of in electrical operation.

The total cost of operation of bullock operated Flour mill were Rs.72.91 per hour.

Due to fluctuation of speed in rotary mode, the performance of the flour milling was lower in a rotary power transmission system than that of the in the electrically operations.

The highest fatigue scores developed during the operation of flour milling were 17 and 15, respectively which were below the threshold fatigue score of 20. The bullock pair gives better performance during operation of flour milling within safer limit of fatigue.

The operation of flour milling through rotary mode was not economical compared to be operated with electric motor, but it was a meaningful utilization of animal power during the idle period in farm operation to take care of the maintenance cost of

bullocks throughout the year by the bullock-owning farmers.

References

1. Swain, S.K., M.K. Ghoshal, A.K. Dash and A.K. Mohapatra, "A study on bullock energy utilization through rotary mode power transmission system in operating potato peeler and slicer for chips making as value added product of potato", *International Journal of Agriculture Engineering*, Volume 6, Issue 2, pp. 529-536, 2013.
2. Behera, D., Behera, B.K., Mohapatra, A.K. and Swain, S, "Draught animal status in Orissa and its utilization pattern in few selected villages", *Agric. Engg. Today*, Vol. 30 (5 & 6) pp. 1-6, 2006.
3. Behera, B.K., Swain, S, Behera, D. and Mohapatra, A.K., "Studies on draftability of non-descript bullocks of Orissa", *J. Agric. Engg.*, Vol.43 (1), pp. 35-41, 2006.
4. Srivastava, N.S.L., "Animal energy in agriculture", *Agric.Engg. Today*, Vol.24 (2), pp. 24-26, 2000.
5. Doshi, C.P. and Tiwari, G. "A review of draught animal power as a prime mover for site specific operations", *Agricultural Mechanization in Asia, Africa & Latin America*, Vol.39 (3), pp. 37-41, 2008.
6. Ghosal, M.K., Behera, D. and Mohapatra, A.K. (2012). "Sustainable utilization of bullock power for chaffing operation through mechanical gear system." *Ani. Sci. Reporter*, 6(4): 123-130.
7. Singh, C.D. and Singh, R.C. "Study on physiological response of malvi breed bullocks in rotary mode transmission system for electricity generation", *Agric. Engg. Today*, Vol. 37(1), pp.1-6, 2013.
8. Khan, Chand, Pandey, R.K., Shahi, N.C. and Lohani, U.C. (2013). "Pedal operated integrated potato peeler and slicer." *Agric. Mechanization in Asia, Africa & Latin America*, 44 (1): 65-68.
9. Khurmi, R.S. and Gupta J.K, "A Text Book of Machine Design", Eurasia Publishing House Pvt. Ltd., New Delhi. pp. 97, 398, 832, 868, 1997.



Growth, Yield and Economics of Chickpea (*Cicer arietinum* L.) as Influenced by Nitrogen Levels and Different Weed Control Practices

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Abstract

Nitrogen and weed control are the key to get maximum crop yield in most of the crops. In order to study the response of nitrogen levels and weed control practices on growth, productivity and economics of chickpea a field experiment was conducted during *rabi* season of 2019-20. The experiment consisting of twelve treatment combinations comprising two levels of nitrogen *i.e.* 15 and 30 kg/ha and six treatments of weed control practices *viz.*, W₁ : Weed free, W₂ : Unweeded, W₃ : Pendimethalin @ 0.75 kg/ha as PE, W₄ : Imazethapyr @ 75 g/ha as PoE at 25 DAS, W₅ : Pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS and W₆ : Imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45 days after sowing. The results obtained during the course of investigation indicated that significantly higher plant height at harvest, number of branches at harvest, number of pods per plant, grain yield and B:C ratio of chickpea were recorded with 30 kg nitrogen per hectare. Among the different weed control practices significantly tallest plant at harvest, number of pods per plant and grain yield were observed with weed free condition (W₁) but it was at par with pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W₅). Significantly the lowest plant height at harvest, number of pods per plant and grain yield were recorded by the application of imazethapyr @ 75 g/ha as PoE at 25 DAS (W₄) due to phytotoxic effect of imazethapyr but number of pods per plant and grain yield were at par with unweeded treatment (W₂). Whereas, the highest B:C ratio was obtained by treatment pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W₅) which was closely followed by weed free treatment (W₁).

Key words : Pendimethalin, imazethapyr, chickpea, nitrogen levels, weed control.

Introduction

Chickpea (*Cicer arietinum* L.), commonly known as gram and locally known as chana is the foremost and important conventional pulse crop in India. During 2018-19, chickpea was cultivated on about 9.54 million hectares area with a production of 9.93 million tonnes having a productivity of 1041 kg/ha (FAOSTAT, 2019). Chickpea is used extensively for human food as 'Dal' (split cotyledons), chhole, dishes *viz.*, sweets, snacks and namkeen from its flour called besan, fodder and source of nitrogen and soil fertility for many cropping systems. The various agronomical practices like sowing time, seed rate, spacing, fertilizer application, weed management, irrigation etc. play an important role in increasing production of chickpea. Among the different agronomic practices, nitrogen application and weed management plays very important role in increasing the production of chickpea. Nitrogen ranks first and very important nutrient which is closely associated with growth and development of the crop. It is the most limiting nutrient in Indian sandy to loamy sand soils having high infiltration and percolation rate that leads to leaching of nitrogen through irrigation water. It imparts green colour to leaves, stem and that enables the plant to transfer energy from sunlight by

photosynthesis. Nitrogen also plays a vital role in synthesis of chlorophyll as well as amino acids, which contribute to the building unit of protein and thus growth of plant. The deficiency of nitrogen causes chlorosis, reduction in growth rate and often early senescence of older leaves, leading to yield losses. (Caliskan *et al.*, 2008; Erman *et al.*, 2011).

Nitrogen is the most mobile element and required throughout for the growth of plant. Moreover, chickpea being a pulse crop required less amount of nitrogen due to legume-rhizobia association fix nitrogen in root nodules. However, it requires small amount of nitrogen during early stage of the crop for its establishment and growth until the onset of N-fixation (Giller and Cadisch, 1995). Thus, there is a need to apply nitrogenous fertilizer in the nitrogen deficient soils to overcome the deficiency of nitrogen and to harness higher yield of chickpea.

In addition to nitrogen in chickpea, weeds are the another limiting factor in chickpea crop production. Weed infestation is reported to cause yield losses to the extent of 40-87% depending on the weed species, period of crop weed competition (30 to 60 days) and its intensity in chickpea (Bhan and Kukula, 1987). The choice of any weed control practices depends largely on its

effectiveness and cost. The predominant methods of weed control are hand weeding and interculturing in chickpea crop, but unavailability of labours at the time of weeding and higher cost of operations make these methods ineffective, tedious and costly. Under such situations, chemical control of weeds may be viable and cost effective alternative for this crop. Therefore, it is essential to control weeds by any means during the growth period of chickpea to obtain higher yield potential.

Keeping above facts in view, this investigation deals with the effect of nitrogen levels and different weed control practices on growth, yield and economics of chickpea.

Materials and Methods

A field experiment was conducted at Agronomy Instructional Farm, C.P. College of Agriculture, Sandarkrushinagar Dantiwada Agricultural University, Sandarkrushinagar during *rabi* season of 2019-20. The experiment consisting of twelve treatment combinations comprising two levels of nitrogen *i.e.* 15 and 30 kg nitrogen per hectare and six treatments of weed control practices *viz.*, W_1 : Weed free, W_2 : Unweeded, W_3 : Pendimethalin @ 0.75 kg/ha as PE, W_4 : Imazethapyr @ 75 g/ha as PoE at 25 DAS, W_5 : Pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS and W_6 : Imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45 DAS were evaluated in randomized block design with factorial concept with three replications. Chickpea variety GJG 3 was used and sown at a distance of 45 cm between the rows and 10 cm within the rows. The soil of experimental field was loamy sand in texture with low in organic carbon (0.19 %) and low in available nitrogen (149.7 kg/ha), medium in available phosphorus (38.6 kg/ha) and high in available potassium (281 kg/ha) having slightly alkaline pH value (7.48). Basal dose of nitrogen fertilizer was applied in respective plots according to treatment whereas basal dose of 40 kg P_2O_5 /ha was common for all treatment plots. The source nitrogen and phosphorus was urea (N, 46%) and single super phosphate (P_2O_5 , 16%), respectively. Application of herbicides was done as per treatment, pre-emergence application of pendimethalin (0.75 kg a.i./ha) while post-emergence application of imazethapyr (75 g a.i./ha) was applied alone at 25 days after sowing. The required quantity of herbicides *viz.*, pendimethalin and imazethapyr was dissolved in water and the solution was sprayed uniformly by knapsack sprayer having flat-fan nozzle. The data recorded for plant height, number of branches per plant, number of pods per plant and grain yield during the course of investigation were statistically analysed by a procedure appropriate to the design of experiment. The significance of difference was tested by "F" test at 5 per

cent level. The critical difference was calculated when the differences among treatments were found significant under "F" test. The economics was calculated on the basis of prevailing market price of inputs and produce. The weather conditions were almost favourable for the crop growth and there was no any severe attack of insect and disease during the course of investigation.

Results and Discussion

Effect on plant height of chickpea

Effect of nitrogen : The data presented in Table-1 showed the significant difference on plant height of chickpea due to application nitrogen. An application of 30 kg nitrogen per hectare showed significantly higher plant height at harvest (42.6 cm) than the application of 15 kg nitrogen per hectare. The magnitude of increase in plant height with 30 kg nitrogen per hectare was 5.44 per cent higher over 15 kg nitrogen per hectare. The taller plant under the higher level of nitrogen might be due to application of nitrogen, which helps in stimulating cell division, cell elongation and protoplasm formation leading to higher plant height. These findings are in agreement with the findings of Singh *et al.* (2012) and Tripathi *et al.* (2013). Singh *et al.* (2012) observed that plant height of chickpea was significantly higher with the application of 20 kg nitrogen per hectare than that of 10 kg nitrogen per hectare.

Effect of weed control practices : Among weed control practices, there was significant effect on plant height at harvest. Significantly maximum plant height (47.2 cm) was recorded by weed free treatment (W_1) which was at par with pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W_5). Significantly the minimum plant height (35.1 cm) was recorded by the treatment of imazethapyr @ 75 g/ha as PoE at 25 DAS (W_4) being at par with imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45 DAS (W_6) at harvest. The higher plant height by keeping the plot weed free might be due to effective weed control which reduced competition with the crop plant for nutrient, light, water and space leading to higher growth of plant in terms of plant height. The lower plant height by post emergence application of herbicide imazethapyr @ 75 g/ha as PoE at 25 DAS (W_4) and imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45 DAS (W_6) might be due to phytotoxic effect resulting in to slow and stunted growth which naturally reduced the plant height of chickpea crop at all crop growth stages. These findings are in close conformity with those reported by Patel *et al.* (2006) and Khope *et al.* (2011).

Interaction effect : The interaction effect on plant height as influenced by nitrogen and weed control practices was found non-significant at harvest.

Effect on number of branches per plant

Effect of nitrogen : Number of primary and secondary branches per plant at harvest were significantly increased by increasing in the level of nitrogen (Table 1). An application of 30 kg nitrogen per hectare recorded significantly higher number of primary and secondary branches per plant (3.9 and 8.9, respectively) but number of secondary branches per plant were found at par with 15 kg nitrogen per hectare. The higher number of primary and secondary branches per plant might be due to higher plant height and increased metabolic activities in the plant which leads to higher growth of the plant and ultimately resulted into more number of branches per plant. The present findings are closely related with the findings of Namvar *et al.* (2011) and Devi *et al.* (2019).

Effect of weed control practices : A perusal of data presented in Table-1 revealed that different weed control practices showed their significant effect on number of primary branches per plant. Significantly higher number of primary branches per plant (4.4) was recorded by the application of imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45 DAS (W_6) but it was statistically at par with treatment imazethapyr @ 75g/ha as PoE at 25 DAS (W_4). Significantly the lowest (2.9) number of primary branches per plant was recorded by unweeded treatment (W_2). There was no significant effect on number of secondary branches per plant due to different weed control practices. The increased in number of branches per plant might be due to higher plant height and more growth of the plant which cumulatively facilitated the crop to utilize more nutrients and water resulting in more number of branches per plant. The higher number of primary and secondary branches in imazethapyr applied treatments might be due to application of imazethapyr changed the plant architecture and plants became bushy with small size leaves which allocated more photosynthates in horizontal direction than the vertical leading to more number of branches per plant. These findings are in accordance with the findings of Poonia and Pithia (2013) and Pritam *et al.* (2015).

Interaction effect : The interaction effect on primary and secondary branches at harvest as influenced by nitrogen and weed control practices was found non-significant.

Effect on number of pods per plant

Effect of nitrogen : The results presented in Table-1 showed the significant influence on number of pods per plant due to nitrogen levels. Significantly higher number of pods per plant (31.9) were observed by the application of 30 kg nitrogen per hectare than that of 15 kg nitrogen per hectare (29.9). The higher number of pods per plant might be due to more supply of nitrogen, which enhanced

photosynthesis activity and the process of tissue differentiation from somatic to reproductive phase leading to more development of floral primordia and more translocation of photosynthates towards floral parts which ultimately increased in more number of pods per plant. These results are in close proximity with the findings of Ali *et al.* (2010) and Kamble *et al.* (2019). Ali *et al.* (2010) observed that number of pods per plant was increased with the increasing in the nitrogen levels from 0 to 30 kg per hectare.

Effect of weed control practices : Weed control practices showed their significant impact on number of pods per plant (Table-1). Keeping the plot weed free throughout the crop season (W_1) produced significantly higher number of pods per plant (35.1) than rest of weed control practices except pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W_5) (34.0). The minimum number of pods per plant (27.5) was recorded by the application of imazethapyr @ 75g/ha as PoE at 25 DAS (W_4) being at par with unweeded treatment (27.6). The higher number of pods per plant might be due to the less competition for resources at critical periods of crop growth and better suppression of weeds which allowed the crop to grow potentially by absorbing sufficient nutrients which facilitate more translocation of photosynthates towards the reproductive parts leading to more number of pods per plant. These results are in close vicinity with the findings of Kaushik *et al.* (2014) and Rupareliya *et al.* (2017). Kaushik *et al.* (2014) recorded significantly higher number of pods per plant of chickpea by hand weeded (weed free) plot over unweeded control plot.

Interaction effect : The interaction effect on number of pods per plant as influenced by nitrogen and weed control practices was found non-significant.

Effect on grain yield of chickpea

Effect of nitrogen : The data presented in Table-1 showed that the grain yield of chickpea was significantly influenced due to nitrogen levels. An application of 30 kg nitrogen per hectare recorded higher grain yield (1663 kg/ha) than that of 15 kg nitrogen per hectare (1448 kg/ha). Fertilizing the chickpea crop by 30 kg nitrogen per hectare produced 14.8 per cent higher grain yield than the application of 15 kg nitrogen per hectare. The higher grain yield due to application of higher dose of nitrogen is ascribed to positive effect on enhancement of growth and yield attributing characters like plant height, number of branches per plant and number of pods per plant. Beside this, fertilizing the crop with higher dose of nitrogen might have decreased the competition for resources particularly nutrients between chickpea and weeds which also ultimately leads to more growth and yield attributing

Table-1 : Effect of nitrogen and weed control practices on growth and yield of chickpea.

Treatments	Plant height (cm)	Number of branches per plant		Number of pods per plant	Grain yield (kg/ha)
		Primary	Secondary		
Nitrogen (N)					
N ₁	40.4	3.4	8.4	29.9	1448
N ₂	42.6	3.9	8.9	31.9	1663
S.Em. ±	0.71	0.08	0.18	0.68	31.5
C.D. at 5 %	2.08	0.2	0.5	1.99	92
Weed control practices (W)					
W ₁	47.2	3.6	9.1	35.1	1942
W ₂	41.4	2.9	7.8	27.6	1280
W ₃	42.9	3.4	8.4	30.4	1504
W ₄	35.1	4.3	8.9	27.5	1222
W ₅	46.5	3.5	8.8	34.0	1811
W ₆	35.8	4.4	9.0	30.6	1572
S.Em. ±	1.23	0.14	0.31	1.18	54.6
C.D. at 5 %	3.59	0.4	NS	3.45	160
Interaction					
N × W	NS	NS	NS	NS	Sign.
C.V. %	7.24	9.58	8.67	9.33	8.59

Table-2 : Interaction effect of nitrogen and weed control practices on grain yield of Chickpea.

Treatments	Grain yield (kg/ha)					
	W ₁	W ₂	W ₃	W ₄	W ₅	W ₆
N ₁	1735	1257	1430	1190	1565	1511
N ₂	2150	1303	1578	1253	2058	1634
C. D. at 5%			226			
C.V. %			8.59			

characters resulting into more grain yield of chickpea crop. Similar results were observed in chickpea by Jakasaniya *et al.* (2012), Rani and Krishna (2016) and Prajapati *et al.* (2017). Jakasaniya *et al.* (2012) found out that an application of 40 kg nitrogen per hectare gave higher yield over 20 kg nitrogen per hectare.

Effect of weed control practices : Data pertaining to grain yield of chickpea presented in Table 1 showed that all the weed control practices significantly increased the grain yield as compared to the unweeded plot (W₂) except imazethapyr @ 75g/ha as PoE at 25 DAS (W₄). Among the different treatments of weed control practices, weed free treatment (W₁) was found significantly superior in enhancing grain yield (1942 kg/ha) and it was statistically at par (1811 kg/ha) with pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W₅). The performance of imazethapyr @ 75g/ha as PoE at 25 DAS (W₄) was poor among different weed control practices due to the phytotoxic effect of imazethapyr and very slow recovery. The lowest grain yield (1222 kg/ha) was recorded by the application of imazethapyr @ 75g/ha as PoE at 25 DAS (W₄) which was statistically at par (1280 kg/ha) with unweeded treatment (W₂). Yield is an output of sequential metamorphosis from source to sink. Effective removal of weeds throughout crop growth period by

physical and integrated weed control practices provide better space, moisture, nutrient and solar radiation for better improvement of plant growth *i.e.* plant height and number of branches per plant as well as yield attribute like number of pods per plant. The more number of weeds in unweeded plot might have reduced the plant growth due to smothering effect of weeds on crop plants thereby poor seed yield of chickpea obtained. The lowest grain yield by the application of imazethapyr @ 75g/ha as PoE at 25 DAS might be due to phytotoxic effect of imazethapyr on chickpea plant. These findings are in conformity with results obtained by Varshney and Larya (2004), Sharma and Kushwaha (2010), Poonia and Pithia (2013), Kaushik *et al.* (2014) and Rupareliya *et al.* (2017). Sharma and Kushwaha (2010) observed significantly higher yield of chickpea with weed free condition and it was followed by hand weeding twice at 30 and 60 DAS and application of pendimethalin @ 1.0 kg per hectare.

Interaction effect : The interaction effect of nitrogen and weed control practices on grain yield was found significant (Table 2). The highest grain yield (2150 kg/ha) was recorded by fertilizing the crop with 30 kg nitrogen per hectare along with weed free treatment and was at par with 30 kg nitrogen per hectare and pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W₅)

Table-3 : Economics of different treatments on chickpea as influenced by nitrogen and weed control practices.

Treatments	Gross realization (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	B:C ratio
Nitrogen (N)				
N ₁	72888	32747	40141	2.23
N ₂	83660	32940	50720	2.54
Weed control practices (W)				
W ₁	97666	37966	59700	2.57
W ₂	64612	30166	34446	2.14
W ₃	75794	31306	44488	2.42
W ₄	61415	30726	30689	2.00
W ₅	91100	33836	57264	2.69
W ₆	79057	33066	45991	2.39

treatment combination. The lowest grain yield (1190 kg/ha) was found by the interaction of 15 kg nitrogen per hectare and imazethapyr @ 75 g/ha as PoE at 25 DAS (W₄). The increase in the grain yield by the application of 30 kg nitrogen per hectare along with weed free treatment (W₁) was about 80.82 per cent higher than the combination of 15 kg nitrogen per hectare and imazethapyr @ 75 g/ha as PoE at 25 DAS (W₄). The higher grain yield by the application of 30 kg nitrogen per hectare along with weed free treatment might be due to higher level of nitrogen and weed free condition which provides suitable environment for the better growth and yield attributes *i.e.* plant height, number of branches per plant and number of pods per plant. The lower level of nitrogen along with phytotoxic effect of imazethapyr might have resulted in lowest grain yield. These findings are in accordance with those reported by Singh and Mukherjee (2009), Upasani *et al.* (2013) in wheat and Deva (2016).

Effect on Benefit cost ratio (BCR)

Effect of nitrogen : Data presented in Table-3 showed that application of 30 kg nitrogen per hectare increased B:C ratio (2.54) as compared to application of 15 kg nitrogen per hectare. Application of 15 kg nitrogen per hectare recorded the lower B:C ratio (2.23). Grain yield increased with increase in nitrogen levels from 15 to 30 kg per hectare (Table 4.8) might be responsible for higher B:C ratio. This finding followed the pattern of those reported by Gudadhe *et al.* (2011).

Effect of weed control practices : The data presented in Table-3 revealed that all the weed control practices except imazethapyr @ 75g/ha as PoE at 25 DAS (W₄) increased B:C ratio as compared to unweeded treatment (W₂). Data further revealed that maximum B:C ratio (2.69) was obtained under pendimethalin @ 0.75 kg/ha as PE + IC at 30 DAS + HW at 45 DAS (W₅) which was closely followed by weed free treatment (2.57). Whereas, under imazethapyr @ 75 g/ha as PoE at 25 DAS + HW at 45

DAS (W₆) and pendimethalin @ 0.75kg/ha as PE (W₃) B:C ratio was 2.39 and 2.42, respectively. This might be due to more number of labour required under weed free treatment to perform operation which increased cost of cultivation, while chemical weeding employed lesser number of labour which saved extra wages and also reduce the risk of drudgery involved in weeding leads to higher monetary advantage and increased B:C ratio. Similar findings were also reported by Arya (2004), Kaushik *et al.* (2014) and Gore *et al.* (2015). Kaushik *et al.* (2014) recorded the highest B:C ratio by the application of pendimethalin @ 0.75 kg/ha + one hand weeding at 25 DAS followed by weed free plot.

Conclusions

On the basis of this one-year experiment, it is concluded that higher growth, yield and economics in chickpea can be obtained by fertilizing the chickpea crop with 30 kg N/ha and application of pendimethalin @ 0.75 kg/ha as PE + intercropping at 30 DAS + hand weeding at 45 DAS under north Gujarat agroclimatic conditions.

References

1. Ali, A.; Ali, Z.; Iqbal, J.; Nadeem, N.; Akhtar, H.M.; Akram and Sattar, A. (2010). Impact of nitrogen and phosphorus on seed yield of chickpea. *Journal of Agriculture Research*. 48 : 330-340.
2. Arya, R.L. (2004). Integrated weed management in chickpea (*Cicer arietinum*) + mustard (*Brassica juncea*) intercropping system under rainfed conditions. *Indian Journal of Agronomy*. 49 (2): 98-100.
3. Bhan, V.M. and Kukula, S. (1987). Weeds and their control in chickpea. CAB International, Wallingford. pp. 319-328.
4. Caliskan, S.; Ozkaya, I.; Caliskan, M.E. and Arslan, M. (2008). The effect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean type soil. *Field Crops Research*. 108 : 126-132.
5. Devi, P.B.; Darvhankar, M.S.; Prakash, A. and Banik, D. (2019). Effect of different doses of nitrogen on growth and

- yield of chickpea (*Cicer arietinum*). *Plant Archives*. 19 : 458-460.
6. Erman, M.; Demir, S.; Ocak, E.; Tufenkci, S.; Oguz, F. and Akkopru, A. (2011). Effects of Rhizobium, arbuscular mycorrhiza and whey applications on some properties in chickpea (*Cicer arietinum* L.) under irrigated and rainfed conditions. *Field Crops Research*. 122 (1) : 14-24.
 7. FAOSTAT (2019). Food and Agricultural Organization Statistical Database. Crop production index. FAO, Rome, Italy.
 8. Giller, K.E. and Cadisch, G. (1995) Future benefits from biological nitrogen fixation : An ecological approach to agriculture. *Plant and Soil*. 174 : 255-277.
 9. Gore, K.; Gobade, S.M. and Patil, P.V. (2015). Effect of pre and post emergence herbicides on yield and economics of chickpea (*Cicer arietinum* L.). *International Journal of Tropical Agriculture*. 33 (2) : 909-912.
 10. Gudadhe, N.N.; Khang, V.T.; Thete, N.M.; Lambade, B.M. and Jibhkate, S.B. (2011). Studies on organic and inorganic sources of nutrient application in cotton-chickpea cropping sequence. *Omon Rice*. 18: 121-128.
 11. Jakasaniya, M.S.; Patel, G.A. and Shelke, A.V. (2012). Response of chickpea (GG 1) to nitrogen, phosphorus and sulphur with and without bio-fertilizers under supplementary irrigation in Bhal region of Gujarat. *International Journal of Forestry & Crop Improvement*. 3(2) : 154-156.
 12. Kamble, G.; Giri, G.K.; Charpe, A.M. and Wakte, P.S. (2019). Effect of nitrogen doses with rhizobium seed inoculation on nodulation and grain yield of chickpea. *Multilogic in Science*. 8 : 169-170.
 13. Kaushik, S.S.; Rai, A.K.; Sirothia, P.; Sharma, A.K. and Shukla, A.K. (2014). Growth, yield and economics of rainfed chickpea (*Cicer arietinum* L.) as influenced by integrated weed management. *Indian Journal of Natural Products and Resources*. 5 (3) : 282-285.
 14. Khope, D.; Kumar S. and Pannu, R.K. (2011). Evaluation of post-emergence herbicides in chickpea (*Cicer arietinum*). *Indian Journal of Weed Science*. 43 (1&2) : 92-93.
 15. Namvar, A.; Sharifi, R.S.; Sedghi, M.; Zakaria, R. A.; Khandan, T. and Eskandarpour, B. (2011). Study on the effects of organic and inorganic nitrogen fertilizer on yield, yield components, and nodulation state of chickpea (*Cicer arietinum* L.). *Communications in Soil Science and Plant Analysis*. 42 (9) : 1097-1109.
 16. Patel, B.D.; Patel, V.J.; Patel, J.B. and Patel, R.B. (2006). Effect of fertilizers and weed management practices on weed control in chickpea (*Cicer arietinum* L.) under middle Gujrat conditions. *Indian Journal of crop Sciences*. 1 : 180-183.
 17. Poonia, T.C. and Pithia, M.S. (2013). Pre and post-emergence herbicides for weed management in chickpea. *Indian Journal of Weed Science*. 45 (3) : 223-225.
 18. Prajapati, M.K.; Kumar V.; Singh, R.P.; Jayant, H. and Shankar, R. (2017). Effect of nitrogen levels and micronutrients on yield of chickpea (*Cicer arietinum* L.) in indo gangatic plain of Varanasi. 6 (6S) : 999-1001.
 19. Pritam, O.; Bhutada and Bhale, V.M. (2015). Effect of herbicides and cultural practices on growth and yield of chickpea. *Journal of Progressive Agriculture*. 6 (1) : 94-99.
 20. Rani, B. S. and Krishna, T. G. (2016). Response of chickpea (*Cicer arietinum* L.) varieties to nitrogen on a calcareous vertisols. *Indian Journal of Agricultural Sciences*. 50 (3) : 278-281.
 21. Rupareliya, V.V.; Chovatia, P.K.; Venkariya, S.J. and Javiya, P.P. (2017). Effects of different pre and post emergence herbicides on growth, yield attributes, yield and quality of chickpea. *International Journal of Science, Environment and Technology*. 6(4) : 2587-2593.
 22. Sharma, C.S. and Kushwaha, B.L. (2010). Effect of inter-cropping and management on yield and quality of chickpea (*Cicer arietinum* L.). *Journal of Progressive Agriculture*. 1 : 32-34.
 23. Singh, G.; Sekhon, H.S. and Kaur, H. (2012). Effect of farmyard manure, vermicompost and chemical nutrients on growth and yield of chickpea (*Cicer arietinum* L.). *International Journal of Agricultural Research*. 7 (2): 93-99.
 24. Singh, R.K. and Mukherjee D. (2009). Influence of biofertilizers, fertility levels and weed management practices on chickpea (*Cicer arietinum* L.) under late sown condition. *Annual Agricultural Research New Series*. 30 (3&4) : 116-120.
 25. Upasani, R.R.; Thakur, R.; Puran, A.N. and Singh, M.K. (2013). Effect of nitrogen and weed control on productivity of wheat. *Indian Journal of Weed Science*. 45 (2) : 106-108.
 26. Varshney, J. and Larya, R. (2004). Effect of integrated nutrients use and weed control methods on sole gram (*Cicer arietinum* L.) and gram + Indian mustard (*Brassica juncea*) intercropping system. *Indian Journal of Agricultural Science*. 74 (3) : 121-125.



Efficacy of Fungal Biocontrol Agents as Seed Dresser for Management of Root Knot Nematode, *Meloidogyne incognita* on Okra, *Abelmoschus esculentus* (L.) Moench

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Abstract

Okra, *Abelmoschus esculentus* (L.) Moench. is an important vegetable crop grown throughout the country except in temperate region. The production of crop of such a high importance suffers from many diseases and pests. Out of which root knot nematode, *Meloidogyne incognita* plays a crucial role in the reduction of crop yield. Present investigation was carried out to evaluate the efficacy of fungal biocontrol agents i.e., *Trichoderma viride*, *Purpureocillium lilacinum* and *Pochonia chlamydosporia* as seed dressers for suppression of root-knot nematode, *Meloidogyne incognita* infecting Okra. Biocontrol agents were tested at 10 g/ kg seed, 15 g/ kg seed and 20 g/ kg seed and untreated control was also maintained to compare the results. The observations on shoot length, root length, shoot weight, root weight, number of galls/ plant, egg masses/ plant, eggs and larvae/ plant, final nematode population/ 200 cc of soil and final biocontrol agent population were recorded. Results showed that *Purpureocillium lilacinum* at 20 g/ kg seed was found to be most effective with highest final bioagent population for the management of root knot nematode on okra followed by *Trichoderma viride* at 20 g/ kg seed and *Pochonia chlamydosporia* at 20 g/ kg seed.

Key words : *Meloidogyne incognita*, *Trichoderma viride*, *Purpureocillium lilacinum*, *Pochonia chlamydosporia* etc.

Introduction

Root-knot nematode, *Meloidogyne incognita* is a polyphagous nematode with short life span. It is sedentary endoparasitic on roots and can survive in adverse conditions. Root-knot nematode causes severe losses in vegetables, fruits, pulses, oilseeds and other ornamental crops. Parvatha Reddy and Singh (1981) reported that the loss caused by root knot nematode is estimated to be 28.08 percent in okra. Bhatti and Jain (1997) also reported the yield losses caused up to 91 percent in okra due to *Meloidogyne incognita*. Jain and Gupta (1986) also reported the yield loss up to 90 percent in okra under field condition. Sharma and Baheti (1992) also reported the evadable yield losses due to *M. incognita* in okra between the range of 46 and 56 percent. The estimated overall annual yield loss due to this nematode in okra has been reported more than 480 million in terms of monetary loss (Jain *et al.*, 2007). Singh and Kumar (2015) documented yield losses of 38 percent in okra caused by root knot nematode.

The traditional method of nematode management is mainly based on chemical nematicides. However, the negative impact on the environment, costly and ineffectiveness after prolonged use have led to a total ban or restricted use of most chemical nematicides (Zukerman and Esnard, 1994). Researchers all over the world are engaged in standardizing the root-knot nematode management strategies by following non-chemical and eco-friendly alternatives such as

sanitation, soil management, organic amendments, fertilization, biological control and heat-based methods to stabilize and enhance vegetable production (Collange *et al.*, 2011).

Biological control promises to be one of the best alternatives. Application of microorganisms antagonistic to nematodes or compounds produced by these microbes could provide an additional option for managing the damage caused by nematodes. Biocontrol agents are host specific and are potential candidates for integrated pest management of nematodes (Arora *et al.*, 2000). The use of bioagents is found an increase in attention and use of such bioagents offer an effective, safe, persistent and natural durable protection against crop pest (Anita and Samiyappan, 2012). Therefore, in the present investigation, pot culture experiment was conducted to test the efficacy of fungal biocontrol agents for suppression of root-knot nematode in Okra.

Materials and Methods

Biocontrol agents play an important role in the management of plant parasitic nematode. They are ecofriendly and host specific. With this view, experiment was conducted to test the efficacy of fungal biocontrol agents for the management of root knot nematode in okra.

I. Root-knot nematode, *M. incognita* as test species :

The test nematode species for the experiment was *M. incognita*. Egg masses of *M. incognita* were collected from okra roots and the population was multiplied on a

susceptible okra variety (Swati) grown in pots containing sterilized soil. This was done six months prior to the starting of the experiment. Other intercultural operations were applied as and when needed.

II. Use of biocontrol agents :

Fungal biocontrol agents *i.e.*, *Trichoderma viride*, *Purpureocillium lilacinum* (formally known as *Paecilomyces lilacinus*) and *Pochonia chlamydosporia* were evaluated for their viability and used as various treatments for the experiment. They were obtained from Department of Entomology, Rajasthan College of Agriculture, Udaipur, TNAU, Coimbatore and commercial products.

III. Sterilization of soil :

Two part soil was thoroughly mixed with one part FYM and one part sand. In order to remove stones and larger soil particles, this mixture was then passed through an ordinary coarse sieve. Steam sterilization of an adequate amount of the mixture for experiment was done through autoclaving for 2 hrs. at 15 psi and 121.6° C temperature. Sterilized soil was left in cage house for at least 10 days for maturation and only then used for experimental purpose.

IV. Disinfection and filling of pots :

Earthen pots were disinfected before use by rinsing them with 4 percent formalin solution. The treated pots were kept open for 8 days for the evaporation of formalin. All the pots were of same size and volume. Every pot had a hole at the bottom, which was covered with a piece of broken pot before filling up the soil and each pot were filled with equal quantity of sterilized soil. About 2.5 cm space from the top was left unfilled for watering. Pots were maintained in weed free condition. The pots were randomly rotated to eliminate the effect of sun and shade.

V. Treatments and experimental layout :

Pot culture experiment was conducted to study the efficacy of fungal biocontrol agents against root-knot nematode, *M. incognita* on okra. Bio agents were used at 10, 15 and 20 g/kg seed as seed dressing treatment. The experiment was laid out in a complete randomized design (CRD) with ten treatments *i.e.*, 3 biocontrol agents at 10, 15 and 20 g/kg seeds and an untreated check also maintain and replicated four times.

(a) Sowing and nematode inoculation : Three seedling of okra cv. Swati were sown in each pot containing 2 kg sterilized soil and watered regularly by passing the water through 400 mesh sieve. After 10-12 days of germination, plants were thinned out. Only one healthy plant (nearly of equal size) was maintained in each pot. After 15th day of sowing, 5000 larvae of *M. incognita* (10 ml stock

suspension containing 1000 larvae of *M. incognita*) were applied (at 2-3 nematodes per g of soil) to all pots. After application of nematodes approximately 1 cm of water applied to all pots as a mean to wash nematodes into the soil. This experiment was terminated at 45 days of nematode inoculation during which care of young seedlings and other intercultural operations were attended regularly.

(b) Harvesting : The plants were harvested 45 days after nematode inoculation. Observation on various plant growth parameters *viz.*, shoot and root weight, shoot and root length, were recorded without delay. For studying the nematode infection, the roots were stained with 0.1 percent acid fuchsin lacto-phenol at 80°C for 2-3 minute (Mc Beth *et al*, 1941). Then the roots were gently washed in tap water. Washed roots were kept in clear lacto-phenol for 24 hrs and then examined under binocular microscope for nematode parameters *viz.*, number of galls per plant, number of egg masses per plant, number of eggs and larvae were recorded. Final nematode population per 200 cc soil was also counted after harvesting alongwith final bioagent population.

Results and Discussion

Shoot length (cm) : Data presented in table-1 and fig.-1 revealed that the maximum shoot length was recorded with the application of *P. lilacinum* at 20 g/kg seed (35.80 cm) at par with *T. viride* at 20 g/kg seed (33.28 cm) followed by *P. chlamydosporia* at 20 g/kg seed (30.30 cm), while minimum shoot length (16.43 cm) was observed in control. Results exhibited that maximum increase in shoot length (117.89 percent) was recorded with the application of *P. lilacinum* at 20 g/kg seed at par with *T. viride* at 20 g/kg seed (102.55 percent) followed by *P. chlamydosporia* at 20 g/kg seed (84.42 percent) over control.

Shoot weight (g) : Data presented in table-1 and fig.-1 showed that the maximum shoot weight was recorded with the application of *P. lilacinum* at 20 g/kg seed (22.26 g) at par with *T. viride* at 20 g/kg seed (21.02 g) followed by *P. chlamydosporia* at 20 g/kg seed (20.06 g), while minimum shoot weight (11.37 g) was observed in control. Data illustrated that maximum increase in shoot weight (95.78 percent) was recorded with the application of *P. lilacinum* at 20 g/kg seed at par with *T. viride* at 20 g/kg seed (84.87 percent) followed by *P. chlamydosporia* at 20 g/kg seed (76.43 percent) over control.

Root length (cm) : Data presented in table-1 and fig.-1 revealed that the maximum root length (18.10 cm) was recorded with the application of *P. lilacinum* at 20 g/kg seed at par with *T. viride* at 20 g/kg seed (17.38cm) and *P. chlamydosporia* at 20 g/kg seed (16.73 cm), while

Table-1 : Efficacy of fungal biocontrol agents as seed dressers against root-knot nematode, *M. incognita* on okra.

S. No.	Treatment	Shoot length (cm)*	Shoot weight (g)*	Root length (cm)*	Root weight (g)*	No. of galls/ plant**	No. of egg masses/ plant**	No. of eggs and larvae/ plant**	Final nematode popn/200 cc soil**	Final bioagent population (CFU/107/g soil)***
1.	<i>T. viride</i> (10 g/kg seed)	20.58 (25.26)	13.25 (16.53)	11.15 (33.85)	5.59 (18.18)	21.25 (27.35)	17.00 (33.98)	143.00 (25.81)	420.00 (41.99)	36.01
2.	<i>T. viride</i> (15 g/kg seed)	27.45 (67.07)	17.42 (53.21)	13.73 (64.83)	6.70 (41.64)	12.25 (58.12)	13.75 (46.60)	126.00 (34.63)	348.25 (51.90)	58.88
3.	<i>T. viride</i> (20 g/kg seed)	33.28 (102.55)	21.02 (84.87)	17.38 (108.64)	8.66 (83.09)	8.25 (71.79)	6.50 (74.76)	117.50 (39.04)	292.50 (59.60)	86.02
4.	<i>P. chlamydosporia</i> (10 g/kg seed)	18.55 (12.90)	12.50 (9.94)	10.35 (24.25)	5.20 (9.94)	24.00 (17.95)	18.50 (28.16)	147.50 (23.48)	438.00 (39.50)	28.83
5.	<i>P. chlamydosporia</i> (15 g/kg seed)	22.53 (37.12)	15.51 (36.41)	11.55 (38.66)	5.85 (23.68)	17.00 (41.88)	16.25 (36.89)	135.75 (29.57)	394.25 (45.55)	42.63
6.	<i>P. chlamydosporia</i> (20 g/kg seed)	30.30 (84.42)	20.06 (76.43)	16.73 (100.84)	7.75 (63.85)	10.00 (65.81)	8.25 (67.96)	120.50 (37.48)	315.50 (56.42)	78.21
7.	<i>P. lilacinum</i> (10 g/kg seed)	24.63 (49.91)	16.63 (46.26)	12.73 (52.82)	6.20 (31.08)	14.50 (50.43)	15.25 (40.78)	128.75 (33.20)	365.50 (49.52)	48.54
8.	<i>P. lilacinum</i> (15 g/kg seed)	28.43 (73.04)	18.23 (60.33)	14.58 (75.03)	7.22 (52.64)	11.25 (61.54)	12.75 (50.49)	122.00 (36.71)	330.00 (54.42)	68.82
9.	<i>P. lilacinum</i> (20 g/kg seed)	35.80 (117.89)	22.26 (95.78)	18.10 (117.29)	9.51 (101.06)	6.75 (76.92)	5.50 (78.64)	115.50 (40.08)	275.50 (61.95)	92.84
10.	Control	16.43	11.37	8.33	4.73	29.25	25.75	192.75	724.00	0.00
	SEm±	0.88	0.53	0.54	0.22	0.64	0.51	4.45	11.86	1.89
	C.D.5%	2.54	1.52	1.55	0.64	1.85	1.48	12.86	34.25	5.47

Note : Data are average value of three replications. Figures in the parentheses are percentage increase /decrease over control. Initial Nematode Population 250 juveniles/100 cc Soil
 *Increased Plant Parameter over Control (%), **Reduction in Nematode Reproduction over Control (%).



Plate-1 : Effect of biocontrol agents as seed dressing against root knot nematode in okra.

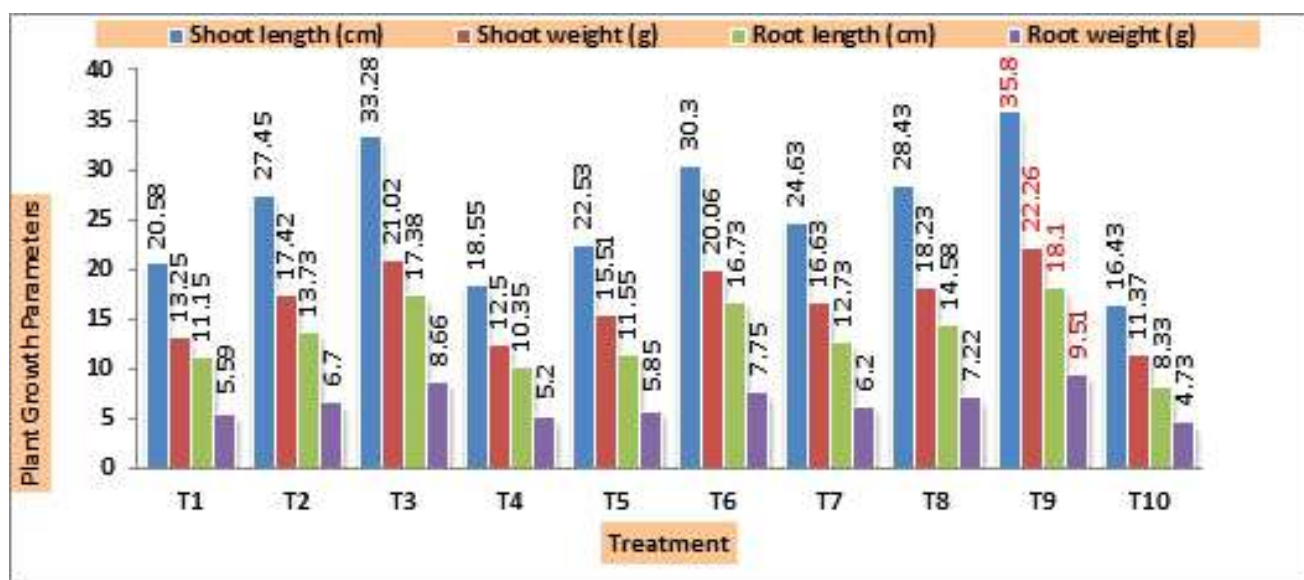


Fig.-1 : Effect of fungal biocontrol agents on plant growth characters of okra against root knot nematode, *M. incognita*.

minimum root length (8.33 cm) was observed in control. Results exhibited that maximum increase in root length (117.29 percent) was recorded with the application of *P. lilacinum* at 20 g/kg seed at par with *T. viride* at 20 g/kg seed (108.64 percent) and *P. chlamydosporia* at 20 g/kg seed (100.84 percent), over control.

Root weight (g) : Data presented in table-1 and fig.-1 showed that the maximum root weight (9.51 g) was recorded with the application of *P. lilacinum* at 20 g/kg seed followed by *T. viride* at 20 g/kg seed (8.66 g), *P. chlamydosporia* at 20 g/kg seed (7.75 g), while minimum root weight (4.73 g) was observed in control. Results presented that highest increase in root weight (101.06 percent) was recorded with the application of *P. lilacinum* at 20 g/kg seed followed by *T. viride* at 20 g/kg seed

(83.09 percent), *P. chlamydosporia* at 20 g/kg seed (63.85 percent) over untreated check.

Number of galls per plant : Data presented in table-1 and fig.-2 revealed that the number of galls produced by *M. incognita* on Okra reduced significantly as compared to control where number of galls produced were maximum (29.25). Among all the treatments, minimum number of galls per plant were observed with the application of *P. lilacinum* at 20 g/kg seed (6.75) at par with *T. viride* at 20 g/kg seed (8.25) followed by *P. chlamydosporia* at 20 g/kg seed (10.00). Data showed that, maximum reduction in no. of galls per plant was observed with the application of *P. lilacinum* at 20 g/kg seed (76.92 percent) at par with *T. viride* at 20 g/kg seed (71.79 percent) followed by *P. chlamydosporia* at 20 g/kg seed (65.81 percent) over control.

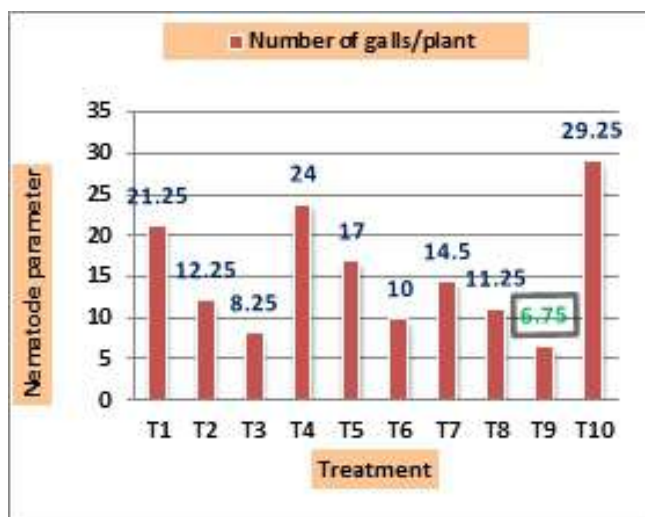


Fig.-2 : Effect of fungal biocontrol agents on number of galls/plant of root knot nematode, *M. incognita*.

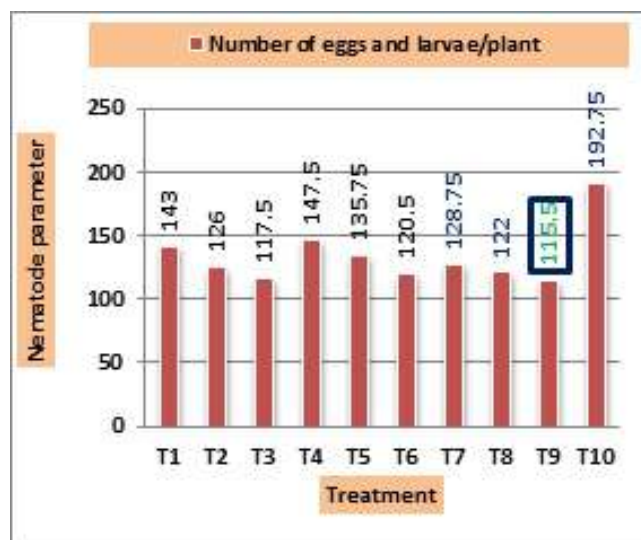


Fig.-4 : Effect of fungal biocontrol agents on number of egg and larvae/plant of root knot nematode, *M. incognita*.

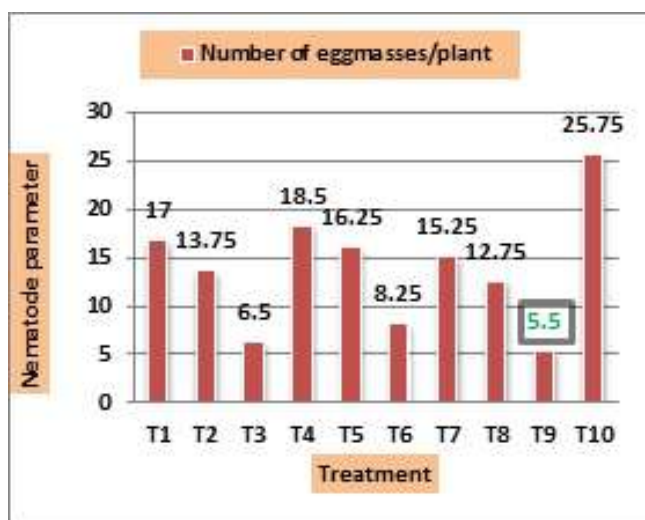


Fig.-3 : Effect of fungal biocontrol agents on number of egg masses/plant of root knot nematode, *M. incognita*.

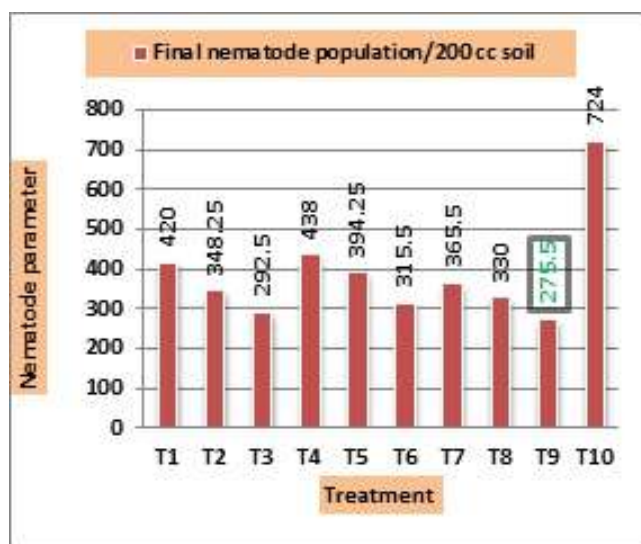


Fig.-5 : Effect of fungal biocontrol agents on final nematode population/200 cc soil.

Number of egg masses per plant : An observation on number of egg masses per plant presented in table-1 and fig.-3 revealed that the egg masses per plant produced by *M. incognita* on Okra reduced significantly as compared to control where number of egg masses per plant were maximum (25.75). Minimum number of egg masses per plant were observed with the application of *P. lilacinum* at 20 g/kg seed (5.50) at par with *T. viride* at 20 g/kg seed (6.50) followed by *P. chlamydosporia* at 20 g/kg seed (8.25). Data showed that, maximum reduction in no. of egg masses per plant was recorded with the application of *P. lilacinum* at 20 g/kg seed (78.64 percent) at par with *T. viride* at 20 g/kg seed (74.76 percent) followed by *P. chlamydosporia* at 20 g/kg seed (67.96 percent) over untreated check.

Number of eggs and larvae per egg mass : Data presented in table-1 and fig.-4 showed that the number of egg mass and larvae produced by *M. incognita* on okra reduced significantly as compared to control where number of eggs and larvae were maximum (192.75). The minimum eggs and larvae per egg mass (115.50) were recorded with the application of *P. lilacinum* at 20 g/kg soil at par with *T. viride* at 20 g/kg seed (117.50) and *P. chlamydosporia* at 20 g/kg soil (120.50). Data showed that, maximum reduction in number of eggs and larvae per egg mass was recorded with the application of *P. lilacinum* at 20 g/kg soil (40.08 percent) at par with *T. viride* at 20 g/kg seed (39.04 percent) and *P. chlamydosporia* at 20 g/kg seed (37.48 percent) over untreated check.

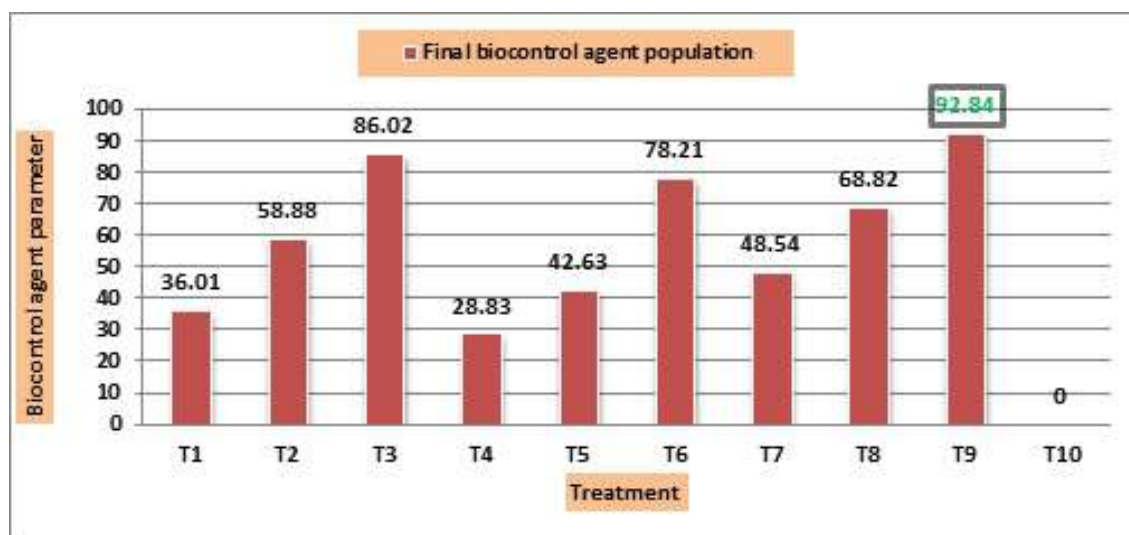


Fig-6 : Effect of fungal biocontrol agents on final biocontrol agents population in soil.

Final nematode population per 200 cc soil : Data presented in table-1 and fig.-5 revealed that the nematode population per 200 cc soil obtained at harvest was found significantly lower in the plants treated with the fungal biocontrol agents as compared to untreated check where final nematode population per 200 cc soil were maximum (724.00). Minimum nematode population per 200 cc soil was observed with the application of *P. lilacinum* at 20 g/kg soil (275.50) at par with *T. viride* at 20 g/kg seed (292.50) followed by *P. chlamydosporia* at 20 g/kg seed (315.50). Results illustrated that, maximum reduction in nematode population per 200 cc soil was observed with the application of *P. lilacinum* at 20 g/kg seed (61.95 percent) at par with *T. viride* at 20 g/kg seed (59.60 percent) followed by *P. chlamydosporia* at 20 g/kg seed (56.42 percent) over control.

Final biocontrol agent population (10⁷ CFU /g soil) : Data presented in table-1 and fig.-6 revealed that the final biocontrol agent population obtained at harvest was found significantly higher in the plants treated with the biocontrol agents, as compare to initial population. Amongst different treatments, maximum population was found with the application of *P. lilacinum* at 20 g/kg seed (92.84 X 10⁷ CFU /g soil) followed by *T. viride* at 20 g/kg seed (86.02 X 10⁷ CFU/ g soil) and *P. chlamydosporia* at 20 g/kg seed (78.21 X 10⁷ CFU/ g soil). Initial population was 4 X 10⁷ CFU/gsoil).

The result of present investigation indicated that the plant growth characters of okra enhanced with the seed dressing application of *P. lilacinum*, *T. viride* and *P. chlamydosporia* as compared to control. The better result was obtained with *P. lilacinum* at 20 g/kg seed followed by *T. viride* at 20 g/kg seed whose performance was statistically at par with *P. lilacinus* and *P. chlamydosporia*

at 20 g/kg seed to enhance plant growth of Okra and reduce reproduction of root-knot nematode.

These results are in agreement with the findings of Zareen *et al.*, (2001) that *P. lilacinum* reduced gall formation, egg mass production, maximum plant height and shoot weight was also achieved. Dhawan *et al.* (2004) also found that seed treatment (10, 15 and 20 g/kg seed) with *P. lilacinus* was significantly effective. Zaki and Maqbool (1990) also reported that weight of brinjal shoot was increased with 170 percent with the application of *P. lilacinus*. Zaki *et al.*, (2008) investigated that *P. lilacinum* caused 42 percent reduction in the growth of tomato plant followed by *P. chlamydosporia* (36 percent). *P. lilacinum* also caused in high reduction (55 percent) in galling and nematode multiplication. Re-isolation of antagonistic fungi from nematodes revealed that *P. lilacinus* parasitized more females and eggs than any other antagonistic fungi. Simon and Pandey (2010) also found *P. lilacinum* to increase the length and weight of shoot and root as well as maximum reduction in root galling. Hanawi (2014) concluded that *P. lilacinum* was the best bioagent in reduction of root galling (57.53 percent). These studies clearly indicated that *P. lilacinum* effectively control root-knot nematode in agri-horticultural crops due to its egg parasitism and effective nematode suppressing abilities. Plants treated with *P. lilacinum* also showed increase in the plant growth character.

References

1. Anita B, Samiyappan R. Induction of systemic resistance in rice by *Pseudomonas fluorescens* against rice root knot nematode *Meloidogyne graminicola*. *Journal of Biopesticides* 2012; 5: 53-59.
2. Arora, R., Battu, G.S. and Ramakrishnan, N. 2000. Microbial pesticides: current status and future outlook. In: Dhaliwal,

- G.S. and Singh, B., Pesticides and Environment. *Common Wealth Publishers*, New Delhi. 344-395.
3. Bhatti, D.S. and Jain, R.K. 1977. Estimation of loss in okra, tomato and brinjal yield due to *Meloidogyne incognita*. *Indian Journal of Nematology*, 7(1): 37-41.
 4. Budge, S.P. and Whipps, J.M. 1991. Glass house trials of *Coniothyrium minitans* and *Trichoderma* spp. for the biological control of *Sclerotinia sclerotiorum* in celery and lettuce. *Journal of Plant Pathology*, 40: 59-66.
 5. Collange, B. Navarrete, M., Peyer, G., Mateille, T. and Tchamitchian, M., 2011. Root-knot nematode (*Meloidogyne*) management in vegetable crop production: the challenge of an agronomic system analysis. *Crop Protection*, 30: 1251-1262.
 6. Dawar, S., Sattar, A. and Zaki, M.J. (2008). Seed Dressing with Biocontrol Agents and Nematicides for the Control of Root-knot Nematode on Sunflower and Okra. *Pakistan Journal of Botany*, 40(6): 2683-2691.
 7. Devi, G. and Bora, L.C. 2018. Effect of some biocontrol agents against root-knot nematode (*Meloidogyne incognita* race2). *International Journal of Environment, Agriculture and Biotechnology*, 3: 1748-1755.
 8. Dhawan, S.C., R. Narayana and N.Prakash babu (2004a). Biomanagement of root knot nematode, *Meloidogyne incognita* in okra by *Paecilomyces lilacinus*. *Annals of plant protection sciences*. 12, 356-359.
 9. Dhawan, S.C. and Singh, S. (2010). Management of root knot nematode, *Meloidogyne incognita* using *Pochonia chlamydosporium* on okra. *Indian Journal of Nematology*. 40 (1): 171-178.
 10. Hanawi, M.J. (2014) A comparative study between some biocontrol agents and nematode furfural on growth of tomato plants and pathogenesis of *M. javanica* under greenhouse condition. *Wastt Journal for Science and Medicine*. 7: 107-115.
 11. Jain, R.K. and Gupta, D.C. (1986) A note on the screening of some chemicals as seed treatment for control of root knot nematode (*M. javanica*) infecting okra. *Haryana Journal of Horticulture Science*. 15: 288-290.
 12. Jain, R.K., Mathur, K.N. and Singh, R.V. 2007. Estimation of losses due to plant-parasitic nematodes on different crops in India. *Indian Journal of Nematology*, 37: 219-221.
 13. McBeth, C.W., Taylor, A.L. and Smith, A.L. (1941). Note on staining nematodes in root tissues. *Proceeding of Helminthological Society of Washington*, 8: 26.
 14. Parvatha Reddy, P. and Singh, D.B. (1981). Assessment of avoidable yield losses in Okra, Brinjal, French bean and Cowpea due to root knot nematode. *International Symposium of Plant Pathology*, New delhi. Pp 93-94.
 15. Sharma, G.L. and Baheti, B.L. (1992). Loss estimates due to root knot nematode in Pea, Okra, Tomato and Bottle gourd crops in Rajasthan, India. *Indian Current Nematology*. 3 (2): 187-188.
 16. Sikora, R.A. and Fernandez, E. 2005. Nematode parasites of vegetables in Luc *et al* (Eds.) Plant Parasitic Nematodes in Subtropical and Tropical Agriculture 2nd Edition. *Centre for Agriculture and Bioscience International*, 319-339.
 17. Simon, L.S. and Pandey, A. (2010) Antagonistic efficacy of *Paecilomyces lilacinus* and *Verticillium chlamydosporium* against *Meloidogyne incognita* infecting okra. *Indian Journal of Nematology*. 40, 113.
 18. Singh, R. and Kumar, U. 2015. Assessment of nematode distribution and yield losses in vegetable crops of Western Uttar Pradesh in India. *International Journal of Science and Research*, 438: 2812-2816.
 19. Zaki, A., Siddiqui and Sayeed Akhtar, (2008) *Biocontrol Science and Technology*. Vol. 18 (3): 279-290.
 20. Zaki, M.J. and Maqbool, M.A. (1990) Effect of *Pasteuria penetrans* and *Paecilomyces lilacinus* on the control of root knot nematode of brinjal and moong. *Pakistan Journal of Phytopathology*. 2 (1-2): 37-42.
 21. Zareen, A., Khan, N.J. and Zaki M.J. (2001a) Biological control of *Meloidogyne javanica* (treub) Chitwood, root knot nematode of okra (*Abelmoschus esculentus* L. Moench). *Pakistan Journal of Biological Sciences*. 4, 990-994.
 22. Zuckerman, B.M. and Esnard, J. 1994. Biological control of plant nematodes-current status and hypothesis. *Japanese Journal of Nematology*, 24: 1-13.



Productivity, Nutrient Uptake of Cotton and Post Harvest Fertility Status of Soil of Cotton Based Intercropping System under Organic and Rainfed Condition

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Abstract

The field experiment was carried out at Agronomy Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during 2018-19 in randomized block design with seven treatment replicated thrice. The study resulted that the treatment of sole cotton recorded significantly higher seed cotton ha⁻¹ (1112 kg ha⁻¹), stalk yield (1358 kg ha⁻¹) and biological yield (2474 kg ha⁻¹) and found at par remaining treatments except treatment of cotton + greengram for grain purpose (1:1) and cotton + cowpea for grain purpose (1:1). Nitrogen, phosphorus and potassium content in plant were not significantly influenced by different treatments. However, nutrient uptake by cotton found to be significantly higher in sole cotton and found to be at par with some treatments. Available nitrogen in soil was significantly improved.

Key words : Seed cotton, greengram, cowpea, rainfed, grain and vegetable.

Introduction

In India, cotton is cultivated in the area of about 124.44 lakh hectares with production of 370 lakh bales and productivity of 505.46 kg lint ha⁻¹ in 2017-18. (Anonymous 2018), Cotton is grown under diverse agro-climatic conditions around the world. It provides fiber, to Indian farmers in one way or the other. The cotton seeds provide protein (20 %), oil (20 %), and starch (3.5 %). It is an important commercial fibre and cotton seed cake is very rich in protein. Seed cake is used as cattle feed and as manure which contain 6.4, 2.9 and 2.2 per cent N, P and K, respectively. Intercropping has been recognized as potentially beneficial and economic system of crop production. Greengram and cowpea are short duration crops, so it fits well in various multiple and intercropping systems (Pujari and Sheelvantar, 2002). At present, farmers are facing problems of shrinking landholding size, degradation of natural resources, climatic vulnerabilities and low monetary returns due to escalating cost of cultivation and inefficient utilization of agro inputs. So, cotton cultivation is becoming risky and less profitable and especially under rainfed condition. Thus, production per unit area of land, time and inputs needs to be improved by efficiently harvesting the solar energy and carbon dioxide for conversion into economic produced. And continuous use of inorganic fertilizer resulted soil degradation, nitrate pollution. Hence legumes are introduced as intercrops for restoring soil fertility. Intercropping of legumes is an important aspect for biological farming system not only for weed control, but also in reducing the leaching of

nutrients, pest control and in reducing soil erosion (Kumar and Kumar, 2006). As cotton is a short-stature crop of relatively longer duration, its slow initial growth and wider spacing offer vast scope for cultivation of suitable legumes and vegetables as intercrops. Short duration crops like green gram, black gram, cowpea, sesame, groundnut and soybean may prove compatible with cotton and can give additional yield and returns. Further, improvements in productivity and profitability of cotton-based cropping systems are possible through efficient agronomic management and crop diversification/intensification by intercrops. Intercropping of short duration pulses / oilseed crops like mothbean, greengram, blackgram, cowpea, groundnut, sesame etc. also help in the stabilizing soil fertility status in soil. This experiment was conducted to know the uptake of nutrients and post harvest soil nutrient status under organic nutrient management in rainfed condition.

Materials and Methods

A field experiment was conducted during *kharif* season of 2018 at Agronomy farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in randomized block design, replicated thrice with seven treatments viz- sole cotton, cotton + greengram for vegetable purpose (1:1), cotton + greengram for grain purpose (1:1), cotton + greengram 50% for vegetable purpose and 50 % for grain purpose (1:1), cotton + cowpea for vegetable purpose (1:1), cotton + cowpea for grain purpose (1:1), cotton + cowpea 50% for vegetable purpose and 50 % for grain purpose (1:1).

Table-1 : Seed cotton yield, stalk yield, biological yield (kg ha⁻¹) and harvest index (%) as influenced by different treatments.

Treatment	Seed Cotton Yield (Kg ha ⁻¹)	Stalk Yield (Kg ha ⁻¹)	Biological Yield (Kg ha ⁻¹)
T ₁ - Sole cotton	1112	1358	2474
T ₂ - Cotton + greengram for vegetable purpose (1:1)	1040	1261	2301
T ₃ - Cotton + greengram for grain purpose (1:1)	807	1125	1932
T ₄ - Cotton + greengram 50% for vegetable and 50% for grain purpose (1:1)	1012	1226	2238
T ₅ - Cotton + cowpea for vegetable purpose (1:1)	1002	1228	2230
T ₆ - Cotton + cowpea for grain purpose (1:1)	937	1113	2050
T ₇ - Cotton + cowpea 50% for vegetable and 50% for grain purpose (1:1)	1038	1293	2331
S.E.(m) ±	55	50	97
C.D. at 5 %	170	155	300

Table-2 : Nitrogen content (%), uptake of nitrogen (kg ha⁻¹) in cotton seed and stalk and total uptake of nitrogen as influenced by different treatments.

Treatments	Nitrogen Content (%)		Uptake of Nitrogen (Kg ha ⁻¹)		Total Uptake of Nitrogen (Kg ha ⁻¹)
	Seed	Stalk	Seed	Stalk	
T ₁ - Sole cotton	1.96	1.19	21.92	16.11	38.02
T ₂ - Cotton + greengram for vegetable purpose (1:1)	1.95	1.16	20.31	14.63	34.95
T ₃ - Cotton + greengram for grain purpose (1:1)	1.94	1.15	15.63	12.96	28.59
T ₄ - Cotton + greengram 50% for vegetable and 50% for grain purpose (1:1)	1.95	1.16	19.67	14.27	33.94
T ₅ - Cotton + cowpea for vegetable purpose (1:1)	1.94	1.16	19.47	14.29	33.76
T ₆ - Cotton + cowpea for grain purpose (1:1)	1.96	1.15	18.39	12.84	31.23
T ₇ - Cotton + cowpea 50% for vegetable and 50% for grain purpose (1:1)	1.94	1.16	20.17	15.05	35.22
S.E.(m) ±	0.02	0.02	1.08	0.59	1.55
C.D. at 5%	NS	NS	3.33	1.80	4.77

Table-3 : Phosphorus content (%), uptake of phosphorus (kg ha⁻¹) in cotton seed and stalk and total uptake of phosphorus as influenced by different treatments.

Treatments	Phosphorus Content (%)		Uptake of Phosphorus (Kg ha ⁻¹)		Total Uptake of Phosphorus (Kg ha ⁻¹)
	Seed	Stalk	Seed	Stalk	
T ₁ - Sole cotton	0.33	0.58	3.72	7.85	11.56
T ₂ - Cotton + greengram for vegetable purpose (1:1)	0.32	0.56	3.29	7.12	10.41
T ₃ - Cotton + greengram for grain purpose (1:1)	0.32	0.57	2.59	6.47	9.06
T ₄ - Cotton + greengram 50% for vegetable and 50% for grain purpose (1:1)	0.31	0.54	3.10	6.57	9.67
T ₅ - Cotton + cowpea for vegetable purpose (1:1)	0.31	0.58	3.10	7.08	10.18
T ₆ - Cotton + cowpea for grain purpose (1:1)	0.30	0.55	2.82	6.14	8.96
T ₇ - Cotton + cowpea 50% for vegetable and 50% for grain purpose (1:1)	0.32	0.57	3.30	7.33	10.63
S.E.(m) ±	0.01	0.02	0.18	0.28	0.42
C.D. at 5 %	NS	NS	0.54	0.86	1.24
General mean	0.32	0.56	3.13	6.94	10.07

Topography of the field was fairly uniform and level. Prior to experimentation, the important physico- chemical properties of soil were studied. Soil samples were drawn from 30 cm depth from randomly selected representative spots spread over the experimental area prior to application of manures. A composite sample was the prepared and analyzed for physico- chemical properties

of soil. The soil was medium black cotton soil belonging to *Vertisol*. The soil of experiment plot was clayey in texture and neutral in reaction. The fertility status of the soil indicates that the soil was medium in organic carbon, low in available nitrogen, phosphorus and moderately high in available potassium. Nutrients (N:P:K) were applied by 5 tonne FYM ha⁻¹ at the time of sowing in row

Table-4 : Potassium content (%), uptake of potassium (kg ha⁻¹) in cotton seed and stalk and total uptake of potassium as influenced by different treatments.

Treatments	Potassium Content (%)		Uptake of Potassium (kg ha ⁻¹)		Total Uptake of Potassium (kg ha ⁻¹)
	Seed	Stalk	Seed	Stalk	
T ₁ - Sole cotton	0.69	1.55	7.72	20.98	28.70
T ₂ - Cotton + greengram for vegetable purpose (1:1)	0.68	1.52	7.08	19.11	26.19
T ₃ - Cotton + greengram for grain purpose (1:1)	0.67	1.53	5.38	17.18	22.56
T ₄ - Cotton + greengram 50% for vegetable and 50% for grain purpose (1:1)	0.68	1.51	6.91	18.78	25.69
T ₅ - Cotton + cowpea for vegetable purpose (1:1)	0.67	1.53	6.68	18.80	25.48
T ₆ - Cotton + cowpea for grain purpose (1:1)	0.68	1.53	6.37	17.03	23.40
T ₇ - Cotton + cowpea 50% for vegetable and 50% for grain purpose (1:1)	0.69	1.54	7.17	19.92	27.09
S.E.(m) ±	0.02	0.02	0.38	0.77	1.06
C.D. at 5 %	NS	NS	1.17	2.36	3.28
General mean	0.68	1.53	6.76	18.83	25.59

Table-5 : Soil fertility status for pH, EC, OC, available nitrogen, phosphorus and potash content (kg ha⁻¹) of soil after harvesting of cotton as influenced by different treatments.

Treatments	pH	EC (dsm ⁻¹)	OC (%)	Available Nitrogen (kg ha ⁻¹)	Available Phosphorus (kg ha ⁻¹)	Available Potassium (kg ha ⁻¹)
T ₁ - Sole cotton	8.11	0.21	0.53	150.67	18.92	260.75
T ₂ - Cotton + greengram for vegetable purpose (1:1)	8.10	0.21	0.54	167.33	19.60	262.28
T ₃ - Cotton + greengram for grain purpose (1:1)	8.10	0.21	0.53	159.65	19.38	264.56
T ₄ - Cotton + greengram 50% for vegetable and 50% for grain purpose (1:1)	8.10	0.21	0.54	162.33	18.72	263.56
T ₅ - Cotton + cowpea for vegetable purpose (1:1)	8.10	0.21	0.54	165.67	18.68	262.87
T ₆ - Cotton + cowpea for grain purpose (1:1)	8.10	0.21	0.53	161.33	18.94	262.25
T ₇ - Cotton + cowpea 50% for vegetable and 50% for grain purpose (1:1)	8.11	0.22	0.53	164.00	18.93	264.01
S.E.(m) ±	0.004	0.003	0.015	2.49	0.31	3.16
C.D. at 5 %	NS	NS	NS	7.69	NS	NS
General mean	8.10	0.21	0.53	161.57	19.02	262.90
Initial value	8.10	0.21	0.54	156.21	20.16	244.22

zone of cotton and intercrops. To protect crops from sucking pest organic pesticides were applied in experiment plot. Genotypes used for cotton, greengram and cowpea were AKA-07 (*G. arboreum*), Utkarsha and Divya-2, respectively. Five plants were selected randomly from net plot area of each experimental plot and tagged for biometric observations. Seed and straw sample were taken for analysis of the nutrient content by standard procedure given by (Piper 1966). Based on nutrient content of plants, yield and dry matter production, uptake of nitrogen, phosphorus and potassium were worked out.

Results and Discussion

Yield of cotton : Data of seed cotton yield ha⁻¹ as affected by different treatments was presented in (Table-1).

Treatments of sole cotton recorded significantly higher seed cotton ha⁻¹ (1112 kg ha⁻¹), stalk yield (1358 kg ha⁻¹) and biological yield (2474 kg ha⁻¹) and found at par with treatment of cotton + greengram for vegetable, 50% vegetable and 50 % grain purpose (1:1) and cotton + cowpea for vegetable, 50% vegetable and 50 % grain purpose (1:1). This might be due to under sole condition cotton utilized environmental and ground resources in more without any competition for growth resources for the production of these parameter. Intercropping system has significant effect on seed cotton yield because early harvested intercrops in treatments of cotton recorded significantly higher seed cotton yield. Similar result also reported by earlier studies by (Khargkharate *et al.* 2014), (Vekariya *et al.* 2015), (Mwamlima *et al.* 2016), (Daisy *et*

al. 2017), (Pujar and Angadi 2017), (Ravindra *et al.* 2017) and (Singh *et al.* (2017).

Effect on nutrient content and uptake of cotton :

Nutrient contents of cotton were not significantly influenced by different intercropping system. However, sole cotton recorded significantly higher uptake of nitrogen (38.02 kg ha^{-1}), phosphorus (11.56 kg ha^{-1}) and potassium (28.70 kg ha^{-1}). Nitrogen and potassium uptake by cotton was found at par with cotton + greengram (1:1) for vegetable purpose, cotton + greengram (1:1) 50 % for vegetable and 50 % for grain purpose, cotton + cowpea (1:1) for vegetable purpose, cotton + cowpea (1:1) 50 % for vegetable and 50 % for grain purpose. Whereas, phosphorus uptake was found at par with cotton + greenram (1:1) for vegetable purpose (10.41 kg ha^{-1}) and cotton + cowpea (1:1) for 50 % for vegetable and 50 % for grain purpose (10.63 kg ha^{-1}). Higher nutrient uptake by sole cotton might be associated with greater nutrient availability to cotton by FYM for longer time without any competition produced higher dry matter accumulation and yield. In the intercropping treatments legumes for vegetable purpose were harvested earlier compared to grain purpose, so decreased crop-intercrops competition and concurrently increased in nitrogen availability. In other treatments less uptake of nutrient might be due to competition between cotton and intercrops for nutrients. Similar findings also reported by (Sankaranarayanan *et al.* 2011), (Marimuthu *et al.* 2014), (Singh *et al.* 2016) and (Ravindra *et al.* 2016).

Chemical properties of soil after harvest of crop :

Chemical properties of soil like pH, EC, organic carbon, available phosphorus and available potassium did not significantly influenced by different treatments and found to be non significant. (Table-4)

Available nitrogen in soil was recorded significantly higher in different treatments of intercrops and found to be at par with each others. Treatments of cotton + greengram and cotton + cowpea (1:1) intercropping system were recorded higher value of available nitrogen and found superior over the sole cotton. Sole cotton recorded lower available nitrogen as compared to rest of the treatments. Available nitrogen was slightly increased in soil. Increase in available nitrogen in soil might be associated with biomass added by intercrops and biological nitrogen fixation by intercrops. Available phosphorus and potassium in soil was not found significant in different treatments. Phosphorus was slightly depleted in all treatments. However, residual potassium was also slightly increased in different treatments cotton intercropped with greengram and cowpea. Intercropping with legumes is an important aspect in cotton based farming system as it helps to improve soil fertility by adding biomass in soil, biological

nitrogen fixation and also improves soil microbial activity. Generally, cotton removes higher quantity of nutrient and moisture from soil. However, intercropping of legumes helps in moisture conservation by covering soil and improving soil fertility status. Similar finding of growing legumes as intercrop in cotton was beneficial to soil health and fertility sustainability were reported by (Ravindra *et al.* 2016), (Reddy *et al.* 2009) and (Sankaranarayanan *et al.* 2011).

Conclusions

Sole cotton recorded significantly higher yield. However cotton intercropped with greengram for vegetable gave higher returns. Nutrient uptake was significantly higher in sole cotton. Cotton intercropped with greengram and cowpea improved soil fertility.

References

1. Anonymous, 2018. ICAR-Central Institute for Cotton Research, Nagpur (MS) <http://www.cicr.org.in/database/dbcapp5.html>.
2. Daisy, M., K. Rajendran and Mohamed Amanullah, M. 2017. Effect of legume fodder intercrops and different fertilizer levels on growth, yield and economics of *Bt.* cotton under irrigated condition. *Int. J. Curr. Microbiol. App.Sci.* 6(7): 2238-2243.
3. Khargkharate, V.K., G.L. Kadam, A.D. Pandagale, V.B. Awasarmal and S.S. Rathod, 2014. Studies on *kharif* legume intercropping with *Bt. Cotton* under rainfed conditions, *J. Cotton Res. Dev.* 28(2): 243-246.
4. Kumar G.P. and Kumar, U.B., 2006. Use of organics for crop production under rainfed situation - A review. *Agric. Rev.*, 27(3): 208-215.
5. Marimuthu, S., U. Surendran and P. Subbian, 2014. Productivity, nutrient uptake and post-harvest soil fertility as influenced by cotton-based cropping system with integrated nutrient management practices in semi-arid tropics, *Archives of Agro. Soil Sci.* 60(1): 87-101.
6. Mwamlima, L.H., V.H. Kabambe, W.G. Mhango and G.K.C. Nyirenda, 2016. Effect of intercropping on growth and yield of cotton (*Gossypium hirsutum*) and cowpea (*Vigna unguiculata* L. Walp) in Malawi. *Agric. Sci. Res. J.* 6(12): 303-312.
7. Piper, C.S., 1966. Soil and plant analysis. *Hans publisher*, Bombay.
8. Pujar, A.M. and V.V. Angadi, 2017. Effect of integrated nutrient management on yield attributes, yield and production efficiency of and soybean intercropping system. *Int. J. Pure App. Biosci.* 5(4): 543-549.
9. Pujari, B.T. and Sheelvantar, M.N., 2002. Dry matter accumulation in plant parts of greengram (*Vigna radiata*) as influenced by cropping system, row proportion and greengram population level. *Indian J. Agric. Res.* (36): 156-161
10. Ravindra K., A.B. Turkhede, Shrimohan Meena and R.K. Nagar, 2016 Performance of American cotton-legumes based intercropping system on nutrient uptake and soil nutrient status. *Agric. Sci. Digest.* 36(3): 234-236.

11. Ravindra K., A.B. Turkhede, R.N. Nagar and Anil Nath. 2017. Effect of different intercrops on growth and yield attributes of American cotton under dryland condition. *Int. J. Curr. Microbial. App. sci.* 6(4): 754-761.
12. Reddy R.R.P. and Shaik M., 2009. Evaluation of cotton (*Gossypium hirsutum* L.) – based intercropping system through different approaches under rainfed conditions. *Indian J. Agric. Sci.* 79(3): 210- 214.
13. Sankaranarayanan, K., P. Nalayini, M. Sabesh and K. Rajendran, 2011. Multi-tier cropping system for profitability and stability in *Bt. Cotton* production. Technical Bulletin No. 2.
14. Singh, Jitendra, A.M. Patel, B.S. Rathore, Shaukat Ali and B. L. Yadav, 2016. Nutrient uptake and physico-chemical properties of soil as influenced by *Bt* cotton (*Gossypium hirsutum* L.) based cropping systems under different spacing. *Adv. Res. J. Crop Improv.* 7(2): 180-186.
15. Singh, Gajendra., Pushkar Choudhary, Dharmraj Saini and Bhanwar Lal Jat, 2017. Effects of legume intercrops on growth, yield and economics of hybrid *American* cotton under controlled condition. *Global J. BIO. Sci. Biotech.* 6(1): 61-82.
16. Vekariya, P.D., M. G. Khokhani, M.S. Gajera and K.N. Akbari, 2015. Productivity and economics of cotton (*Gossypium hirsutum* L.) based intercropping system under rainfed conditions of North Saurashtra agro climatic zone of Gujarat. *J. Cotton Res. Dev.* 29(2): 264-267.



Estimation of Selection Indices in Desi Chickpea (*Cicer arietinum* L.)

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Abstract

The present empirical study was conducted to evaluate selection index in forty-eight genotypes of desi chickpea (*Cicer arietinum* L.) by involving eleven quantitative characters viz., days to 50% flowering, days to maturity, plant height (cm), number of pod bearing branches per plant, number of pods per plant, first pod bearing node (cm), number of seeds per pod, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index. The experiment was carried out in Pulses Research Station, Junagadh Agricultural University, Junagadh during rabi 2019-20. The maximum efficiency in selection for seed yield was exhibited by a discriminant function involving seed yield per plant, days to maturity, 100-seed weight, biological yield per plant and harvest index which had high genetic advance and relative efficiency of 36.201 g and 1609.573 %. The present study also revealed that the discriminant function method of making selections in plants appears to be the most useful than the straight selection for seed yield per plant hence; the weightage should be given to the important selection indices while making the selection for yield advancement in chickpea.

Introduction

Chickpea is an ancient cultivated pulse crop, domesticated during the early age of civilization and being cultivated throughout the world. Its nomenclature is well documented in different countries such as gram, Bengal gram, homes, chole, garbanzo bean, hommos, chana, chiating vetch, nakhud, nakhut, kicher, poischice, etc.

The genus *Cicer* belongs to the sub-family Papilionaceae of the family Leguminosae (Bentham and Hooker, 1970). The *Cicer* genus presently comprises 43 species, out of which 9 are annual and 34 are perennial species (Muehlbauer *et al.*, 1994). Most of these species are found in West Asia and North Africa, covering Turkey in the north to Ethiopia in the south and Pakistan in the east to Morocco in the west. The genus consists of 39 known species distributed mainly in Central and Western Asia of which two species viz., *Cicer arietinum* (2n=16) and *C. soongaricum* (2n=16) are cultivated in India. The origin of the crop is considered in Western Asia from where it started spreading to India and also the other parts of the world.

The suitable selection index has been found to be superior to direct selection for yield. An application of discriminant function analysis developed by Fisher (1936) and first applied by Smith (1936) gives information on proportionate weightage that should be given to a particular yield component. Thus, selection indices help the breeder to discriminate desirable genotypes on the basis of phenotypic performance.

Materials and Methods

A field experiment was conducted at the Pulses Research Station, Junagadh Agricultural University, Junagadh

during rainy season 2019-20 in randomized block design with three replications by using forty-eight genotypes of desi chickpea (*Cicer arietinum* L.) by involving eleven quantitative characters viz., days to 50% flowering, days to maturity, plant height (cm), number of pod bearing branches per plant, number of pods per plant, first pod bearing node (cm), number of seeds per pod, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g) and harvest index.

Application of discriminant function as a basis for making the selection on several characters simultaneously is aimed at discriminating the desirable genotypes from undesirable ones based on their phenotypic performance. The concept of the selection index was first proposed by Smith (1936) on the basis of the discriminant function of Fisher (1936). The model suggested by Robinson *et al.* (1951) was used for the construction of selection indices and the development of a required discriminant function. Smith (1936) defined the genetic worth (H) of an individual as,

$$H = a_1G_1 + a_2G_2 + \dots + a_nG_n$$

Where, $G_1, G_2, \dots, G_n$ is the genotypic values of individual characters and $a_1, a_2, \dots, a_n$ signify their relative economic importance

Another function (I), based on phenotypic performance of various characters was defined as

$$I = b_1p_1 + b_2p_2 + \dots + b_np_n$$

Where, $b_1, b_2, \dots, b_n$ are to be estimated such that the correlation between H and I i.e., $r(H, I)$ becomes maximum. One such function is obtained, discrimination of good genotypes/characters from the undesirable ones

Table-1 : Selection index, discriminant function, expected genetic advance in seed yield and relative efficiency from the use of different selection indices in desi chickpea.

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative efficiency per character (%)
1.	X1 Seed yield per plant	0.948	2.249	100.000	100.000
2.	X2 Days to maturity	0.573	3.705	164.743	164.743
3.	X3 Number of pod bearing branches per plant	0.729	0.885	39.366	39.366
4.	X4 100-seed weight	0.839	6.595	293.218	293.218
5.	X5 Biological yield per plant	0.942	6.956	309.298	309.298
6.	X6 Harvest index	0.892	13.450	598.022	589.022
7.	X1.X2	$1.332X1 + 0.533X2$	5.355	238.080	119.040
8.	X1.X3	$1.041X1 + 0.688X3$	3.030	134.731	67.366
9.	X1.X4	$1.824X1 + 0.655X4$	8.862	394.024	197.012
10.	X1.X5	$0.984X1 + 0.943X5$	7.679	341.412	170.706
11.	X1.X6	$0.956X1 + 0.892X6$	13.707	609.428	304.714
12.	X2.X3	$0.571X2 + 1.691X3$	4.522	201.045	100.523
13.	X2.X4	$0.582X2 + 0.846X4$	7.658	340.505	170.253
14.	X2.X5	$0.581X2 + 0.952X5$	8.018	356.483	178.242
15.	X2.X6	$0.573X2 + 0.892X6$	13.956	620.532	310.266
16.	X3.X4	$1.010X3 + 0.841X4$	6.907	307.090	102.363
17.	X3.X5	$0.741X3 + 0.947X5$	7.195	319.897	106.632
18.	X3.X6	$1.005X3 + 0.894X6$	13.573	603.487	201.162
19.	X4.X5	$0.841X4 + 0.947X5$	9.732	432.714	144.238
20.	X4.X6	$0.846X4 + 0.895X6$	15.125	672.504	224.168
21.	X5.X6	$0.935X5 + 0.891X6$	14.989	666.445	222.148
22.	X1.X2.X3	$1.156X1 + 0.557X2 + 1.535X3$	6.187	275.096	91.699
23.	X1.X2.X4	$2.983X1 + 0.356X2 + 0.403X4$	10.443	464.334	154.778
24.	X1.X2.X5	$1.368X1 + 0.537X2 + 0.935X5$	9.212	409.597	136.532
25.	X1.X2.X6	$1.340X1 + 0.533X2 + 0.890X6$	14.549	646.868	215.623
26.	X1.X3.X4	$2.429X1 + -0.186X3 + 0.553X4$	9.364	416.350	104.088
27.	X1.X3.X6	$0.931X1 + 1.089X3 + 0.893X6$	13.948	620.170	155.043
28.	X1.X3.X5	$1.010X1 + 0.908X3 + 0.948X5$	8.160	362.832	90.708
29.	X1.X4.X5	$1.924X1 + 0.636X4 + 0.908X5$	11.646	517.818	129.455
30.	X1.X4.X6	$1.796X1 + 0.670X4 + 0.892X6$	16.298	724.637	181.159
31.	X1.X5.X6	$0.995X1 + 0.937X5 + 0.891X6$	15.400	684.706	136.941
32.	X2.X3.X4	$0.566X2 + 2.119X3 + 0.826X4$	8.407	373.798	74.760
33.	X2.X3.X5	$0.572X2 + 1.889X3 + 0.933X5$	8.662	385.132	77.026
34.	X2.X3.X6	$0.562X2 + 1.977X3 + 0.891X6$	14.312	636.330	127.266
35.	X2.X4.X5	$0.589X2 + 0.848X4 + 0.957X5$	10.585	470.648	94.130
36.	X2.X4.X6	$0.582X2 + 0.854X4 + 0.895X6$	15.623	694.647	138.929
37.	X2.X5.X6	$0.583X2 + 0.911X5 + 0.003X6$	7.755	344.817	68.963
38.	X3.X4.X5	$1.329X3 + 0.840X4 + 0.942X5$	10.167	452.042	90.408
39.	X3.X4.X6	$1.411X3 + 0.843X4 + 0.895X6$	15.381	683.869	136.774
40.	X3.X5.X6	$1.204X3 + 0.934X5 + 0.892X6$	15.220	676.706	135.341
41.	X4.X5.X6	$0.849X4 + 0.941X5 + 0.894X6$	16.594	737.819	147.564
42.	X1.X2.X3.X4	$3.500X1 + 0.349X2 + 0.002X3 + 0.315X4$	11.077	492.523	98.505
43.	X1.X2.X3.X5	$1.126X1 + 0.561X2 + 1.766X3 + 0.930X5$	9.918	440.972	88.194
44.	X1.X2.X3.X6	$7.262X1 + -6.570X2 + 1.443X3 + 0.863X6$	8.657	384.929	76.986
45.	X1.X2.X4.X5	$3.137X1 + 0.347X2 + 0.372X4 + 0.868X5$	12.992	577.656	115.531
46.	X1.X2.X4.X6	$2.948X1 + 0.360X2 + 0.419X4 + 0.888X6$	17.209	765.134	153.027
47.	X1.X2.X5.X6	$1.380X1 + 0.536X2 + 0.929X5 + 0.889X6$	16.225	721.385	144.277
48.	X1.X3.X4.X5	$2.382X1 + 0.077X3 + 0.560X4 + 0.915X5$	12.164	540.820	108.164
49.	X1.X3.X4.X6	$2.080X1 + 0.413X3 + 0.625X4 + 0.894X6$	16.633	739.542	147.908
50.	X1.X3.X5.X6	$0.903X1 + 1.316X3 + 0.937X5 + 0.892X6$	15.733	699.506	139.901

Table-1 : Contd...

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative efficiency per character (%)
51.	X2.X3.X4.X5	0.568X2 + 2.324X3 + 0.824X4 + 0.927X5	11.329	503.690	100.738
52.	X2.X3.X4.X6	0.557X2 + 2.402X3 + 0.828X4 + 0.892X6	16.117	716.611	143.322
53.	X2.X3.X5.X6	0.564X2 + 2.189X3 + 0.919X5 + 0.889X6	15.968	709.948	141.990
54.	X2.X4.X5.X6	0.590X2 + 0.856X4 + 0.951X5 + 0.894X6	17.113	760.880	152.176
55.	X3.X4.X5.X6	1.616X3 + 0.842X4 + 0.929X5 + 0.893X6	16.943	753.308	150.662
56.	X1.X4.X5.X6	1.901X1 + 0.650X4 + 0.903X5 + 0.890X6	17.836	793.004	158.601
57.	X1.X2.X3.X4.X5	3.482X1 + 0.352X2 + 0.274X3 + 0.318X4 + 0.874X5	13.625	605.812	121.162
58.	X1.X2.X3.X4.X6	3.073X1 + 0.378X2 + 0.649X3 + 0.405X4 + 0.890X6	17.659	785.165	157.033
59.	X1.X2.X3.X5.X6	1.020X1 + 0.560X2 + 2.176X3 + 0.920X5 + 0.890X6	16.738	744.204	148.841
60.	X1.X2.X4.X5.X6	-22.214X1 + 2.882X2 + 5.625X4 + 22.332X5 + 1.77X6	36.201	1609.573	321.915
61.	X1.X3.X4.X5.X6	2.038X1 + 0.677X3 + 0.632X4 + 0.908X5 + 0.889X6	18.236	810.789	162.158
62.	X2.X3.X4.X5.X6	0.559X2 + 2.621X3 + 0.826X4 + 0.914X5 + 0.890X6	17.691	786.590	157.318
63.	X1.X2.X3.X4.X5.X6	3.060X1 + 0.379X2 + 0.921X3 + 0.406X4 + 0.870X5 + 0.888X6	19.247	855.747	142.625

will be possible based on phenotypic performance *i.e.*, p_1 , $p_2, \dots, p_n$ directly.

The maximization of $r(H, I)$ leads to a set of simultaneous equations which upon solving give the desired estimate of b_i values. Considering three characters as an example, the simultaneous equations look like as follows :

$$b_1X_{11} + b_2X_{12} + b_3X_{13} = a_1G_{11} + a_2G_{12} + a_3G_{13}$$

$$b_1X_{21} + b_2X_{22} + b_3X_{23} = a_1G_{21} + a_2G_{22} + a_3G_{23}$$

$$b_1X_{31} + b_2X_{32} + b_3X_{33} = a_1G_{31} + a_2G_{32} + a_3G_{33}$$

The matrix form of the above simultaneous equations is as under :

$$\begin{matrix} X_{11} & X_{12} & X_{13} & b_1 & G_{11} & G_{12} & G_{13} & a_1 \\ X_{21} & X_{22} & X_{23} & b_2 & G_{21} & G_{22} & G_{23} & a_2 \\ X_{31} & X_{32} & X_{33} & b_3 & G_{31} & G_{32} & G_{33} & a_3 \end{matrix} =$$

The solution of these equations gives the estimate of ' b_i ' values in the following manner :

$$b_i = X^{-1} \cdot G.a.$$

The mathematical description of the function (I) is known as selection index :

$$I = b_1p_1 + b_2p_2 + \dots + b_n p_n$$

Using this function it is possible to discriminate among the superior and inferior plants or a combination of characters. The selection index or score is calculated for all the plants or combinations of characters and those with the highest values are considered.

Expected genetic advance : The expected genetic advance through selection was calculated as per the formula suggested by Robinson *et al.* (1951).

$$G = \frac{Z}{P} \frac{a b_j G_{ij}}{b b_j P_{ij}^2}$$

Relative efficiency : The relative efficiency of different discriminant functions was calculated according to Robinson *et al.* (1951), assuming the efficiency of selection for seed yield per plant as 100%.

$$RI(\%) = \frac{GA(D)}{GA(S)} \times 100$$

Results and Discussion

Seed yield in desi chickpea is a complex entity associated with many contributing traits which are interrelated among them. The inter dependence of contributory traits affects the selection criteria. The objective of this study to construct suitable selection indices for obtaining high genetic gain for seed yield.

The plant breeder has certain desired plant characteristics in his mind while selecting for particular genotypes and he applies various weights to different traits for arriving at decisions. This suggests the use of a selection index that gives proper weight to each of the two or more characters to be considered. Hazel and Lush (1943) showed that the selection based on such an index is more efficient than selecting individuals for the various characters. The basis for the development of the selection indices has been provided by Smith (1936), Hazel (1943) and Robinson *et al.* 1951.

Hazel and Lush (1943) stated that the superiority of selection based on index increases with an increase in the number of characters under selection. In the present study also the genetic advance and relatively efficiency assessed for different indices increased considerably

when the selection was based on two or more characters. The harvest index showed maximum genetic advance (GA) and relative efficiency in single character discriminant function was 13.45 g and 598.022 %, respectively. However, it boomed up to 15.125 g and 672.504 %, respectively in two-character combinations (100-seed weight and harvest index) and 16.594 g and 737.819 %, respectively in three characters combination (100-seed weight, biological yield and harvest index). Finally, it shows that increase in the genetic advance simultaneously increase relative efficiency in the character combination.

In four trait combinations (seed yield per plant, 100-seed weight, biological yield, harvest index) the highest genetic advance and relative efficiency were 17.836 g and 793.004 % respectively. While, peak genetic advance and relative efficiency were observed in five-character combinations (seed yield per plant, days to maturity, 100-seed weight, biological yield, and harvest index) were 36.201 g and 1609.573 %, respectively. Similar results obtained by Sable *et al.* (2002), Raval and Dobariya (2005). However, six-character combinations were observed 19.247 g and 855.747 % of genetic advance and relative efficiency respectively which has comparatively less than five character combinations.

The efficiency of selection increased with the inclusion of more characters in the index. The selection index based on five characters viz., seed yield per plant, days to maturity, 100-seed weight, biological yield per plant and harvest index exhibited maximum gain and relative efficiency. It is expected that seed yield could be improved if due consideration is given to these traits in the future breeding programme of chickpea.

Further, it was observed that the straight selection for yield was not rewarded as much because it includes (GA=2.249 g, RI=100 %) it was through its components like harvest index (GA=13.450 g, RI=598.002 %), biological yield per plant (GA=6.956 g, RI=309.298 %), 100-seed weight (GA=6.595 g, RI=293.218 %), days to maturity (GA=3.705 g, RI=164.743 %) and number of pod bearing branches per plant (GA=0.885 g, RI=39.366 %)

The maximum efficiency in selection for seed yield was exhibited by a discriminant function involving seed yield per plant, days to maturity, 100-seed weight, biological yield per plant and harvest index which had high genetic advance and relative efficiency of 36.201 g and 1609.573 % respectively, followed by an index of six characters (seed yield per plant, days to maturity, number of pod bearing branches per plant, 100-seed weight,

biological yield per plant and harvest index) had 19.247 g of genetic advance and 855.747 % relative efficiency.

The current experiment showed a consistent increase in the relative efficiency of the succeeding index with simultaneous inclusion of each character until five traits. In the practice of plant breeding might be interested in maximum gain with the minimum number of characters in which five characters have maximum genetic advance and relative efficiency rather than on six characters. The present study also revealed that the discriminant function method of making selections in plants appears to be the most useful than the straight selection for seed yield per plant hence, the weightage should be given to the important selection indices while making the selection for yield advancement in chickpea.

Conclusions

In a nutshell, through the current research investigation, it can be concluded that selection index comprised of seed yield per plant, days to maturity, 100-seed weight, biological yield per plant and harvest index can be concluded as an efficient one as it displayed maximum genetic advance and relative efficiency. Hence, due weightage should be given to these traits while making selection for yield advancement in chickpea.

References

1. Bentham, G. and Hooker, J.P. (1970). *Genera platinum* (Genera of plant), 1: 324.
2. Hazal, L.K. and Lush, J.K. (1943). The efficiency of three methods of selection. *Journal of Heredity*, 33: 393-399
3. Hazal, L.N. (1943). The genetic basis for constructing selection indices. *Genetics*, 28: 476-490.
4. Muehlbauer, F.J.; Kaiser, W.J. and Simon, C.J. (1994). Potential for wild species in cool season food legume breeding. *Euphytica*, 73: 109-114.
5. Raval, L.J. and Dobariya, K.L. (2005). Selection indices for yield improvement in chickpea (*Cicer arietinum* L.). *Research on Crops*, 6(1): 127-130.
6. Robinson, H.F.; Comstock, R.E. and Harvey, P.H. (1951). Genotypic and phenotypic correlation in corn and their implications in selection. *Agronomy Journal*, 43: 282-287.
7. Sable, N.H.; Narkhede, M.N.; Wakode, M.M. and Lande, G.K. (2002). Genetic parameters and formulation of selection indices in chickpea. *Bioved Journal*, 13(1/2): 89-92.
8. Smith, H.F. (1936). A discriminant function for plant selection. *Annals of Eugenics*, 7:240-Fisher, R.A. (1936). The use of multiple measurements in taxonomic problem. *Annals of Eugenics*, 7: 179.
9. Fisher, R.A. (1936). The use of multiple measurements in taxonomic problem. *Annals of Eugenics*, 7: 179.



Effect of Plant Geometry on Growth and Qualitative Characters of Transplanted Indian Mustard (*Brassica juncea* L.)

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Abstract

A field experiment was conducted at Research Farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur during *rabi* season of 2016-17 to study the effect of plant geometry on growth and qualitative characters of transplanted Indian mustard. The results reveal that higher values of growth characters namely plant height, number of primary and secondary branches, number of leaves, chlorophyll content, dry matter accumulation and oil yield were exerted under row spacing of 60x30 cm of transplanted mustard.

Key words : Transplanted mustard, protein content, primary branches and quality.

Introduction

Oilseeds are backbone of agricultural economy of India since long and considered as the second largest agricultural commodity in India after cereals (Yadav, 2011). Rapeseed/mustard is the third major oilseed of India, ranking after groundnut and soybean with around 23 per cent share of total oilseed production (Rajak *et al.*, 2011). Rapeseed-Mustard crop offers immense scope for further yield enhancement. For India, the attainment of self-sufficiency in edible oils is possible if the production potential of our annual edible oilseed crops is harnessed through improved technologies of managing nutrients and weeds, resulting into the higher yield of the crop and their timely transfer to the oilseed cultivators. Among the various constraints attributing to low productivity of mustard in arid and semi-arid region, the erratic nature of climate, inefficient irrigation water, weed infestation, fertilizer management and poor soil physical conditions are the most important factors which lead to the low crop yield (Alam, 2004).

Establishment of optimum plant population by maintaining proper row spacing is one of the important factors to secure a better translocation of photosynthates, which render better yield of crop (Alam, 2004). Spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. Among the agronomic factors known to augment the mustard production are spacing and plant geometry which plays a pivotal role in enhancing the production. Optimum row spacings are necessary for interception of sunlight to each strata of leaves. This will enhance the rate of photosynthesis and consequently, the dry matter production which can

ultimately increase the crop yield. The plant density per unit area and the yield per plant are two most important and inter-dependent factors responsible for crop yield.

Transplanting of Indian mustard is gaining importance in present time due to higher yields and wider sowing window. Transplanting of Indian mustard rather than normal drilling perceived as costlier method of crop establishment, however, the labour requirement for sowing and then thinning the crop twice to remove extra plants in drilled crop may be more costlier. Transplanted crop have the exact plant population with mathematical precision, and there is also some time benefit after harvest of the *kharif* crops. Through transplanting, the full potentiality of individual plants can be realized and yield more than drilling of seeds.

However, information regarding plant geometry on growth and qualitative characters of transplanted Indian mustard in Rajasthan is lacking. Keeping in view the above discussed facts of sufficient information and sparse related research, the present investigation was undertaken to find out the effect of plant geometry on growth and qualitative characters of transplanted Indian mustard (*Brassica juncea* L.).

Materials and Methods

An experiment was conducted during *rabi* season of 2016-17 at Research Farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur (situated at 27°15' N latitude and 77°03' E longitude with an altitude of 178.37 m above mean sea level). The soil was loamy sand in texture having a pH of 8.3 (Alkaline), EC 1.3 (dSm⁻¹), low in organic carbon (0.24 %) and low available

Table-1: Plant height (cm) of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	45 DAT	60 DAT	90 DAT	At harvest
45x30 cm	88.85	163.68	199.68	216.65
60x30 cm	83.78	167.83	199.58	217.65
90x30 cm	88.70	174.03	200.20	220.80
30x10 cm	56.73	109.39	125.29	138.12
SEm±	3.34	2.88	1.94	2.08
C.D.at 5%	10.29	8.89	5.99	6.39
CV(%)	9.39	4.20	2.40	2.34

Table-2 : Number of primary branches of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	45 DAT	60 DAT	90 DAT	At harvest
45x30 cm	8.64	11.33	26.10	21.45
60x30 cm	9.10	12.23	25.45	20.90
90x30 cm	10.03	12.80	25.65	21.55
30x10 cm	6.34	8.03	16.11	13.57
SEm±	0.22	0.20	0.24	0.27
CD at 5%	0.67	0.61	0.73	0.85
CV (%)	5.67	3.97	2.75	2.63

Table-3 : Number of secondary branches of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	60 DAT	90 DAT	At harvest
45x30 cm	34.60	48.40	55.83
60x30 cm	36.90	49.95	56.23
90x30 cm	38.75	48.20	55.95
30x10 cm	24.32	30.15	35.00
SEm±	0.95	0.47	0.51
C.D.at 5%	2.93	1.46	1.58
CV(%)	6.33	2.39	2.26

nitrogen (126.30 kg ha⁻¹), medium in available phosphorus (17.23 kg ha⁻¹) and low in available potassium (149.26 kg ha⁻¹). The experiment was conducted in randomized block design with replicate thrice consisted of four crop geometry treatments viz. 45x30 cm, 60x30 cm, 90x30 and 30x10 cm. The treatments were allocated randomly to each plot. Urea, di ammonium phosphate and murate of potash were used as a source of nitrogen, phosphorus and potassium. The crop was uniformly fertilized with 100 kg N, 60 kg P₂O₅ and 50 kg K₂O ha⁻¹ giving a full dose of phosphorus and potassium as basal and nitrogen applied as basal as well as top dressing. The total rainfall experienced during the crop growth season was 55.8 mm in 2016-17. RH-406 variety of mustard was used as a test crop. Fifteen days old seedlings were transplanted on 13th October and spacing maintained as per treatment. Other crop management methods were accompanied as per the recommendation of the area.

Statistical analysis and interpretation of data : Data recorded on relative composition of weeds in the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The levels of significance used in 'F' and 't' test was p= 0.05. Critical

difference values were calculated where F test was found significant.

Results and Discussions

The outcomes of the study showed that crop geometry showed significant effect on all growth characters at all growth stages and qualitative characters except for oil content during *rabi* 2016-17 are presented in Table 1-6. In general, growth characters showed an increasing trend up to 120 DAT (days after transplanting) and at harvest stage irrespective of the treatments.

Further, perusal of data (Table-1) advocated that significantly higher plant height was observed with spacing of 45x30 cm at 45 DAT which was statistically at par with 90x30 cm and 60x30 cm. However, later stages significantly higher values of plant height was noted with 90x30 cm which was statistically at par with 60x30 and 45x30 cm. While, least plant height at all growth stages was observed under spacing of 30x10 cm. This might be probably tended the plants to be taller for getting the light and produced more secondary branches. Similar results were also reported by Patel *et al.* (2002).

Data enumerated in Table-2 and 3 that significantly higher number of primary and secondary branches plant⁻¹ was observed under 90x30 cm which was statistically at

Table-4 : Chlorophyll content of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	45 DAT	60 DAT	90 DAT
45x30 cm	40.32	41.29	42.62
60x30 cm	39.63	41.99	41.14
90x30 cm	38.76	41.36	43.01
30x10 cm	24.32	25.89	26.97
SEm±	0.37	0.67	0.54
C.D.at 5%	1.14	2.05	1.66
CV(%)	2.32	3.96	3.13

Table-5 : Number of leaves and dry matter accumulation (g) of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	Number of leaves	Dry matter accumulation (g)			
		45 DAT	60 DAT	90 DAT	120 DAT
45x30 cm	32.08	36.43	53.36	102.74	
60x30 cm	33.33	38.33	50.60	97.28	
90x30 cm	32.93	39.30	52.58	96.10	
30x10 cm	21.56	25.96	32.99	60.13	
SEm±	1.25	1.47	1.79	2.05	
C.D.at 5%	3.84	4.54	5.53	6.33	
CV(%)	9.33	9.41	8.47	5.16	

Table-6 : Oil content (%) and oil yield (kg ha⁻¹) of transplanted mustard as influenced with crop geometry at different growth stages.

Treatment	Oil content (%)	Oil yield (kg ha ⁻¹)
45x30 cm	41.26	1360
60x30 cm	40.69	1454
90x30 cm	40.69	1398
30x10 cm	40.26	810
SEm±	0.55	235.14
C.D.at 5%	NS	73.51
CV(%)	2.68	11.71

par with 60x30 and 45x30 cm at 45 DAT in primary branches and 60 DAT in case of secondary branches plant⁻¹. Similar trend was also noted at 90 DAT and at harvest stage. This might be due to less plant population in crop geometry of 90x30cm, plants get adequate nutrient, moisture and space to produce more vigorous plants, branches and leaves. Similar results were also reported by Thakuria and Gogoi (1996) and Oad *et al.* (2001).

A cursory glance of Table-4 revealed that significantly higher value of chlorophyll content was observed with spacing of 45x30 cm at 45 DAT which was statistically at par with 90x30 cm and 60x30 cm. However, at 60 DAT higher value of chlorophyll content was exerted with 60x30 cm spacing but was statistically at par with 90x30 cm and 45x30 cm. In case of 90 DAT, significantly higher chlorophyll content was observed with spacing of 90x30 cm and at par with 45x30 and 60x30 cm, respectively. While, least chlorophyll content was observed under spacing of 30x10 cm at all growth stages. This may be due to the plants were more spaced and

obtained ore light, thereby more chlorophyll. Similar results were also reported by Singh *et al.* (2015).

Data presented in Table 5 revealed that number of leaves and dry matter accumulation influenced with row spacing's at all stages. Significantly higher number of leaves was exerted with spacing of 60x30 cm which was statistically at par with 90x30 and 45x30 cm spacing at 45 DAT. However at 60 DAT, significantly higher number of leaves was observed with spacing of 90x30 cm and statistically at par with 60x30 and 45x30 cm, respectively. In case of dry matter accumulation, significantly higher values was noted with spacing of 45x30 cm which was statistically at par with 60x30 and 90x30 cm, respectively. However, least values was noted under spacing of 30x10 cm at all stages. The increased plant population in crop geometry of 45x30 cm probably produced more plants per unit area, total dry matter and translocated more food in to sink due to more competition at higher plant population. Similar results were also reported by Singh and Prasad (2003).

Data enumerated in Table 6 that oil content could not reach the level of significance with different row spacing during experiment. Oil yield was significantly influenced with row spacing of transplanted mustard. Significantly higher oil yield was noted with spacing of 45x30 cm which was statistically at par with 60x30 cm spacing. However, least oil yield was observed under 30x10 cm spacing. Increase in oil yield per unit area increased with the density which was mainly resulted from the increase in seed yield per unit area. Similar results were also reported by Kardgara *et al.* (2010).

Conclusions

From the above overall study, it is recommended that to obtain higher growth and oil yield of transplanted mustard should be grown by row spacing of 60 x 30 cm under ago-climatic conditions of Bharatpur region of Rajasthan.

References

1. Alam, M.M. (2004). Effect of variety and row spacing on the yield and yield contributing characters of rapeseed and mustard, M.Sc. Thesis, Bangladesh Agricultural University, Mymensingh (Bangladesh).
2. Gomez, A.K. and Gomez, A.A. (1984). *Statistical Procedures for Agriculture Res.* A Wiley-Inter Sci. Publication. Johan Wiley and Sons, New York, 1984, 680p.
3. Kardgara, V., Delkhosh, B., Noormohammadi, G. and Shiranirad, A.H. (2010). Effects of nitrogen and plant density on yield of field mustard (*Brassica campestris*). *Plant Ecophysiology*, 2: 157-164.
4. Oad, F.C., Solangi, B.K., Samo, M.A., Lakho, A.A. and Oad, N.L. (2001). Growth, yield and relationship of rapeseed (*Brassica napus* L.) under different row spacing. *International Journal of Agricultural Biology*, 3(4): 475-476.
5. Patel, J.R., Desai, C.N. and Patel, J.B. (2002). Response of mustard (*Brassica juncea*) to spacing and direction of sowing. (In) *Extended Summaries, 2nd International Agronomy Congress*, Nov. 26-30, New Delhi, India, pp.896-897.
6. Rajak, D.R., Patel, H.A., Chaudhari, K.N., Patel, N.K., Panigrahy, S. and Parihar, J.S. (2011). Spatial temporal sowing pattern of rapeseed-mustard crop in India. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XXXVIII-8/W20.
7. Singh, G.K. and Prasad, K. (2003). Studies on the effect of row spacings and nitrogen doses on the yield of and profit from Indian mustard. *Progressive Agriculture*, 3(1/2): 146-147.
8. Singh, P.K., Tiwari, S.P. and Singh, A.K. (2015). Effect of different dates of sowing and irrigation scheduling on growth and yield of mustard (*Brassica juncea* L.). *Journal of Progressive Agriculture*, 5(2): 18-21.
9. Thakuria, J. and Gogoi, K. (1996) Response of promising varieties of Indian mustard (*Brassica juncea*) to nitrogen and spacing under mid hills, rainfed conditions of Himachal Pradesh. *Indian Journal of Agronomy*, 44(4): 816-819.
10. Yadav, K. (2011). *Oilseed scenario in India*. Retrieved from <http://agropedia.iitk.ac.in>



Grouping of Kabuli Chickpea (*Cicer arietinum* L.) Genotypes Based on Quality Seed Parameters and Chemical Tests

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Abstract

An experiment was carried out at the Seed Testing Laboratory, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh, to characterize forty two kabuli chickpea genotypes based on seed quality parameters and chemical tests. Among 42 genotypes, seed germination percent was observed in DL-17-1306 (97.22%) with a mean of 92.77% while, seedling vigour index I was high in all forty two genotypes. The seeds were subjected to NaOH, CuSO₄, Na₂CO₃, KOH, FeSO₄ and GA₃ growth response test for differentiating the genotypes and no colour change (8 genotypes). Based on the CuSO₄ test, genotypes were grouped into two categories dark brown (29 genotypes) and no change (13 genotypes). Based on the modified phenol test B (Na₂CO₃ test) genotypes were grouped into two categories dark brown (32 genotypes) and no change 10 genotypes. On the basis of KOH test genotypes were grouped into dark brown (14 genotypes) and no colour change (28 genotypes). Based on FeSO₄ test, genotypes were grouped into two categories black in (24 genotypes) and no change (18 genotypes). Based on GA₃ growth response test varied significantly among the forty-two genotypes and the GA₃ growth response test ranged from 25.28 cm (GKL-14306) to 48.21 cm (ICCV-2) with a mean of 36.80 cm.

Key words : Chickpea, characterization, quality parameters, chemical tests

Introduction

Chickpea popularly known as Gram, Bengal gram, Homes, Chhola, Garbanzo bean is one of the first seed legumes to be domesticated by humans in old world. Chickpea (*Cicer arietinum* L.) a diploid (2n=16) member of the family Fabaceae and sub family Faboideae. Among pulses chickpea is the third most important food legume crop in the world after dry beans (*Phaseolus vulgaris* L.) and dry peas (*Pisum sativum* L.). In India, the area under chickpea was 10.56 million hectares with a production of 11.37 million tonnes and productivity of 1077 kg/ha during rabi 2017-18. In Gujrat, area under chickpea was 0.293 million hectares with a total production of 0.376 million tonnes and productivity of 1285 kg/ha during 2017-18. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka are major growing states (Anon., 2019). However, India being largest producer of chickpea is unable to meet the demands of its own. Chickpea originated in the temperate regions of Southeastern Turkey and adjoining Syria. The chickpea has been divided in to two groups. (1) Macrospora referred as *kabuli* and (2) Microspora referred as *desi* type by Indian breeders. *Desi* and *kabuli* chickpea production ratio throughout the world is 3:1.

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 (PBR) 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 the documentation of characters for chickpes genotypes was planned with the objective to identify stable diagnostic characteristics of plant morphology of chickpea genotypes.

Materials and Methods

The experiment was conducted in the Seed Testing Laboratory of the Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh during 2019-20 to characterize the 42 genotypes of kabuli chickpea (*Cicer arietinum* L.) viz., RVSSG-62, ICCV-181310, ICCV-171312, IPCK-175, ICCV-171316, VIHAR, IPCH-175, ICCV-181316, PHULE-G-13315, PG-220, ICCV-171703, HK-1534, ICCV-181313, ICCV-181306, ICCV-171309, ICCV-2, RKGK-13-159, ICCV-171310, NBEG-810, GJGK-1617, ICCV-181311, ICCV-181312, ICCV-181301, ICCV-171302, ICCV-181305, RVSIG-63, ICCV-181315, ICCV-181304, ICCV-181302, HK-13-103, ICCV-171317, ICCV-181303,

Table-1 : Identification and grouping of kabuli chickpea genotypes based on seed germination (%), shoot length (cm) and root length (cm).

Genotypes	Seed germination (%)	Shoot length (cm)	Root length(cm)
RVSSG-62	84.85	7.89	8.86
ICCV-181310	84.78	10.56	9.53
ICCV-171312	90.58	11.21	9.64
IPCK-175	90.64	9.23	11.65
ICCV-171316	93.87	11.94	10.08
VIHAR	93.56	15.01	12.10
IPCH -175	94.85	14.63	12.10
ICCV-181307	92.16	20.45	11.00
ICCV-181316	91.48	14.65	10.91
PHULE-G-13315	93.98	18.36	14.37
PG-220	94.02	15.99	10.96
ICCV-171703	97.21	8.56	12.20
HK-1534	92.45	16.23	12.16
ICCV-181313	93.75	11.52	13.38
ICCV-181306	94.41	18.56	11.52
ICCV-171309	97.01	15.19	12.29
ICCV-2	91.20	14.73	9.86
RKGK-13-159	93.48	18.32	15.29
ICCV-171310	94.76	13.99	9.77
NBEG-810	95.74	16.01	11.51
GJGK-1617	91.68	9.63	12.99
ICCV-181311	93.50	15.88	15.57
ICCV-181312	88.36	11.99	11.98
ICCV-181301	90.37	17.62	16.23
ICCV-171302	94.25	15.03	12.68
ICCV-181305	91.67	9.63	14.46
RVSIG-63	92.49	16.70	13.40
ICCV-181315	95.02	19.63	15.84
ICCV-181304	93.50	8.63	10.46
ICCV-181302	89.47	16.64	12.89
HK-13-103	95.25	9.65	9.36
ICCV-171317	92.44	16.79	16.33
DK-16-313	93.78	10.25	13.51
ICCV-181303	91.60	18.26	19.21
DL-17-1306	97.22	17.09	13.05
GKL-14306	92.46	7.85	12.72
GJGK-1616	95.81	15.62	12.86
KAK-2	87.90	8.85	16.37
RKGK-13-416	93.27	17.09	13.53
GNG-2404	92.01	9.86	13.56
ICCV-171306	95.76	8.12	10.30
ICCV-181318	94.16	15.99	14.70
Mean	92.77	13.81	12.65
S.Em ±	1.11	0.23	0.22
C.D. at 5%	3.11	0.65	0.62
CV %	2.39	3.35	3.53

Table-2 : Identification and grouping of kabuli chickpea genotypes based on seedling dry weight (g), seedling vigour index I and seedling vigour index II.

Genotypes	Seedling dry weight (mg)	Seedling vigour index I	Seedling vigour index II	Group
RVSSG-62	45.44	1421.16	3854.21	High vigorous
ICCV-181310	40.21	1702.94	3410.41	High vigorous
ICCV-171312	49.06	1888.71	4444.64	High vigorous
IPCK-175	42.01	1892.57	3813.36	High vigorous
ICCV-171316	45.32	2067.37	4254.49	High vigorous
VIHAR	64.81	2536.20	6062.39	High vigorous
IPCH -175	61.24	2535.27	5808.29	High vigorous
ICCV-181307	62.48	2898.27	5755.57	High vigorous
ICCV-181316	73.67	2338.59	6740.03	High vigorous
PHULE-G-13315	50.80	3076.05	4773.32	High vigorous
PG-220	53.29	2534.14	5009.46	High vigorous
ICCV-171703	72.38	2018.40	7036.54	High vigorous
HK-1534	43.30	2624.38	4002.46	High vigorous
ICCV-181313	49.65	2334.07	4655.24	High vigorous
ICCV-181306	53.23	2839.85	5024.65	High vigorous
ICCV-171309	51.63	2666.54	5007.97	High vigorous
ICCV-2	51.27	2242.66	4675.14	High vigorous
RKGK-13-159	37.82	3142.73	3535.42	High vigorous
ICCV-171310	58.47	2251.31	5541.71	High vigorous
NBEG-810	73.43	2634.32	7029.83	High vigorous
GJGK-1617	39.90	2073.94	3657.92	High vigorous
ICCV-181311	57.27	2940.30	5354.40	High vigorous
ICCV-181312	64.40	2117.75	5689.27	High vigorous
ICCV-181301	51.51	3058.94	4655.87	High vigorous
ICCV-171302	39.15	2611.45	3689.18	High vigorous
ICCV-181305	63.14	2208.12	5786.53	High vigorous
RVSIG-63	57.96	2784.50	5360.29	High vigorous
ICCV-181315	50.50	3370.71	4797.87	High vigorous
ICCV-181304	80.86	1784.88	7560.55	High vigorous
ICCV-181302	71.02	2642.07	6352.29	High vigorous
HK-13-103	52.28	1810.79	4978.39	High vigorous
ICCV-171317	51.63	3062.06	4772.31	High vigorous
DK-16-313	62.94	2228.48	5902.43	High vigorous
ICCV-181303	58.32	3431.43	5341.73	High vigorous
DL-17-1306	40.68	2931.43	3955.02	High vigorous
GKL-14306	35.81	1901.53	3310.75	High vigorous
GJGK-1616	57.25	2728.11	5484.04	High vigorous
KAK-2	54.80	2217.11	4817.05	High vigorous
RKGK-13-416	73.08	2856.08	6817.33	High vigorous
GNG-2404	48.09	2154.92	4425.15	High vigorous
RVSSG-62	62.76	1763.52	6009.82	High vigorous
ICCV-181310	53.06	2889.64	4997.01	High vigorous
Mean	54.90	2569.70	5098.81	
S.Em ±	0.70	39.88	89.98	
C.D. at 5 %	1.96	111.60	251.85	
CV %	2.55	3.10	3.52	

Note : Seedling vigour index-I = Less vigorous < 500, High vigorous > 500

Table-3 : Identification and grouping of kabuli chickpea genotypes based on sodium hydroxide test (NaOH), modified phenol test A (CuSO₄) and modified phenol test B (Na₂CO₃).

Genotypes	Sodium hydroxide test (NaOH)	Modified phenol test A (CuSO ₄)	Modified phenol test B (Na ₂ CO ₃)
RVSSG-62	Light yellow	Dark brown	No change
ICCV-181310	Dark yellow	Dark brown	Dark brown
ICCV-171312	No change	Dark brown	Dark brown
IPCK-175	Light yellow	No change	No change
ICCV-171316	Light yellow	No change	Dark brown
VIHAR	Dark yellow	Dark brown	Dark brown
IPCH -175	Dark yellow	No change	No change
ICCV-181307	Light yellow	No change	No change
ICCV-181316	Light yellow	No change	Dark brown
PHULE-G-13315	Light yellow	No change	No change
PG-220	Dark yellow	Dark brown	Dark brown
ICCV-171703	Light yellow	Dark brown	Dark brown
HK-1534	No change	Dark brown	Dark brown
ICCV-181313	Dark yellow	Dark brown	Dark brown
ICCV-181306	Dark yellow	Dark brown	Dark brown
ICCV-171309	Light yellow	No change	Dark brown
ICCV-2	Light yellow	No change	Dark brown
RKGK-13-159	No change	Dark brown	Dark brown
ICCV-171310	Dark yellow	Dark brown	Dark brown
NBEG-810	Light yellow	Dark brown	Dark brown
GJGK-1617	Light yellow	No change	Dark brown
ICCV-181311	No change	No change	Dark brown
ICCV-181312	Light yellow	Dark brown	Dark brown
ICCV-181301	Dark yellow	Dark brown	Dark brown
ICCV-171302	Dark yellow	Dark brown	Dark brown
ICCV-181305	No change	Dark brown	No change
RVSIG-63	Light yellow	Dark brown	Dark brown
ICCV-181315	Dark yellow	Dark brown	Dark brown
ICCV-181304	No change	Dark brown	Dark brown
ICCV-181302	Light yellow	Dark brown	Dark brown
HK-13-103	No change	No change	No change
ICCV-171317	Dark yellow	Dark brown	Dark brown
DK-16-313	Dark yellow	Dark brown	Dark brown
ICCV-181303	Light yellow	Dark brown	Dark brown
DL-17-1306	Dark yellow	Dark brown	Dark brown
GKL-14306	Light yellow	Dark brown	Dark brown
GJGK-1616	Light yellow	No change	Dark brown
KAK-2	Light yellow	No change	No change
RKGK-13-416	Light yellow	Dark brown	No change
GNG-2404	No change	Dark brown	Dark brown
ICCV-171306	Light yellow	Dark brown	No change
ICCV-181318	Light yellow	Dark brown	Dark brown

Table-4 : Identification and grouping of kabuli chickpea genotypes based on potassium hydroxide (KOH), ferrous sulphate test (FeSO₄) and GA₃ growth response test.

Genotypes	Potassium hydroxide test (KOH)	Ferrous sulphate test (FeSO ₄)	GA ₃ growth response test Seedling length (cm)	Group
RVSSG-62	No change	No change	36.33	High response
ICCV-181310	Dark brown	Black	32.40	High response
ICCV-171312	No change	Black	33.97	High response
IPCK-175	No change	No change	28.64	Low response
ICCV-171316	No change	No change	35.43	High response
VIHAR	No change	No change	43.45	High response
IPCH -175	Dark brown	Black	41.35	Low response
ICCV-181307	No change	No change	42.22	Low response
ICCV-181316	No change	Black	33.24	Low response
PHULE-G-13315	No change	No change	45.22	Low response
PG-220	Dark brown	Black	34.69	Low response
ICCV-171703	No change	Black	33.93	High response
HK-1534	Dark brown	Black	36.25	Low response
ICCV-181313	Dark brown	Black	31.68	Low response
ICCV-181306	Dark brown	No change	41.68	High response
ICCV-171309	Dark brown	Black	41.63	High response
ICCV-2	No change	Black	48.21	Low response
RKGK-13-159	No change	No change	50.31	High response
ICCV-171310	Dark brown	No change	42.72	Low response
NBEG-810	No change	Black	31.76	Low response
GJGK-1617	Dark brown	Black	28.49	High response
ICCV-181311	No change	No change	52.41	Low response
ICCV-181312	No change	Black	31.82	High response
ICCV-181301	Dark brown	Black	44.04	Low response
ICCV-171302	No change	Black	33.04	Low response
ICCV-181305	No change	Black	35.01	Low response
RVSIG-63	Dark brown	No change	36.23	High response
ICCV-181315	No change	Black	45.21	High response
ICCV-181304	No change	Black	36.14	Low response
ICCV-181302	No change	Black	28.23	Low response
HK-13-103	No change	Black	27.30	Low response
ICCV-171317	No change	No change	32.77	High response
DK-16-313	No change	Black	36.89	Low response
ICCV-181303	No change	No change	32.13	High response
DL-17-1306	No change	Black	29.23	Low response
GKL-14306	No change	Black	25.28	High response
GJGK-1616	Dark brown	No change	45.94	Low response
KAK-2	No change	No change	35.60	High response
RKGK-13-416	No change	Black	32.97	Low response
GNG-2404	No change	No change	36.83	High response
ICCV-171306	Dark brown	No change	39.07	High response
ICCV-181318	Dark brown	No change	35.73	Low response
Mean			36.80	
S.Em ±			0.73	
C.D. at 5%			2.03	
CV %			3.95	

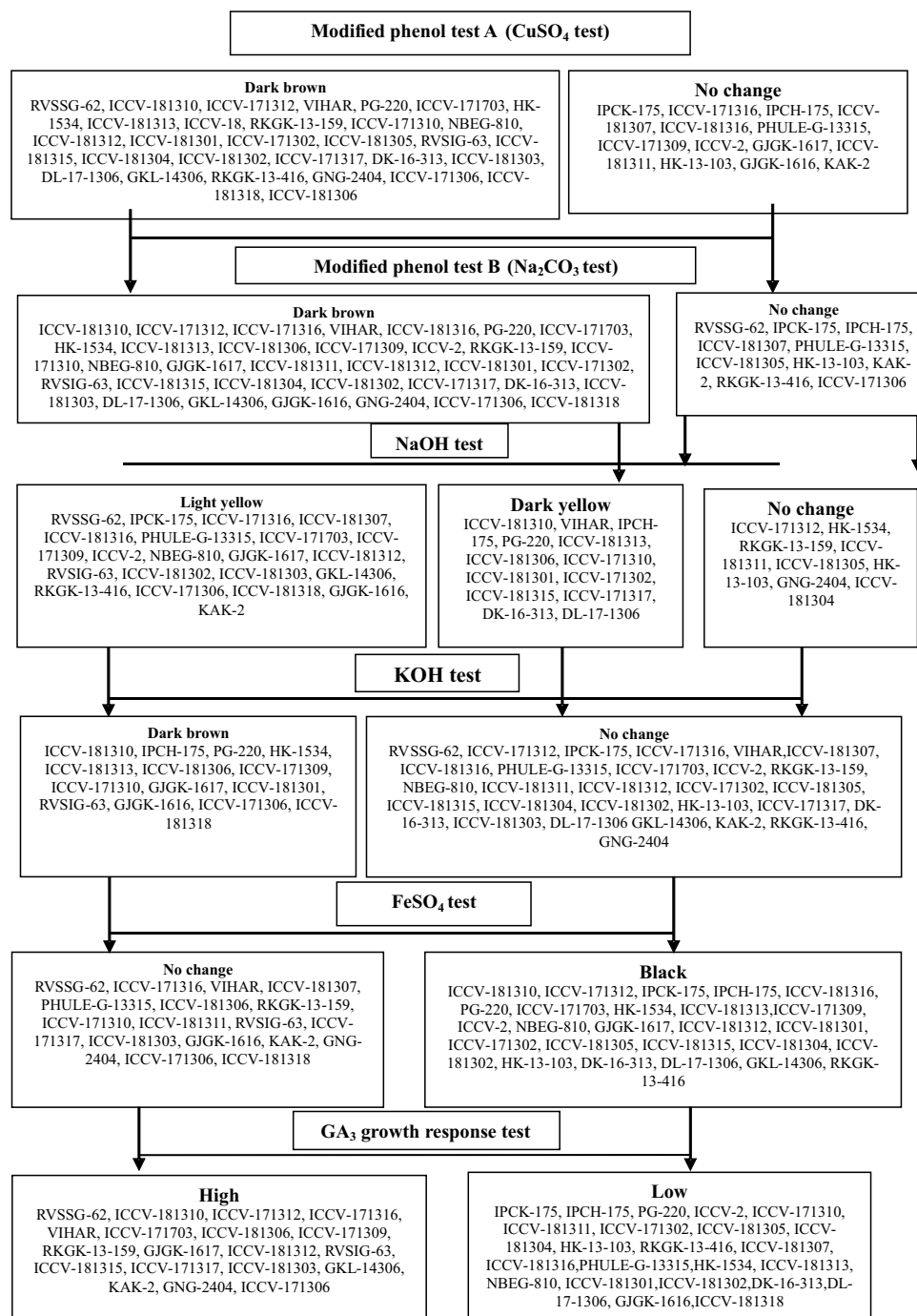


Figure-1 : Kabulichickpea genotypes identification keys on the basis of chemical tests.

DL-17-1306, GKL-14306, GJGK-1616, KAK-2, RKGK-13-416, GNG-2404, ICCV-171306 and ICCV-181318 based on quality seed parameters and chemical tests. The experiment was conducted as per Completely Block Design with four repetitions. The observations viz., seed germination, shoot length, root length, seedling dry weight, seedling vigour index I, seedling vigour index II, NaOH test, Modified phenol test A, Modified phenol test B, KOH test, FeSO_4 test and GA_3 growth response test. The data obtained from laboratory experiment conducted in

CRD were analyzed as per standard method suggested by Panse and Sukhatme (1985).

Results and Discussion

Based on seed germination and seedling characters, chickpea genotypes were categorized into different groups (Table-1 and 2). The seed germination percentage varied among the genotypes due to the quality parameters and could be attributed to better development of seeds. The seed germination percentage ranged from

NaOH test



Dark yellow –ICCV-181310



Light yellow – ICCV-181316



Modified phenol test A (CuSO_4)



Dark brown – PG-220



No change – ICCV-2

Modified phenol test B (Na_2CO_3)



Dark brown –ICCV-181301



No change HK-13-103

Plate-2 : NaOH, modified phenol test A and modified phenol B of kabuli chickpea genotypes.

DL-17-1306 (97.22%) followed by ICCV-171703 (97.21%) and ICCV-171309 (97.01%) and lowest was observed in ICCV-181310 (84.78%) with a mean seed germination percentage of 92.77%. Shoot length ranged from 7.85 cm (GKL-14306) to 20.45 cm (ICCV-181307) with a mean of 13.81 cm. Root length varied significantly among the forty-two genotypes and the root length ranged from 8.86 cm (RVSSG-62) to 19.21 cm (ICCV-181303) with a mean of 12.65 cm. Seedling dry weight varied significantly among the genotypes and the seedling dry weight ranged

from RKGK-13-159 (37.82 mg) to ICCV-181304 (80.86 mg) with a mean of 54.90 mg. Seedling vigour index I varied significantly among the forty-two genotypes and the seedling vigor index I ranged from RVSSG-62 (1421.16) to ICCV-181303 (3431.71) with a mean of 2569.70. Seedling vigour index II varied significantly among the forty-two genotypes and the seedling vigor index II ranged from GKL-14306 (3310.75) to ICCV-181304 (7560.55) with a mean of 5098.81.

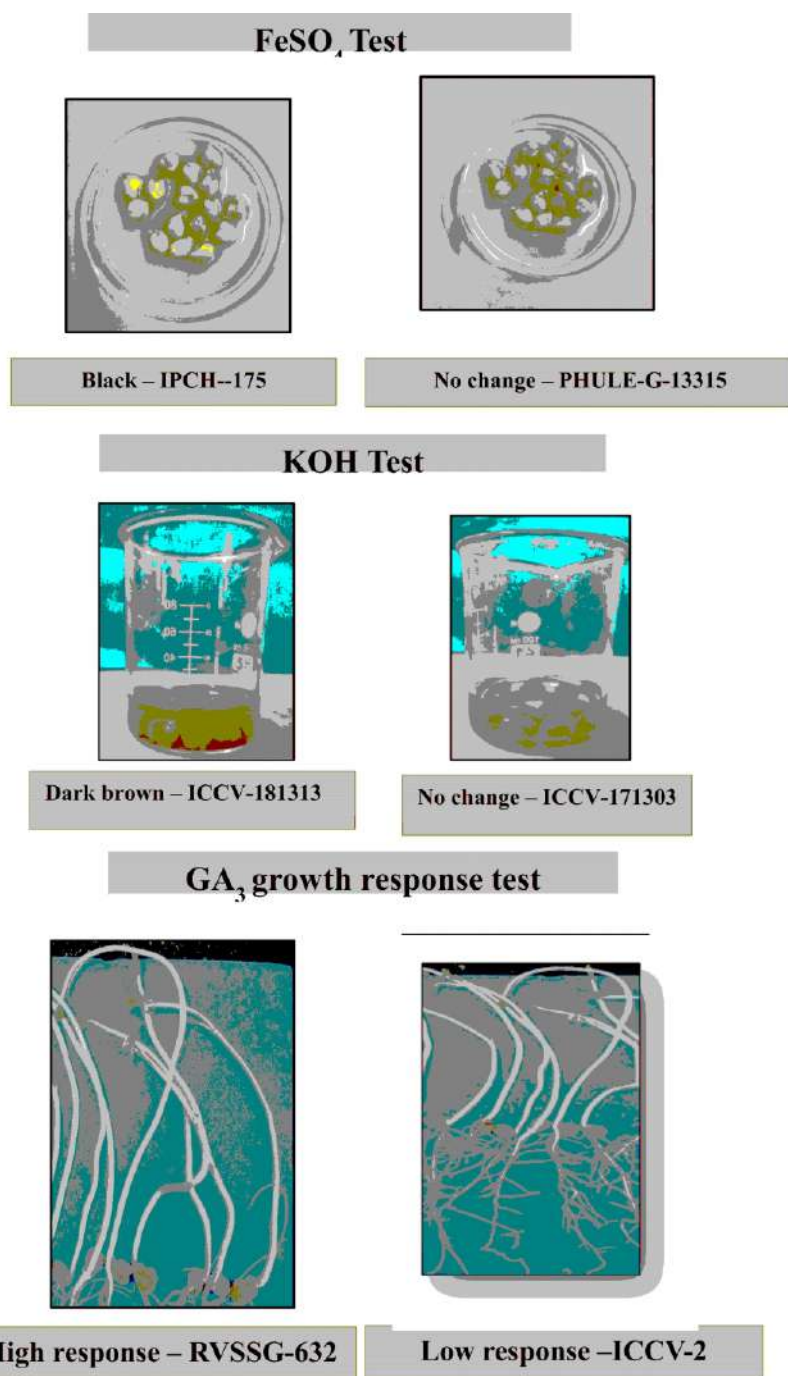


Plate-3 : FeSO₄ test, KOH test and GA₃ growth response test of kabuli chickpea genotypes.

The chemical tests such as NaOH test, Modified phenol test A, Modified phenol test B, KOH test, FeSO₄ test and GA₃ growth response test, which help for classifying the genotypes into different groups (Table-3 and 4). On the basis of chemical tests, genotype identification keys were prepared (Figure-1). The genotypes RVSSG-62, were having dark brown colour in copper sulphate test, black colour in sodium phenol test, light yellow colour reaction in NaOH test, no colour

change in KOH and FeSO₄ test and high GA₃ growth response test, while the genotypes ICCV-181312, GKL-14306 and RKGK-13-1416 varied from above genotypes with respect to black colour FeSO₄, and ICCV-181303 had no change in copper sulphate test.

The genotypes, ICCV-171306 were having dark brown colour in copper sulphate test, dark brown in sodium phenol test, light yellow colour reaction in NaOH test, brown colour in KOH and no colour in FeSO₄ test and

high GA₃ growth response test, while the genotype NBEG-810 differed from low response GA₃ test and the genotypes ICCV-181302 and ICCV-181318 varied from above genotypes with respect to low response GA₃.

The genotypes ICCV-181310, and were having dark brown colour in copper sulphate test, black colour in sodium phenol test, dark yellow colour reaction in NaOH test, dark brown in KOH and black colour in FeSO₄ test and high GA₃ growth response test and the genotype ICCV-181301 varied from low response GA₃ test and the genotypes ICCV-181315, DK-16-313 and DL-17-1306 varied from above genotypes with respect to no change in KOH and genotype ICCV-181313 differed from low GA₃ growth response test.

The genotypes ICCV-171317 and VIHAR were having dark brown colour in copper sulphate test, brown colour in sodium phenol test, dark yellow colour reaction in NaOH test, no change in KOH and no change in FeSO₄ test and high GA₃ growth response test, while the genotypes ICCV-181306 varied from above genotypes with respect to dark brown in KOH test.

The genotype PG-220 having colour in copper sulphate test, black colour in sodium phenol test, dark yellow colour reaction in NaOH test, dark brown in KOH test, black colour in FeSO₄ test and low GA₃ growth response test, while the genotypes ICCV-171302 differed from above genotypes with respect to low GA₃ growth response test and ICCV-171301 varied in no change in FeSO₄.

The genotypes RKGK-13-159 and GNG-2404 were having dark brown colour in copper sulphate test, black colour in sodium phenol test, no change in NaOH test, no change in KOH and no change in FeSO₄ test and high GA₃ growth response test.

The genotypes ICCV-181305 and ICCV-181304 were having dark brown colour in copper sulphate test, black colour in sodium phenol test, no change in NaOH test, no change in KOH and black colour in FeSO₄ test and low GA₃ growth response test, while the genotypes HK-1534 varied from above genotypes with respect to dark brown colour in KOH test.

The genotypes ICCV-171309 and GJGK-1617 were having no change in copper sulphate test, black colour in sodium phenol test, light yellow colour reaction in NaOH test, dark brown in KOH and black colour in FeSO₄ test and high GA₃ growth response test.

The genotypes ICCV-2 and IPCK-175 were having no change in copper sulphate test, black colour in sodium phenol test, light yellow colour reaction in NaOH test, no change in KOH and black colour in FeSO₄ test and low GA₃ growth response test, while the genotypes IPCH-175

varied from above genotypes with respect to dark yellow colour NaOH test and dark brown colour in KOH test.

The genotypes ICCV-181311 were having no change in copper sulphate test, black colour in sodium phenol test, no change in NaOH test, no change in KOH and no change in FeSO₄ test and low GA₃ growth response test, while the genotypes HK-13-103 varied from above genotypes with respect to black colour in FeSO₄ test.

The genotypes KAK-2 were had no change in copper sulphate test, black colour in sodium phenol test, light yellow in NaOH test, no change in KOH and no change in FeSO₄ test and high GA₃ growth response test, while the genotypes GJGK-1616 varied from above genotypes with respect to dark brown in KOH test and low response GA₃ test.

The genotype ICCV-171312 had dark brown colour in modified phenol test A and modified phenol test B, no change in NaOH and KOH test, black colour in FeSO₄ test and high GA₃ growth response test.

The genotype ICCV-171316 had no change in modified phenol test A test and dark brown in modified phenol test B test, light yellow colour in NaOH test, no change in KOH test, no change in FeSO₄ test and high GA₃ growth response test, while ICCV-181316 differed in low in GA₃ growth response test.

The genotype ICCV-181307 had no similar in all chemical test and low GA₃ growth response test, while genotype PHULE-G-13315 differ in light yellow in NaOH test.

The genotype RVSIG-63 had dark brown colour in both modified phenol test A and B, light yellow colour NaOH test, dark brown colour in KOH test, no change in FeSO₄ test and high GA₃ growth response test.

The genotype ICCV-171703 were having dark brown colour in both modified phenol A test and B test, light yellow colour in NaOH test, no change in KOH test and black colour in FeSO₄ test and high response GA₃ test.

Similar observations and grouping was made based on the seed germination and seedling characters by Vadivelu and Ramakrishnan (1983) in chickpea; Ankaiah *et al.* (2013) in groundnut; Das *et al.* (2014) in french bean; Shivangi (2015) in finger millet; Hemender *et al.* (2017) in pearl millet; Sushma *et al.* (2017) in wheat; Nithyananda *et al.* (2018) in green gram; Rawat *et al.* (2019) in urdbean.

Conclusion

Assessment of genetic purity is an important criterion in

seed production programme. Therefore, simple and reliable techniques need to be developed for genetic purity assessment and genotype characterization. The study suggested that seed quality parameters and chemical test, were found to be useful in broad classification of kabuli chickpea genotypes.

References

1. Ankaiah, R.; Bharathi, M.; Varma, V.; Kumari, S.; Durga, K. and Kanaka, R. 2013. Effect of seed size on seedling vigour in groundnut (*Arachis hypogaea* L.). *Madras Agricultural Journal*, (3): 324-327.
2. Anonymous 2019. Project coordinator's report, All India Coordinated Research Project on chickpea. IIPR-Indian Institute of Pulses Research, Kanpur. pp 22-25.
3. Das, R.; Thapa, U., Debnath, S., Lyngdoh, Y. A. and Mallick, D. 2014. Evaluation of frenchbean (*Phaseolus vulgaris* L.) genotypes for seed production. *J. Appl. Nat. Sci.*, 6(2): 594-598.
4. Hemender, A.; Sangwan, V.P.; Mor, V.S. and Sushma, S. 2017. Correlation and regression analysis of various viability and vigour parameters in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Seed Res.*, 45(1): 16-22.
5. Nithyananda, N.; Chaurasia, A.K.; Bineetha, M.B.; Katipelly, R.R. and Raghu, G. 2018. Studies on seed quality parameters of greengram (*Vigna radiata* (L.) Wilczek) genotypes. *Trends in Biosciences*, 11(24): 3229-3232.
6. Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*, ICAR. New Delhi.
7. Rawat, A.K.; Sharma, L.K.; Kulkarni, G.U.; Javia, R.M. and Singh, S.P. 2019. Characterization of urdbean (*Vigna mungo* L. hepper) genotypes through quality parameters and chemical tests. *Frontiers In Crop Improvement*, 7(2): 83-87.
8. Shivangi, N. 2015. Studies on morphological characterization, seed quality parameters and genetic divergence in finger millet (*Eleusinecoracana* (L.) Gaertn.) germplasm. *M.Sc. (Agri.) Thesis (unpublished) submitted to VCSG Uttarakhand University of Horticulture and Forestry*, Bharsar.
9. Sushma, S.; Punia, R.C.; Vikram, S.; Mor, V.S. and Hemender, T. 2017. Prediction of seedling establishment in field by using various seed vigour parameters in wheat (*Triticum* spp.). *Int. J. Curr. Microbiol. App. Sci.*, 6(11): 410-414.
10. Vadivelu, K.K. and Ramakrishnan, V. 1983. Effect of seed size on quality attributes and yield of seeds in bengalgram (*Cicer arietinum* L.). *Seed Research*, 11(2): 177-181.



Effect of Microalgae and Organic Manure on Leaf Spot of (*Alternaria* sp.) of Quinoa

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Abstract

A Randomized Block Design (RBD) field experiment was conducted in Central Research Farm (CRF) at Department of Plant Pathology, SHUATS, Prayagraj, U.P. during the *Rabi* season of 2019-2020 to evaluate the effect of microalgae and organic manure on leaf spot disease of Quinoa. The organic amendments used as treatment were cow dung, goat manure and microalgae. The treatment cow dung @ 6 ton/ha + microalgae @ 2.5 kg/ha + goat manure @ 3 ton/ha was found to be the most effective against *Alternaria* spp. causing leaf spot of Quinoa. The minimum disease intensity (%) was recorded in T₆- Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (5.66 %, 12.67 % and 23.50 %, respectively) at 40, 80 and 120 days, respectively. The same treatment recorded maximum plant height (cm) (62.29, 90.48 and 117.31, respectively) at 40, 80 and 120 DAS, respectively. The same treatment recorded maximum yield (q/ha) recorded (23.45q/ha) at 120 DAS. The same treatment recorded maximum gross return, net return and cost: benefit ratio (Rs.70350/ha, 41326/ha and 1:1.42, respectively). Based on the result obtained, it was concluded that Cow dung @ 6 ton/ha + microalgae @ 2.5 kg/ha + goat manure @ 3 ton/ha was proved to be most effective against *Alternaria* spp. of Quinoa under Prayagraj condition.

Key words : *Alternaria* spp., cow dung, goat manure, microalgae and Quinoa.

Introduction

Its common name in Hindi is Bathua, and is locally notorious by diverse names like lambs quarter, fat-hen, white goosefoot, meld, and frost bite. It is most widely distributed weeds in the world, cultivated throughout India particularly Western Rajasthan, Kulu valley, Shimla, and widely distributed in Europe, North America, Asia, and in different parts of Iran (Jan *et al.*, 2015).

Quinoa is the traditional crop in South America. In the recent past quinoa has witnessed increasing popularity globally, due to its exceptional nutritional properties.



Plate-1 : Overall view of Research plots



Plate-2 : Healthy plant of Quinoa

The seeds are gluten-free and rich in minerals, proteins, and vitamins (Ruales and Nair, 1992). Quinoa cultivation is spreading worldwide. Being a facultative halophyte, quinoa is able to cope with high level of salinity and drought stress. Some varieties even accept sea water for irrigation. Among potential climate change-adapted crops for future agriculture, quinoa there for stand out as a prime candidate (Pitzschke, 2016).

Leaf spot disease is important disease in quinoa. Fungal pathogens like *Alternaria* spp. And *Ascochyta* spp. have been found responsible for causing round, yellow, brown or black spots, often with concentric rings. Foliage is heavily affected with estimated 10-60% mortality in plants of Chenopodiaceae family (Siddiqui *et al.*, 2009).

Materials and Methods

Six soil treatments were applied to the plots namely cow dung @ 6 ton/ha(T₁), Goat manure @ 3 ton/ha (T₂), Microalgae @ 9 kg/ha (T₃), cow dung @ 6 ton/ha + Microalgae @ 9 kg/ha (T₄), Goat manure @ 3 ton/ha + Microalgae @ 5 kg/ha (T₅) and cow dung @ 6 ton/ha + Microalgae @ 2.5 kg/ha + Goat manure @ 3 ton/ha (T₆). T₀ was kept as untreated control.

Organic manures were applied as pre sowing treatment and microalgae was applied after sowing.

Isolation of Pathogen : Naturally infected quinoa leaves showing typical symptoms of leaf spot were collected from the field, brought to the laboratory and washed thoroughly with distilled water.

These leaves were then blot dried and cut with sharp sterilized blade into small bits (5 mm), keeping half healthy and half diseased portion intact. These pieces were surfaces sterilized with 0.1 per cent aqueous solution of sodium hypochloride (NACIO) for two minutes and then washed by giving three changes with sterile distilled water to remove traces of mercuric chloride and again blot dried. These pieces were inoculated aseptically



Plate-3 : Leaf spot symptoms on Quinoa.

on autoclaved and cooled PDA medium poured in sterilized petriplate under aseptic conditions of Laminar-air- flow cabinet. Inoculated plates were incubated in BOD incubator at $27 \pm 2^\circ\text{C}$ temperature. After a week of incubation, the well developed mycelial growth, free from any contaminant was obtained. Following hyphal tip isolation technique, the fungus was transfer red aseptically on the PDA slant in test tubes. Through frequent sub-culturing, the test fungus was purified and the pure culture was maintained on agar slant in test tubes.

Identification of the pathogen : For identification of the pathogen, parameters viz., symptomatology (visual and microscopic), cultural and morphological characteristics were used Yao and Kollar (1994, 1995).

Morphological characteristics of *Alternaria* spp.

Isolates : The morphological characteristics of viz., mycelial width, size of conidia, length of beak and number of transverse and longitudinal septa in respect of each test isolate were recorded. The size of conidia and beak was measured using ocular micrometer (calibrated using stage micrometer) under the compound microscope at 40 X magnification.

Assessment for Growth Parameters and Disease Intensity : Assessment of the plants was conducted. The growth parameters were monitored and plant were also inspected for disease symptoms and any other factors affecting them. Observations were recorded at 40, 80 and 120 day after sowing (DAS) for plant height (cm), number of leaves and per cent Disease Intensity (DI). After harvesting grain yield was calculated.

Results and Discussion

The experimental results of the present investigation entitled, "Effect of micro algae and organic manure on *Alternaria* sp. of Quinoa" comprise of a field experiment which was carried out at the Plant Pathology Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Rabi* season 2019 - 2020 are presented in the subsequent pages under

appropriate in order to have an easy understanding of the findings the table and bar diagram have also presented.

Disease intensity (%) : The results at 40, 80 and 120 DAS indicate that all the treatments significantly reduced leaf spot disease intensity as compared to control T₀ (11.45, 21.11 and 30.19, respectively). The treatment T₆- Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (5.66, 12.67 and 23.50, respectively) significantly reduced the disease intensity as compared with T₅ Goat manure @ 3 ton/ha+ micro algae @ 5 kg/ha (7.47, 17.65 and 26.71, respectively), T₄- Cow dung @ 6 ton/ha+ micro algae @ 5 kg/ha (8.25, 17.90 and 26.83, respectively), T₃ -Micro algae @ 9 kg/ha (8.38, 19.73 and 27.96, respectively), T₂- Goat manure @ 3 ton/ha (19.90 ,9.06 and 28.11, respectively), T₁- Cow dung @ 6 ton/ha (9.21, 20.50 and 28.91, respectively).

Plant heights (cm) : At 40, 80 and 120 DAS, the observed plant height (cm) of quinoa under field condition was T₆ -Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (62.29, 90.48 and 117.31, respectively) which was significantly greater as compared to T₅ - Goat manure @ 3 ton/ha+ micro algae @ 5 kg/ha (55.03, 83.22 and 111.89, respectively), T₄ - Cow dung @ 6 ton/ha+ micro algae @ 5 kg/ha (54.24, 80.97 and 106.58, respectively), T₃ - Micro algae @ 9 kg/ha (50.82, 74.61 and 102.40, respectively), T₂ - Goat manure @ 3 ton/ha (44.35, 67.16 and 99.30, respectively), T₁- Cow dung @ 6 ton/ha (41.97, 61.42 and 93.50, respectively) and T₀- Untreated control (39.51, 48.73 and 71.86, respectively).

Yield (q/ha.) : At 120 DAS, the calculated yield (q/ha) of quinoa under field condition was T₆ - Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (23.45) which was significantly greater as compared to T₅ - Goat manure @ 3 ton/ha+ micro algae @ 5 kg/ha (22.50), T₄ - Cow dung @ 6 ton/ha+ micro algae @ 5 kg/ha (21.07), T₃ - Micro algae @ 9 kg/ha (20.32), T₂- Goat manure @ 3 ton/ha (18.24) , T₁ - Cow dung @ 6 ton/ha (13.84) and T₀- Untreated control (11.33).

Economics of different treatments : Maximum gross return, net return and cost: benefit ratio was observed in treatment T₆ - Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (Rs.70350/ha, 41326/ha and 1:1.42, respectively) followed by treatment T₅ - Goat manure @ 3 ton/ha + micro algae @ 5 kg/ha (Rs. 67500/ha, 38530/ha and 1:1.32, respectively), T₄ – Cow dung @ 6 ton/ha+ micro algae @ 5 kg/ha (Rs.63210/ha, 34294/ha and 1:1.18, respectively), T₃ - Micro algae @ 9 kg/ha (Rs.60960/ha, 32098/ha and 1:1.11, respectively), T₂ - Goat manure @ 3 ton/ha (Rs. 54720/ha, 25912/ha and 1:0.89, respectively), T₁ – Cow dung @ 6 ton/ha

Table-1 : Effect of micro algae singly in combination with organic manure on Disease intensity in leaf (%), Plant height (cm) and Yield (q/ha.) of Quinoa.

Treatments	Disease intensity (%)			Plant height (cm)			Yield (q/ha.)
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS	120 DAS
T ₀ Control	11.45	21.11	30.19	39.51	48.73	71.86	11.33
T ₁ Cow dung@ 6 ton/ha	9.21	20.50	28.91	41.97	61.42	93.50	13.84
T ₂ Goat manure @ 3 ton/ha	9.06	19.90	28.11	44.35	67.16	99.30	18.24
T ₃ Micro algae @ 9kg/ha	8.38	19.73	27.96	50.82	74.61	102.40	20.32
T ₄ Cow dung @ 6 ton/ha+micro algae 5kg/ha	8.25	17.90	26.83	54.24	80.97	106.58	21.07
T ₅ Goat manure @3 ton/ha+ microalgae@5kg/ha	7.47	17.65	26.71	55.03	83.22	111.89	22.50
T ₆ Cow dung@6 ton/ha + micro algae @ 2.5kg/ha + goat manure@3ton/ha	5.66	12.67	23.50	62.29	90.48	117.31	23.45
F-test	S	S	S	S	S	S	S
S.Ed (±)	1.35	1.18	1.12	1.16	1.13	1.01	0.44
CD at 5%	2.97	2.59	2.45	2.52	2.46	2.20	0.96

(Rs.41520/ha,12766/ha and 1:0.44, respectively) and Untreated control T₀ – (Rs.33990/ha, 5290/ha and 1:0.18, respectively).

The results revealed that amendments cow dung + goat manure + microalgae were found to produce significantly superior outcomes as seen in the form of maximum plant growth parameters and minimum disease intensity of *Alternaria* leaf spot of quinoa (*Alternaria* spp.). The probable reasons for such findings may be that organic manure causes slow release of macro and micronutrients in the soil, which is beneficial for growing healthy plants. Cow dung comprises of 0.25 per cent nitrogen, 0.5 per cent phosphorus and 0.25 per cent potash whereas goat manure contains 3 per cent nitrogen, 1 per cent phosphorus and 2 per cent potash. The goat manure can provide higher nutrients than even farmyard manure and compost. Also, humic and fulvic acid like substances, formed by the humification of organic manure during decomposition have high potential for improving plant growth. They also promote nitrate uptake in plants as suggested by Park *et al.* (2019).

Organic manure helps to increase the population of soil micro-organisms which have some influence in protecting plant against pathogens and also provides plant growth hormones like auxins. The application of organic manure has thus been found to be effective in increasing plant height, number of branches and number of leaves as also seen in reports by Usman (2015). Additionally, investigations done by Basak and Lee (2002) and Mary *et al.* (1986) have suggested that organic manures reduce disease incidence caused by a wide range of plant pathogens. Studies on the use of microalgae have shown positive effect on plant growth.

This is likely due to the presence of several molecules such as plant growth hormones (cytokinins, auxins, abscisic and gibberellic acid), polysaccharides, betaines and micronutrients. Among biotic stresses, microalgae showed antifungal activity against different pathogens of plants. Microalgae are thus being used in agriculture as soil amendment for their beneficial effects on plant health and productivity. Similar findings have been reported by Righini and Roberti (2019) and Kempenaar *et al.* (1996). It has been concluded is Cow dung@6ton/ha + microalgae@2.5kg/ha + goat manure@3ton/ha recorded minimum disease intensity of leaf spot caused by *Alternaria* spp. In Quinoa (*Chenopodium quinoa* Willd). It also recorded maximum plant height (cm), number of branches, number of leaves, yield (q/ha) and highest cost benefit ratio. The results of the present study are limited to one crop season (November 2019 to March 2020) under Prayagraj agroclimatic conditions as such to validate the findings more such trials should be taken up in future.

References

1. Basak, A.B., Lee, M.W. And Lee, T.S. (2002). In vitro inhibitory activity of cow urine and dung to *Fusarium solani* f. sp. *cucurbitae*. *Mycobiology*. 30(1): 51-54.
2. Jan, R.I, Saxena¹ D.C. and Singh I.S. (2015). Physico-chemical and textural property of starch isolated from *Chenopodium* (*Chenopodium album*) grains. *Food science & technology* 1: 1095052
3. Kempenaar, C., Wannigen, R. and Scheepens, P.C. (1996). Control of *Chenopodium album* by soil application of *Ascochyta caulina* under greenhouse conditions. *Annals of applied biology*. 129(2): 343-354.
4. Mary, C.A., Dev, V.P.S. And Karunakaran, K. (1986). Cow dung extract for controlling bacterial blight (BB)[India]. International Rice Research Newsletter (Philippines)

5. Park, J., Cho, K.H., Ligaray, M. And Choi, M.J. (2019). Organic matter composition of manure and its potential impact on plant growth. *Sustainability*, 11(8): 2346.
6. Pitzschke, A., (2016). Developmental Peculiarities and Seed-Borne Endophytes in Quinoa: Omnipresent, Robust Bacilli Contribute to Plant Fitness. *Frontiers in Microbiology* 7:2. Doi: 10.3389/fmicb.2016.00002.
7. Righini, H. And Roberti, R. (2019). Algae and Cyanobacteria as Biocontrol Agents of Fungal Plant Pathogens. In *Plant Microbe Interface*. 219-238. Springer, Cham.
8. Ruales, J., and Nair, B.M. (1992). Nutritional quality of the protein in quinoa *Chenopodium quinoa*. Willd seeds. *Plant Foods Hum. Nutr.* 42, 1–11. doi: 10.1007/BF02196067
9. Siddiqui, I., Bajwa, R. And Javaid, A. (2009). A new foliar fungal pathogen, *Alternaria alternata* isolated from *Chenopodium album* in Pakistan. *Pakistan Journal of Botanical*. 41(3): 1437-1438.
10. Usman, M. (2015). Cow dung, goat and poultry manure and their effects on the average yields and growth parameters of tomato crop. *Journal of biology, agriculture and healthcare* . 5(5): 7-10.
11. Yao, C., and Köller, W. (1994). Diversity of cutinases from plant pathogenic fungi: cloning and characterization of a cutinase gene from *Alternaria brassicicola*. *Physiological and molecular plant pathology*, 44(2): 81-92.



Path Analysis for Bulb Yield and its Components in Garlic (*Allium sativum* L.) Genotypes

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Abstract

The present investigation was conducted to estimate path analysis among 24 genotypes of garlic for fifteen characters comprised of bulb yield and its contributing characters. These genotypes were planted in Randomized Block Design with three replications during Rabi season, 2019-20 at SKN College of Agriculture, Jobner. Path coefficient analysis revealed that characters viz. bulb weight, number of leaves, clove weight, clove girth, equatorial diameter, chlorophyll content, TSS, neck thickness, pyruvic acid and cloves per bulb had positive direct effect on bulb yield. Results obtained from the present study based on path analysis revealed that selection programme based on bulb weight, clove weight, equatorial diameter, clove girth, polar diameter might prove effective in enhancing productivity level in garlic.

Key words : *Allium sativum*, garlic, path analysis, bulb.

Introduction

Garlic (*Allium sativum* L.), is an asexually propagated and most widely cultivated bulb crop after onion with diploid chromosome number 16 ($2n=2x=16$) belongs to family Amaryllidaceae (Allen, 2009). The primary centre of origin of garlic is Central Asia whereas Mediterranean region is considered as its secondary centre of origin (Brewster, 1994)⁵. The progenitor of cultivated garlic is *Allium longicuspis* which is a herbaceous annual for the bulb production. Botanically, economic part of garlic is a compound bulb made up of numerous smaller bulbs called cloves. Garlic bulb does not store food, instead matures as dry scales enclosing cloves which are well developed axillary buds within foliage leaves. Path analysis is helpful in choosing the characters that have direct and indirect effects on yield. Such a study may be useful in effective selection and simultaneous improvement of the component characters which contribute towards yield.

Materials and Methods

The experiment was laid out at Horticulture farm, SKN College of Agriculture, Jobner (Jaipur) (Rajasthan). during "rabi" season of 2019-20. Twenty-four genotypes of garlic used in the present experiment were collected from NHRDE, Karnal, HAU, Hissar and CHF, Jhalawar. The experiment was laid out in randomized complete block design with three replications and each replication consisting of twenty-four genotypes. The seeds material (cloves) were planted in row at 15 cm apart by hand dibbling method and spacing within the row was maintained, 10 cm. The standard cultural practices as

mentioned in package of Practices for Vegetables crops by Thamburaj and Singh were followed to raise the healthy crop stand. Five plants were randomly selected from each genotype and following observations were recorded for plant height, leaves per plant, chlorophyll content, equatorial diameter, polar diameter, neck thickness, clove length, clove girth, cloves per bulb, clove weight, bulb weight, days to maturity, bulb yield, TSS & pyruvic acid content in garlic bulb. The direct and indirect effects were estimated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

The path coefficient analysis was carried out for different yield contributing characters of garlic viz., plant height at 75 DAP (cm), leaves per plant at 75 DAP, chlorophyll content at 60 DAP (mg/g), equatorial diameter (cm), polar diameter (cm), neck thickness (cm), clove length (cm), clove girth (cm), cloves per bulb, clove weight (g), bulb weight (g), days to maturity, bulb yield (q/ha), TSS (%) & Pyruvic acid content (μ moles/g). In this investigation the bulb yield/ha was considered as dependent variable and the remaining fourteen characters were considered as independent variables. The results of various causes influencing bulb yield are presented in Table-1 and 2 at phenotypic and genotypic levels.

The results of path coefficient analysis indicated that at the phenotypic level (Table-1), the maximum direct positive effect on bulb yield was bulb weight (0.539) followed by clove weight (0.453), number of leaves (0.293), clove girth (0.203), equatorial diameter (0.173), chlorophyll content (0.136), TSS content (0.043) and neck

Table-1 : Phenotypic path coefficient analysis showing direct (diagonal) and indirect (Non diagonal) effects of 15 characters on bulb yield of garlic.

Characters	PH	LP	CC	ED	PD	NT	CL	CG	CPB	CW	BW	DM	TSS	PA	Correlation with bulb yield
PH	-0.0163	0.090	0.054	0.012	-0.017	-0.0004	-0.016	-0.045	0.005	0.042	-0.014	-0.001	-0.002	-0.045	0.048
LP	-0.0050	0.293	0.034	0.036	-0.038	0.0010	-0.032	-0.002	0.002	-0.008	-0.007	-0.014	0.001	0.020	0.282*
CC	-0.0065	0.073	0.136	0.032	-0.051	-0.0006	-0.012	0.014	0.000	0.037	0.008	0.001	0.005	-0.037	0.198
ED	-0.0011	0.060	0.025	0.173	-0.046	0.0018	-0.046	0.033	-0.006	0.074	0.057	0.008	0.010	0.018	0.362**
PD	-0.0025	0.100	0.062	0.071	-0.111	0.0012	-0.080	0.072	-0.010	0.054	0.066	-0.013	0.001	-0.066	0.144*
NT	0.0011	0.055	-0.016	0.059	-0.025	0.0054	-0.070	0.074	-0.007	0.018	0.031	-0.003	0.009	0.038	0.170
CL	-0.0011	0.041	0.007	0.035	-0.039	0.0016	-0.228	0.103	-0.007	0.043	0.046	0.024	0.014	-0.104	-0.066
CG	0.0036	-0.002	0.009	0.028	-0.039	0.0020	-0.116	0.203	-0.002	0.155	0.075	-0.001	0.013	-0.070	0.258*
CPB	0.0025	-0.022	0.002	0.035	-0.036	0.0011	-0.049	0.012	-0.032	-0.259	0.045	-0.004	0.004	0.089	0.213*
CW	-0.0015	-0.005	0.011	0.028	-0.013	0.0002	-0.021	0.070	0.018	0.453	0.156	0.017	0.004	-0.150	0.466**
BW	0.0016	-0.014	0.008	0.071	-0.053	0.0012	-0.076	0.109	-0.010	0.183	0.539	0.024	0.013	-0.065	0.757**
DM	-0.0001	0.026	-0.001	-0.009	-0.009	0.0001	0.034	0.001	-0.001	-0.049	-0.021	-0.159	-0.014	0.037	-0.166
TSS	0.0006	0.008	0.016	0.040	-0.004	0.0011	-0.075	0.061	-0.003	0.038	0.042	0.052	0.043	0.010	0.232
PA	-0.0023	-0.018	0.015	-0.010	-0.023	-0.0006	-0.074	0.044	0.009	0.211	0.028	0.018	-0.001	-0.323	-0.126

* and ** refers to significant at P = 0.05 and P = 0.01, respectively.

PH-Plant Height at 75 DAP (cm),
 ED- Equatorial Diameter (cm),
 CL-Clove Length (cm),
 CW-Clove Weight (g),
 TSS-Total Soluble Solid (%),
 LP-Leaves per Plant at 75 DAP,
 PD-Polar Diameter (cm),
 CG-Clove Girth (cm)
 BW-Bulb Weight (g),
 PA-Pyruvic Acid (μ moles/g),
 CC-Chlorophyll Content (mg/g) at 60 DAP,
 NT-Neck Thickness (cm),
 CPB-Cloves Per Bulb,
 DM-Days to Maturity,
 BY-Bulb Yield (q/ha).

Table-2 : Genotypic path coefficient analysis showing direct (diagonal) and indirect (Non diagonal) effects of 15 characters on bulb yield of garlic.

Characters	PH	LP	CC	ED	PD	NT	CL	CG	CPB	CW	BW	DM	TSS	PA	Correlation with bulb yield
PH	-0.0268	0.196	0.152	0.008	-0.088	0.011	-0.027	-0.098	-0.023	0.045	-0.056	0.007	0.009	-0.055	0.052
LP	-0.0090	0.586	0.097	0.027	-0.230	-0.034	-0.060	0.016	-0.007	-0.004	-0.014	-0.084	-0.007	0.023	0.301*
CC	-0.0112	0.156	0.365	0.023	-0.273	0.017	-0.022	0.016	0.004	0.035	0.028	-0.006	-0.030	-0.044	0.256*
ED	-0.0018	0.140	0.073	0.114	-0.228	-0.047	-0.077	0.100	0.026	0.084	0.211	0.041	-0.055	0.028	0.407**
PD	-0.0043	0.246	0.181	0.047	-0.548	-0.029	-0.133	0.156	0.043	0.052	0.253	-0.016	-0.017	-0.085	0.148*
NT	0.0022	0.148	-0.048	0.040	-0.120	-0.134	-0.103	0.184	0.018	0.012	0.098	0.037	-0.061	0.051	0.126
CL	-0.0021	0.103	0.024	0.026	-0.213	-0.040	-0.341	0.217	0.024	0.044	0.184	0.089	-0.098	-0.129	-0.113
CG	0.0064	0.023	0.014	0.028	-0.208	-0.060	-0.180	0.410	0.010	0.193	0.273	0.011	-0.097	-0.091	0.332**
CPB	0.0053	-0.035	0.011	0.025	-0.202	-0.021	-0.068	0.033	0.118	-0.319	0.160	-0.004	-0.069	0.118	0.248*
CW	-0.0026	-0.005	0.028	0.021	-0.063	-0.004	-0.033	0.175	-0.083	0.454	0.227	0.101	-0.036	-0.184	0.597**
BW	0.0034	-0.019	0.023	0.055	-0.316	-0.030	-0.143	0.255	0.043	0.235	0.740	0.096	-0.097	-0.096	0.929**
DM	0.0005	0.131	0.006	-0.013	-0.023	0.013	0.081	-0.012	0.001	-0.122	-0.113	-0.376	0.093	0.059	-0.273*
TSS	0.0010	0.018	0.046	0.026	-0.038	-0.034	-0.138	0.164	0.034	0.067	0.177	0.145	-0.242	0.021	0.246*
PA	-0.0039	-0.035	0.043	-0.008	-0.122	0.018	-0.116	0.099	-0.037	0.220	0.112	0.059	0.013	-0.379	-0.139

* and ** refers to significant at P = 0.05 and P = 0.01, respectively.

PH-Plant Height at 75DAP (cm),
 ED- Equatorial Diameter (cm),
 CL-Clove Length (cm),
 CW-Clove Weight (g),
 TSS-Total Soluble Solid (%),
 LP-Leaves per Plant at 75 DAP,
 PD-Polar Diameter (cm),
 CG-Clove Girth (cm)
 BW-Bulb Weight (g),
 PA-Pyruvic Acid (μ moles/g),
 CC-Chlorophyll Content (mg/g) at 60 DAP,
 NT-Neck Thickness (cm),
 CPB-Cloves Per Bulb,
 DM-Days to Maturity,
 BY-Bulb Yield (q/ha).

thickness (0.0054). The maximum negative direct effect on bulb yield was exerted by pyruvic acid (0.323) followed by clove length (-0.228), days to maturity (-0.159) polar diameter (-0.111), cloves per bulb (-0.032) & plant height (-0.0163).

The results of path coefficient analysis also indicated that at the genotypic level (Table-2), the maximum direct positive effect on bulb yield was bulb weight (0.740) followed by number of leaves (0.586), clove weight (0.454), clove girth (0.410), chlorophyll content (0.365), cloves per bulb (0.118), and equatorial diameter (0.114). The maximum negative direct effect on bulb yield was exerted by polar diameter (-0.548) followed by pyruvic acid (-0.379), days to maturity (-0.376), clove length (-0.341), TSS content (-0.242) neck thickness (-0.134) and plant height (-0.0268).

The path coefficient analysis revealed that the maximum direct positive effect on bulb yield was noted by bulb weight followed by number of leaves, clove weight, clove girth, equatorial diameter, chlorophyll content, TSS content, neck thickness and cloves per bulb. Hence its result confirmed the role of these characters in determining the bulb yield and these characters are important in constructing selection criteria.

The positive direct effects of bulb weight, cloves per bulb, clove girth, equatorial diameter was observed for bulb yield of garlic. Similar results were also reported by Agarwal and Tiwari (2009); Kassahun *et al.* (2010); Awale *et al.* (2011); Dewangan and Sahu (2012); Patil *et al.* (2012); Sonkiya *et al.* (2012); Dhall and Brar (2013); Pervin *et al.* (2014); Ijaz *et al.* (2015); Prajapati *et al.* (2016); Pyasi and Tiwari (2016); Raja *et al.* (2018) and Yadav *et al.* (2018) or clove equatorial diameter the maximum positive direct effect followed by weight of 50 cloves, cloves per bulb and leaves per plant were reported by Singh *et al.* (2011).

The highest negative direct effects were recorded for days to maturity, clove length, neck thickness and plant height by Singh *et al.* (2011) and Bhatt *et al.* (2017); However, highest negative direct effect for bulb polar diameter was suggested by Prajapati *et al.* (2016).

Conclusions

Path coefficient analysis revealed that bulb weight, number of leaves, clove weight, clove girth, equatorial diameter, chlorophyll content, TSS, neck thickness and cloves per bulb were found the important contributing characters for bulb yield of garlic because these characters had high and direct effect on bulb yield. Based on the path analysis study, it is inferred that bulb weight, number of leaves, clove weight, clove girth and equatorial diameter are the important yield attributing characters.

References

- Agarwal, A. and Tiwari, R.S. 2009. Character association and path analysis in garlic. *Vegetable Science*, 36: 69-73.
- Allen. 2009. Garlic production factsheet, Garlic production, order number 97-007. www.omafr.gov.on.ca/english/crops/facts/09-011w.htm
- Awale, D., Sentayehu, A. and Getachew, T. 2011. Genetic variability and association of bulb yield and related traits in shallot (*Allium cepa* var. *aggregatum*) in Ethiopia. *International Journal of Agricultural Research*, 6 (7): 517-536.
- Bhatt, B., Sonil, K.A., Jangid, K. and Kumar, S. 2017. Path coefficient analysis in promising indigenous genotypes of garlic (*Allium sativum* L.). *International Journal of Pure and Applied Bioscience*, 5: 679-686.
- Brewster, J. 1994. Onions and other vegetable Alliums. *Horticultural Research International*, Wellesbourne, Warwick, UK University press, Cambridge. 83-125.
- Dewangan, S.R. and Sahu, G.D. (2012). Path coefficient analysis of different Kharif onion genotypes in Chhattisgarh plains. *Indian Horticulture Journal*, 9 (1-2): 9-12.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of crested wheat grass seed production. *Agronomy Journal*, 51(5): 515-518.
- Dhall, R.K. and Brar, P.S. 2013. Path coefficient studies in garlic (*Allium sativum* L.). *Vegetable Science*, 40: 102-110.
- Ijaz, U., Smi, U., Tahir, I.S., Muhammad, N. and Shahid, N. 2015. Genetic association and assessment of variability in garlic (*Allium sativum* L.). *International Journal of Vegetable Science*, 21: 141-147.
- Kassahun, T., Tiwari, A. and Woldetsadik, K. 2010. Path coefficient among bulb yield and yield traits in Ethiopian garlic germplasm. *Indian Journal of Horticulture*, 67: 489-499.
- Patil, B.T., Gidmare, P.P., Bhalekar, M.N. and Shinde, K.G. 2012. Path coefficient studies in garlic (*Allium sativum* L.). *Vegetable Science*, 39: 98-100.
- Pervin, M., Kamrul, H.M., Hassan, K. and Hoque, AKMA. 2014. Genetic variation of indigenous, improved and exotic garlic (*Allium sativum* L.) germplasm. *Advances in Plant and Agriculture Research*, 1: 48-49.
- Prajapati, S.K., Tiwari, A., Prajapati, S., Singh, Y. and Verma, N.R. 2016. Path coefficient analysis in garlic (*Allium sativum* L.). *Hortiflora Research Spectrum*, 5: 183-188.
- Pyasi, R. and Tiwari, A. 2016. Genetic variability and character association for yield and its component traits in kharif onion genotypes. *International Journal of Basic and Applied Agricultural Research*, 14(1): 43-49.
- Raja, H., Ram, N.C., Yadav, S., Sriom, Jain, A. and Maurya, R. 2018. Studies on correlation coefficients among yield and its contributing traits in garlic (*Allium sativum* L.). *International Journal of Chemical Studies*, 6: 2470-2472.
- Singh, K.R., Dubey, B.K., Bhonde, R.S. and Gupta, P.R. 2011. Path coefficient studies in garlic (*Allium sativum* L.). *Journal of Spices and Aromatic Crops*, 20: 81-85.
- Sonkiya, A.K., Singh, P.P. and Naruka, I.S. 2012. Path coefficient analysis in garlic (*Allium sativum* L.). *Journal of Medicinal Plants*, 4: 291-296.
- Wright, S. 1921. Correlation and causation. *Agriculture Research*, 20: 557-585.
- Yadav, S., Pandey, P.V., Maurya, R.S., Jain, Akshay. 2018. Studies of genetic variability and correlation among the characters of different genotypes of garlic (*Allium sativum* L.). *International Journal of Chemical Studies*, 6: 128-130.



Stability Analysis in Wheat (*Triticum aestivum* L.)

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Abstract

The present experiment conducted with forty genotypes of wheat by using Eberhart and Russell (1966) model for days to 50% heading, days to maturity (days), plant height (cm), spikelets per spike, effective tillers per plant, 1000 grain weight (g), seed yield per hectare (q), biological yield per hectare (q) and harvest index in three farming conditions where date of sowing during Rabi- 2020-21 viz. 9th Nov. (Restricted irrigation), 20th Nov. (Irrigated timely sown) and 25th Dec. (Irrigate late sown) at All India Co-ordinated Wheat Improvement Project, B.T.C. College of Agriculture and Research Station, Bilaspur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The variances due to genotypes was found significant revealed the presence of genetic variability for all the characters under study. Differences due to Genotype × Environment were also found highly significant for all the study traits, indicates that genotypes interacted considerably to environmental conditions in different environments. The genotype Chhattisgarh Hansa wheat (CG 1023), Kanishka (CG 1029), CG 1036, CG 1040 and CG 2022 were stable having high mean performance, non-significant regression coefficient deviation from unity ($b_i=1$) and non-significant deviation from zero ($S^2d=0$) in term of grain yield per hectare. Hence, in term of grain yield per hectare CG-1029 can be considered the most stable and adopted to all environments compared to other stable genotypes.

Introduction

Wheat (*Triticum aestivum* L.) ($2n=6x=42$ Hexaploid) is a self-pollinated crop belongs to true grass (Poaceae) family and one of the most consumed cereal crop. Wheat is a second most important stable food crop of the world after rice crop. Wheat contributes up to 20% of total food calories and protein to the people on national. It is also known as “King of cereals” for its good quality, high productivity and uses. In India, wheat covers an area of 31.45 million ha, with total production of 107.59 million tonnes per ha and productivity 3421 kg per ha (Anonymous, 2019-20). In Chhattisgarh wheat covers an area of 102.19 ('000 ha) with 141.64 ('000 tonnes) of production and 1386 kg/ha productivity (Anonymous, 2019=20). The quality trait and yield of wheat grain is also influence by genotypes, environment and their interaction (G×E). Environment conditions such as drought stress, sowing date, heat stress, etc. Many genotypes may be perform well in certain environment condition but several genotypes falls. To overcome this situation it is necessary to develop and identify of good phenotypically stable genotypes, which can significantly perform over a wide range of environment conditions. Yield is a quantitative character which are controlled by polygenic system and their expression is depend on the genotype and environment interaction and such character are greatly influence by environmental condition. The primary objective of any breeding improvement program is to increase yield stability and improve quality. The yield of the cultivar will be defined as stable when the yield of the

varieties is consistent across different environments. Stability reflects the suitability of a variety for general cultivation over a wide range of environments. Stable performance of wheat genotypes in different environments is critical to the maintenance of food production. There are two possible strategies for the development of genotype with limited magnitude of genotype × environment interaction. The first is the development of a variety for a specific environmental condition and the second strategy to reduce genotype × environmental interaction with better stability across a wide range of environmental conditions. The basic variation between genotypes and in there yield is the broad occurrence of interaction between genotype and environments. The present experiment was conduct for restricted irrigation, irrigated timely sown and irrigated late sown late condition in rabi season 2020-2021. Testing the stability of genotypes and estimating the genotype × environment (G × E) interaction Eberhart and Russell (1966) [5] models were used.

Materials and Methods

Thirty three genotypes of wheat along with seven checks were evaluated in Randomize Block Design with 2 replications during Rabi- 2020-21 viz. 9th Nov. (restricted irrigated), 30th Nov. (irrigated timely sown) and 25th Dec. (irrigated late sown) at All India Co-ordinated Wheat Improvement Project, B.T.C. College of Agriculture and Research Station, Bilaspur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Each genotype was grown in a plot size 6 X 2.4 meter keeping row to row

spacing of 20 cm. for each plot in each replication. Data were recorded on 9 traits viz. days to 50% heading (day), days to maturity (day), plant height (cm), spikelets per spike, effective tillers per plant, 1000 grain weight (g), seed yield per hectare (q), biological yield per hectare (q) and harvest index. Data from the three environments were subjected to stability analysis using the Eberhart and Russell (1966) [5] model. As per the model, three parameters, viz., mean yield over locations or seasons ($\bar{X}$), regression coefficient (bi), and deviation from regression (S^2_{di}) were estimated. Genotypes that proved to be stable for most stability analysis or at least for the yield then selected as the best. According to this model, a regression coefficient (bi) of approximately one coupled with a deviation from regression coefficient (S^2_{di}) least/zero, it implies average stability over different environments.

Results and Discussion

Stability analysis as per Eberhart and Russell (1966) model showed highly significant differences among fourty genotypes for all the 9 characters viz. 50% heading, days to maturity (days), plant height (cm), (cm), spikelets per spike, effective tillers per plant, 1000 grain weight (g), seed yield per hectare (q), biological yield per hectare (q) and harvest index. The studies on estimate of parameters of stability revealed that five genotypes Chhatisgarh hansa wheat, Kanishka, CG 1036, CG 1040 and CG 2022 was stable for all the characters. This is revealing not only the amount of variability that existed among environments but also the presence of genetic variation among the genotypes. It was emphasized that both linear (bi) and non-linear (S^2_{di}) components of G×E interactions are necessary for judging the stability of a genotype. A regression coefficient (bi) of approximately one coupled with a deviation from regression coefficient (S^2_{di}) least/zero, it implies average stability. The value of regression coefficient more than one identify genotype with greater sensitivity to changing environments (below average stability) and higher specificity of adaptability to high yielding environments. A value of regression coefficient less than one contribute a measurement of higher resistance to environmental chances (above average stability) and thus increases the specificity of adaptability to low yielding environments. The analysis of variance as per the Eberhart and Russell (1966) model showed a very significant differences between the forty variety for all characters over three farming conditions. The variances due to environment were also found highly significant for all the studied characters, indicating that the presence of wide variation among environmental conditions used for the evaluation of the materials. Thakur *et al.*, 2019, Krupal *et al.*, 2018, Mut *et al.*, 2010 and Singh

Table-1 : Combined analysis of variance for stability in wheat considering three different environments.

Source	DF	Mean Sum of Square								
		Days to 50 % heading	Days to maturity	Plant height (cm)	Spikelets per spike	1000 grain weight (g)	Number of effective tillers/plant	Seed yield per plot (qt/ ha)	Biological Yield per plot (qt/ha)	Harvest index per plot
Genotypes	39	24.81**	32.94*	116.00**	5.66**	24.04*	2.74**	23.00**	95.21	24.17**
Environments	2	464.70**	397.83*	978.92**	57.53*	72.87*	9.95**	2393.49**	13794.79**	30.72
Genotypes×Environment	78	3.63**	20.42**	19.04*	1.29*	13.46*	1.23**	10.45**	51.83**	11.81**
Env. (Gen. × Env.)	80	15.16**	17.00**	43.03**	2.69**	7.23	0.74	7.04	395.40*	12.28*
Environment (linear)	1	929.41**	795.65*	1957.8**	115.07*	145.7*	19.90**	4786.98**	27589.59**	61.45**
Genotypes × Env. (linear)	39	3.73**	6.85	17.86	1.62**	4.39	0.48	10.69**	57.64**	16.31**
Pooled deviation	40	1.56**	7.43**	14.03	0.74	6.54**	0.52*	5.16	44.87	5.02
Pooled error	117	0.66	0.48	20.74	0.69	2.70	0.34	4.09	9.35	3.51

Significance check of genotype and environment against genotype × environment, env+(gen×env), environment (linear), genotype × env.(linear) check against pooled deviation and pooled deviation check against pooled error at 5% and 1% level of significance* indicate significance at 1% and ** at 5%

et al., 2018 had observed similar results. Differences due to Genotypes $\times$ Environment ($G \times E$) were also found highly significant for all the traits. Present results are in agreement with those of earlier reports of Patel et al., 2014, Amin et al., 2005, Verman et al., 2015. Components analysis of the Environment + (Genotype $\times$ Environment) interaction ($E + (G \times E)$) was found to be highly significant for all the characters except for effective tillers per plant. Similar results was reported for grain yield by Singh et al., 2018, Mekuria et al., 2018, Kabir et al., 2009. Genotype $\times$ Environment (linear) variances was significant for days to heading, spikelets per spike, seed yield (q/ha), 1000 grain weight, harvest index and biological yield (q/ha). Mean square due to pooled deviation was found significant for all characters except plant height, spikelets per spike indicating greater role of non-predictable components in genotypes $\times$ environment interaction. Thus, both linear and non-linear components were useful for determining the stability in the current study. Similar results reported for days to 50% heading and spike length by Thakur et al., 2019; Pansuriya et al., 2014; Verman et al., 2015 and Gulzar et al., 2015. When the genotypes were grouped according to stability parameters as Eberhart and Russell model (1966), it was found that genotype CG 1707, CG 2001, CG 2005, CG 2022, GW 322 and CG 104 for days to 50% heading, genotype CG 1923, CG 1804-2, CG 2002, CG 2021 and CG 1029 for days to maturity, genotype CG 2022, SAWSN-3005, CG 1023 and CG 1040 for seed yield (q/ha) and genotype CG 2023, OS-484, CG 1023 and CG 1311-6 for tillers per plant were found average response to environment and stable in all farming condition. Similar results were obtained by Pujer et al., 2020, Haydar et al., 2018, Singh et al., 2018, Jhinjer et al., 2017, Polat et al., 2016, Verman et al., 2015.

Conclusions

Chhattisgarh hansa wheat (CG 1023), Kanishka (CG 1029), CG 1036, CG 1040 and CG 2022 having high mean performance, non-significant regression coefficient deviation from unity ($b_i=1$) and non-significant deviation from zero ($S^2d=0$) in term of grain yield per hectare. Hence, in term of grain yield per hectare CG 1029 can be considered the most stable and adopted to all environments compared to other stable genotypes. Therefore, it could be included in the hybridization program to converge the stability characteristics of grain yield for the development of stable cultivar adapted to a wide range of environments.

References

- Amin M, Mohammad T, Khan AJ, Irfaq M, Ali A, Tahir GR. Yield stability of spring wheat (*Triticum aestivum* L.) in the North West Frontier Province, *Pak. J. Sci. Tech.*, 2005; 27(6): 1147-1150.
- Anonymous, Ministry of Agriculture and Farmer Welfare, Government of India, 2019-20.
- Anonymous, ACRIP on Wheat and Barley, Progress Report. *Crop Improvement*, 2019-20, 1.
- Arain MA, Alisial M, Rajput MA, Mirbahar AA. Yield stability in bread wheat genotypes. *Pak. J. Bot.* 2011; 43(4): 2071-2074.
- Eberhart SA, Russell WA. Stability parameter for comparing varieties. *Crop Sci.* 1966; 6: 36-40.
- Gulzar S, Kamaluddin, Bhatt MA, Yusuf N, Khan MA. Stability analysis for yield, yield component and quality traits in wheat (*Triticum aestivum* L.) under temperate conditions in Kashmir valley. *Plant Archives.* 2015; 15(1): 433-440.
- Hayder FMA, Uddin MN, Roy UK, Uddin GM, Siddique AB. Stability analysis of yield performance in wheat (*Triticum aestivum* L.). *Pl. Environ. Dev.* 2018; 7(2): 10-15.
- Jhinjer RK, Mavi GS, Malhotra A, Sood N, Singh B, Kaur B. Stability Analysis for Grain Yield and Micronutrients in Bread Wheat Genotypes. *Adv. in Res.* 2017; 11(1): 1-8.
- Kabir MR, Hossain A, Rahman MM, Hakim MA, Saker MAZ. Stability analysis of wheat for grain yield affected by different environment. *Bangladesh Res. Publ. J.* 2009; 3(1): 833-840.
- Krupal SM, Rathod ST, Kamble BG. Stability analysis for yield and quality traits in wheat (*Triticum aestivum* L.). *Electron. J. Plant Breed.* 2018; 9(1): 160-168.
- Mekuria T, Wasihun L, Shitaye H. Stability analysis of durum wheat (*Triticum durum* Desf.) genotypes by regression measurement in Ethiopia. *Int. J. of Adv. in Sci. Res. and Engr.* 2018; 4(8): 132-138.
- Mut Z, Aydin N, Bayramoglu HO, Hasan O. Stability of some quality traits in bread wheat (*Triticum aestivum* L.) genotypes. *J. Environ. Biol.*, 2010; 31(4):489-495.
- Pansuriya AG, Dhaduk LK, Patel MB, Vanpariya LG, Savaliya JJ, Madariya RB. Stability analysis for grain yield and its components in bread wheat (*Triticum aestivum* L.). *Int. J. Electron.* 2014; 3(1): 62-67.
- Patel BC, Rojasara YM, Akbari VR, Patel JA. Stability analysis for grain yield in bread wheat (*Triticum aestivum* L.) for irrigated ecosystems. *J. of Wheat Res.* 2014; 6(2):160-162.
- Polat PO, Cifci EA, Yagdi K. Stability performance of bread wheat (*Triticum aestivum* L.) lines. *J. Agri. Sci. Tech.* 2016; 18(2): 553-560.
- Pujer S, Naik VR, Biradar SS, Uday G. Stability analysis to study the effects of different date of sowing on grain yield performance in wheat (*Triticum* sp.). *Int. J. Curr. Microbiol. App. Sci.* 2020; 9(5): 2319-7706.
- Singh C, Srivastava P, Sharma A, Kumar P, Chhuneja P, Sohu VS. Stability analysis for grain yield and some quality traits in bread wheat (*Triticum aestivum* L.). *J. of App. and Natural Sci.* 2018; 10(1): 466-474.
- Thakur P, Prasad LC, Prasad R, Omprakh, Chandra K, Rashmi K. Stability analysis for yield and related traits over four environments in wheat (*Triticum aestivum* L.). *Plant Archives.* 2019; 19(2): 3541-3545.
- Verman M, Jatav SK, Gautam A. Phenotypic stability over different sowing times in wheat. *Annals of Plant and Soil Res.* 2015; 17(3): 292-295.



Nutrient Uptake Studies in Barley (*Hordeum vulgare* L.) as affected by NP Fertilization and Zinc Nutrition under Southern Rajasthan

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Abstract

A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *rabi*, 2017-18 on sandy clay loam soil to evaluate the effect of NP levels and zinc nutrition on nutrient uptake by barley under southern Rajasthan. The experiment consisted of 12 treatment combinations comprises of four NP levels (75% RDF = 45 kg N and 15 kg P₂O₅ ha⁻¹, 100% RDF = 60 kg N and 20 kg P₂O₅ ha⁻¹, 125% RDF = 75 kg N and 25 kg P₂O₅ ha⁻¹ and 150% RDF = 90 kg N and 30 kg P₂O₅ ha⁻¹) and three zinc levels (1.0, 2.50 and 5.00 kg ha⁻¹). These treatments were tested in a Factorial Randomized Block Design (FRBD) with three replications. Application of 125% NP level (75 kg N and 25 kg P₂O₅ ha⁻¹) recorded significantly higher grain, straw and biological yield and net return and BC ratio, NPK and Zn uptake by grain, straw and total uptake by the crop over 100 and 75% and it was found statistically at par with 150% NP level. Application of 125% NP level (75 kg N and 25 kg P₂O₅ ha⁻¹) recorded significantly higher grain, net return, and total NPK and Zn uptake by 43.08, 88.46, 53.91, 53.33, 48.62 and 51.86 percent, respectively over 75% NP level. The crop fertilized with 5.0 and 2.50 kg zinc ha⁻¹ with significant difference between these two increased grain, straw and biological yield and net return and BC ratio, NPK and Zn uptake by grain, straw and total uptake by the crop over unfertilized control and it was registering 22.21, 26.05, 39.41, 27.52, 27.61, 28.45 and 32.66 % over control, respectively by application of 5.0 kg zinc ha⁻¹.

Key words : Barley, NP level, Zn level, NPK and Zn content, uptake, yield and economics.

Introduction

Barley (*Hordeum vulgare* L.) is a valuable cereal crop, grown for several purposes such as food for human being and feed for cattle and poultry birds. Besides these conventional uses, it is an important industrial crop, used as a raw material for beer, whisky and brewing industries. In India, the crop occupied nearly 0.68 lakh hectares area, producing nearly 17.88 lakh tons grain with a productivity of 2641 kg/ha (United States Department of Agriculture 2018). While in Rajasthan, the crop was cultivated on 2.81 lakh hectares with 8.56 lakh tons of production with the productivity of 3046 kg/ha (Anonymous 2017-18). The average productivity of barley in the state is far behind the attainable yielding of 40-50 q/ha (Choudhary *et al.* 2014). This suggests an ample scope for enhancing productivity of this crop in the zone. Adequate mineral fertilization is considered to be one of the most important prerequisites for enhancing its productivity. Among essential plant nutrients, N and P play the most important role in augmenting agriculture production which is required in the larger quantity of all the mineral nutrients absorbed by plant roots.

With the intensification of agriculture by the use of

high yielding short duration varieties and high analysis fertilizer, the deficiency of micro nutrient in general and zinc in particular has turned out to be an important limiting factor in agriculture. Zinc deficiency is rated as the most wide spread micro nutrient problems in Indian soils as it is deficient in 15 % soils of Indian states (Katyal and Rattan, 1990) and crop like barley has been found to respond zinc application. This indicates that in addition to major nutrients there is need to supply micro nutrient specially zinc to this crop. Wide spread deficiency of zinc leads to low productivity of many crops including barley has been reported in various experiments in different location of India. Zinc malnutrition is a major global health issue associated with cereal-based diets. Agronomic biofortification with zinc aims to provide edible parts of the crop plants with sufficient zinc (Cakmak and Kutman, 2017). Keeping in view these facts, a field experiment "Effect of NP levels and zinc nutrition on morphology, yield attributes and yield of barley under southern Rajasthan condition" has been planned to explore the possibility of better nutrient management using different fertility and zinc levels in this crop and was conducted during *rabi* 2017-18 at the Instructional Farm of Rajasthan College of Agriculture, Udaipur (Rajasthan, India).

Materials and Methods

The field experiment was conducted during *rabi* 2017-18 at the Instructional farm, Rajasthan College of Agriculture, Udaipur which is situated at 24° 34' N latitude and 73° 42' E longitude and altitude of 570.90m above mean sea level. The region falls under agroclimatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. The mean annual rainfall of the region is 637mm, most of which is contributed by south-west monsoon from July to September. Rainfall received during crop season was only 4.20 mm. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.8), medium in available NPK (295.30, 24.50 and 292.70 kg ha⁻¹, respectively) and low in available Zn status (0.58 ppm). The experiment consisted of 12 treatment combinations comprises of four NP levels (75% RDF = 45 kg N and 15 kg P₂O₅ ha⁻¹, 100% RDF = 60 kg N and 20 kg P₂O₅ ha⁻¹, 125% RDF = 75 kg N and 25 kg P₂O₅ ha⁻¹ and 150% RDF = 90 kg N and 30 kg P₂O₅ ha⁻¹) and three zinc levels (1.0, 2.50 and 5.00 kg ha⁻¹). These treatments were tested in a factorial randomized block design (FRBD) having three replications. As per treatment, full dose of phosphorous through DAP and nitrogen through urea after adjusting the amount of nitrogen available from DAP and Zn through zinc sulphate (containing 20% Zn) was applied in two equal splits i.e. at the time of first and second irrigations. The high yielding barley variety RD 2035 (developed from a cross between RD 137 PL101) was sown on 14th November, 2017 in furrows opened at 22.50 cm apart and seeds were placed at a depth of 3-4 cm using seed of 100 kg ha⁻¹. Other agronomic and plant protection measures were adopted as and when crop required crop was harvested on 18th March, 2018. The crop was harvested from individual plots when colour of crop changed to yellowish and plants were fully dried. First of all, plants from border area were harvested and removed out from each plot. Thereafter, plants of net area were harvested, bundled and sundried separately. Dried bundles of each plot were weighed separately to record biological yield and then threshed with power operated small thresher and the produce was winnowed and weighed separately to record grain yield plot⁻¹.

Results and Discussion

NP levels : Data presented in Table-1, 2 and 3 revealed that application of each successive increase in NP levels up to 125% RDF significantly increased grain, straw, biological yield, net return and BC ratio and N, P, K and Zn uptake by grain, straw and total uptake by the crop. Enhancing the nutrient application beyond 125% RDF found statistically at par with other under all the above

parameters. Application of 100, 125 and 125% RDF significantly increased grain yield over 75% RDF (2530 kg ha⁻¹) by 21.34, 43.08, 52.88; straw yield over 75% RDF (3754 kg ha⁻¹) by 22.11, 44.14, 55.43; biological yield over (6284 kg ha⁻¹) by 21.80, 44.14, 54.41, respectively; net return (₹21992 ha⁻¹) by 9620, 19454, 23684 ha⁻¹ higher over 75% RDF and BC ratio (0.89) by 41.57, 82.21 & 96.63 percent, respectively. Application of 125% RDF significantly recorded higher N, P, K and Zn uptake by grain, straw and total uptake over 75% RDF. The corresponding increases by 54.03, 53.35, 53.91, 49.84, 51.58, 50.33, 47.97, 48.81, 48.62, 47.92, 54.70 and 51.86 percent, respectively. Data on NPK and Zn content in soil after harvest of barley influenced non significant effect on these parameters.

The increasing N P levels enhanced the availability of the nutrients in the soil and led to higher nutrient uptake and plant growth. Better plant growth and higher dry matter production in turn resulted into better development of reproductive structures and sink. These findings are in close conformity with the findings of (Pervez *et al.*, 2009 and Gebreslassie and Demoz, 2016). The higher level of N P favourably and significantly enhanced grain, straw and biological yield of the crop over its lower levels. This may possibly due to the reason that grain yield is the function of dry matter accumulation and yield attributes which were significantly improved with higher N P levels. The correlation studies carried out for grain yield (Table 3) with dry matter accumulation and all the yield attributes showed a significant and positive correlation with the corresponding *r* values (*r* = 0.948, 0.898, 0.952, 0.929, 0.975, 0.961) substantiated the facts. From the regression analysis it was observed that a unit increase in dry matter accumulation plant⁻¹ at harvest and yield attributes viz. effective tillers m⁻¹ row length, length of ear, number of grains ear⁻¹, weight of grains ear⁻¹ and weight of 1000 - grains increased the yield of barley by 14.335, 60.164, 1642.660, 113.798, 3051.167 and 216.607 kg ha⁻¹. Higher grain yield at higher N P levels may also be attributed due to higher nutrient availability and uptake by the crop. This has been substantiated by significant and positive correlation between grain yield and total uptake of nitrogen (*r* = 0.994), phosphorous (*r* = 0.996), potassium (*r* = 0.999) and zinc (*r* = 0.998). The results so obtained under varying N P levels corroborate with the findings of (Meena *et al.*, 2016). Significant increase in straw yield with higher levels of N P could be attributed to the enhanced plant growth and dry matter yield, possibly as a result of higher nutrient uptake. Also a regression studies indicate that a unit increase in plant height and dry matter accumulation at harvest significantly increased straw yield by 93.694 and 22.612 kg ha⁻¹,

Treatment	Yield (Kg ha ⁻¹)		Harvest index (%)	Net Return (ha ⁻¹)	B C ratio	Nutrient content							
	Grain	Straw				N (%)		P (%)		K (%)		Zn (ppm)	
						Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
NP levels													
75% RDF	2530	3754	6284	21992	0.89	1.53	0.26	0.36	0.19	0.46	1.25	37.54	34.15
100% RDF	3070	4584	7654	31612	1.26	1.62	0.27	0.37	0.12	0.46	1.27	38.25	35.55
125% RDF	3620	5438	9058	41446	1.62	1.65	0.28	0.38	0.12	0.47	1.28	38.82	36.44
150% RDF	3868	5835	9703	45676	1.75	1.68	0.29	0.38	0.12	0.48	1.31	39.35	36.95
SEm±	107	160	200	1613	0.06	0.014	0.004	0.002	0.001	0.003	0.004	0.18	0.20
CD (P=0.05)	315	470	589	4729	0.18	0.040	0.011	0.006	0.002	0.010	0.013	0.52	0.59
Zinc levels (kg ha ⁻¹)													
0	2931	4327	7257	29173	1.17	1.59	0.27	0.37	0.12	0.46	1.26	37.06	34.72
2.5	3304	4929	8232	35701	1.40	1.62	0.27	0.38	0.12	0.47	1.28	38.76	35.68
5.0	3582	5454	9035	40670	1.57	1.64	0.28	0.38	0.12	0.48	1.29	39.66	36.91
SEm±	93	139	173	1396	0.05	0.012	0.003	0.002	0.001	0.003	0.004	0.15	0.17
CD (P=0.05)	272	407	507	4096	0.16	0.034	0.010	0.005	0.002	0.009	0.011	0.45	0.51

Treatments	Nutrient uptake										Available nitrogen (kg ha ⁻¹)	Available phosphorus (kg ha ⁻¹)	Available potassium (kg ha ⁻¹)	Available zinc (ppm)				
	N (Kg ha ⁻¹)				P (Kg ha ⁻¹)				K (Kg ha ⁻¹)						Zn (g ha ⁻¹)			
	Grain	Straw	Total		Grain	Straw	Total		Grain	Straw					Total		Grain	Straw
NP levels																		
75% RDF	38.74	9.84	48.58	9.21	4.44	13.65	11.57	46.96	58.54	95.12	128.54	223.65	294.70	26.73	289.95	0.68		
100% RDF	49.77	12.34	62.10	11.47	5.55	17.02	14.28	58.23	72.51	117.66	163.37	281.03	295.97	27.32	291.70	0.71		
125% RDF	59.67	15.09	74.77	13.80	6.73	20.52	17.12	69.88	87.00	140.79	198.85	339.64	296.71	27.67	294.45	0.72		
150% RDF	65.07	16.79	81.86	14.94	7.29	22.23	18.67	76.40	95.06	152.56	216.06	368.61	297.98	28.14	296.69	0.74		
SEM±	1.83	0.45	1.89	0.45	0.21	0.54	0.50	2.10	2.23	4.09	6.13	7.69	2.90	0.72	3.05	0.01		
CD (P=0.05)	5.36	1.32	5.54	1.32	0.61	1.57	1.47	6.15	6.53	12.00	17.97	22.56	NS	NS	NS	NS		
Zinc levels (kg ha ⁻¹)																		
0	46.93	11.58	58.50	10.88	5.21	16.08	13.58	54.82	68.40	108.78	150.95	259.73	293.00	26.70	288.53	0.69		
2.5	53.81	13.56	67.37	12.44	6.02	18.46	15.57	63.01	78.58	128.48	176.93	305.41	297.42	27.80	294.03	0.71		
5.0	59.20	15.40	74.60	13.75	6.78	20.52	17.08	70.77	87.86	142.32	202.24	344.56	298.61	27.90	297.03	0.74		
SEM±	1.58	0.39	1.64	0.39	0.18	0.46	0.43	1.82	1.93	3.54	5.31	6.66	2.52	0.63	2.65	0.01		
CD (P=0.05)	4.65	1.15	4.80	1.14	0.53	1.36	1.27	5.33	5.66	10.39	15.57	19.54	NS	NS	NS	0.04		

Table-3 : Correlation coefficient and regression equation showing relationship between independent (X) and dependent (Y) variables on mean basis.

S. No.	Dependent variable (Y)	Independent variable (X)	Correlation coefficient (r)	Regression equation Y= a + bx
1.	DMA at harvest (g)	Plant height at harvest (cm)	0.970**	Y= -99.821 + 4.101X
2.	Grain yield (kg ha ⁻¹)	DMA at harvest (g)	0.948**	Y= -111.06 + 14.335X
3.	Straw yield (kg ha ⁻¹)	DMA at harvest (g)	0.984**	Y= -433.115 + 22.612X
4.	Biological yield (kg ha ⁻¹)	DMA at harvest (g)	0.977**	Y= -544.177 + 36.948X
5.	Grain yield (kg ha ⁻¹)	Plant height at harvest (cm)	0.916**	Y= -523.291 + 58.567X
6.	Biological yield (kg ha ⁻¹)	Plant height at harvest (cm)	0.952**	Y= -291.445 + 152.261X
7.	Grain yield (kg ha ⁻¹)	Effective tillers (m ⁻¹ row length)	0.898**	Y= -226.308 + 60.164X
8.	Grain yield (kg ha ⁻¹)	Length of ear (cm)	0.952**	Y= -5621.248 + 1642.660X
9.	Grain yield (kg ha ⁻¹)	Number of grains ear ⁻¹	0.929**	Y= -2034.028 + 113.798X
10.	Grain yield (kg ha ⁻¹)	Weight of grains ear ⁻¹	0.975**	Y= -1735.023 + 3051.167X
11.	Grain yield (kg ha ⁻¹)	1000-grains weight (g)	0.961**	Y= -4474.624 + 216.607X
12.	Total N uptake (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	0.994**	Y= -11.980 + 0.010X
13.	Total P uptake (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	0.996**	Y= -2.398 + 0.003X
14.	Total K uptake (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	0.999**	Y= -8.530 + 0.011X
15.	Total Zn uptake (g ha ⁻¹)	Biological yield (kg ha ⁻¹)	0.998**	Y= -51.425 + 0.043X
16.	Grain yield (kg ha ⁻¹)	N uptake by grain	0.999**	Y= 498.883 + 52.017X
17.	Grain yield (kg ha ⁻¹)	P uptake by grain	0.999**	Y= 407.876 + 231.822X
18.	Grain yield (kg ha ⁻¹)	K uptake by grain	0.999**	Y= 341.957 + 190.138X
19.	Grain yield (kg ha ⁻¹)	Zinc uptake by grain	0.996**	Y= 425.393 + 22.498X
20.	Grain yield (kg ha ⁻¹)	Total chlorophyll content at 30 DAS (mg g ⁻¹ fresh leaf weight)	0.771**	Y= -7548.565 + 7917.535X
21.	Grain yield (kg ha ⁻¹)	Total chlorophyll content at 60 DAS (mg g ⁻¹ fresh leaf weight)	0.857**	Y= -5699.187 + 8688.099X
22.	Protein content in grain (%)	N content in grain (%)	1.000**	Y= -0.008 + 6.255X
23.	Straw yield (kg ha ⁻¹)	Plant height at harvest (cm)	0.964	Y= -768.155 + 93.694X

**Significant at 1 per cent level of significance.

respectively. Biological yield is a function of grain and straw yield. Thus, significant increase in biological yield with 150% RDF could be ascribed to the increased grain and straw yield. It was well established fact that yields components is outcome of complimentary interaction between vegetative and reproductive growth of a crop. This suggests greater availability of nutrients and metabolites to enhance the growth and development of each reproductive structure which ultimately led to realization of their potential up to higher stage. This has been substantiated by significant and positive correlation between biological yield and total uptake of nitrogen ($r = 0.994$), phosphorus (0.996), potassium (0.999) and zinc (0.998). Such results were also reported by Shafi *et al.* (2011).

Different treatments of N P levels enhanced nitrogen, phosphorus, potassium and zinc content of grain and straw could be ascribed to their greater availability in the soil environment along with extraction and translocation towards plant system. Role of fertilization in improving congenial conditions in plant system for higher extraction of nutrients was well emphasized. It is generally believed that in plant system, extracted nutrients are used for maintaining their critical

concentration which can be used for growth of developing structures. Thus, greater availability of nutrients with increasing N P levels seems to have maintained critical concentration at cellular level, fulfilled their requirement and their efficient translocation towards grain and straw. Similar findings were also reported by Shaktawat & Shekhawat (2010). The nutrient uptake by the crop is mainly dependent on total biomass and nutrient content in crop. The concomitant improvement in both of these components reflected higher accumulation of nutrients. The relationship analysis also narrated positive relation between grain yield and uptake of nitrogen ($r=0.999$), phosphorus ($r=0.999$), potassium ($r=0.999$) and zinc ($r=0.996$) by grain. The result of present investigation is strongly supported by Kumar *et al.* (2011) and Meena *et al.* (2011).

Zinc levels : Data presented in Tables revealed that yields, net returns and BC ratio, NPK and Zn content in grain and straw and their uptake by grain, straw as well as total uptake were significantly increased by 2.50 and 5.00 kg Zn ha⁻¹ compared to control. Application of 2.50 and 5.00 kg Zn ha⁻¹ with significantly difference between these two increased the grain, straw, biological yield, net return, BC ratio, Zn content in grain and straw and NPK Zn uptake

by grain, straw as well as total uptake by crop by a margin of 12.73, 22.21; 13.91, 26.05; 13.44, 24.50; 22.50, 22.38, 39.41; 19.66, 34.19; 4.597.01; 2.77, 6.31; 14.66, 26.15; 17.10, 33.00; 15.16, 27.52; 14.33, 26.38; 15.55, 30.13; 14.80, 27.61; 14.65, 25.77; 14.93, 29.10; 14.88, 28.45; 18.11, 30.83; 17.21, 33.98; 17.59 & 32.66 % higher over control, respectively.

The enhancement in yield attributes might be due to the fact that zinc plays a role in biosynthesis of indole acetic acid (IAA) which in turn resulted in initiation of reproductive parts and partitioning of photosynthesis towards them consequently resulted into better yield. The increase in yield components may also be due to enhanced supply of available zinc to crop through its addition to soil which reflected in better growth & development and ultimately led to enhance yield components and yield of the crop (Dhaliwal *et al.* (2012). Application of zinc in the soil enhances the CEC of roots which in turn enhances absorption of nutrients from the soil. Grains with higher zinc content will have a major effect on seedling vigour which resulted into bigger roots and shoots during early growth consequently more extraction of nutrients from the soil. Thus, favourable influence of zinc on photosynthesis and metabolic process augment the production of photosynthesis and their translocation to different crop parts which ultimately enhanced the content of nutrients in grain and straw of barley. Improvement in zinc content in grain with increased levels of nitrogen, suggesting a synergistic effect of nitrogen on zinc uptake. The enhanced uptake of nitrogen, phosphorus, potassium and zinc seems partly due to their increased content in grain as well as straw along with the enhancement in grain, straw and biological yields. The positive correlation was obtained between total uptake of N ($r = 0.994$), P ($r = 0.996$), K ($r = 0.999$) and Zn ($r = 0.998$) with biological yield (Table 3) in the present investigation. These findings are in conformity with those of Choudhary (2004) who also reported increase in content and uptake of zinc with increase in zinc application. Zinc content of soil at harvest of the crop was significantly influenced due to zinc application probably due to fact that zinc has residual effect in the soil and it continues 4-5 years after its application into the soil. The results corroborate with the findings of Dhaliwal (2012).

References

- Anonymous 2017-18. Agricultural Statistics Division. New Delhi.
- Cakmak, I. 2008. Enrichment of cereal grains with zinc: Agronomy and genetic biofortification. *Plant and Soil* 302: 1-17.
- Cakmak, I. and Kutman, U.B. 2017. Agronomic biofortification of cereals with zinc: a review. *European Journal of Soil Science* (Special Issue Article). Available online at <http://onlinelibrary.wiley.com/doi/10.1111/ejss.12437/full> pp. 1-13.
- Cakmak, I., Ekiz H., Yilmaz, A., Torun, B., Koleli, N., Gultekin, I., Alkan, A. and Eker, S., 1997: Differential response of rye, triticale, bread and durum wheat to zinc deficiency in calcareous soils. *Plant and Soil* 188: 1-10.
- Choudhary S, Yadav LR, Shivran AC and Puniya MM. 2014. Effect of fertilizers and manures with foliar application of iron on barley (*Hordeum vulgare* L.). *Green Farming* 5(1): 41-45.
- Dhaliwal, S. S, Sadana, U.S, Khurana, M.P.S. and Sidhu, S. S. 2012. Enrichment of wheat grains with Zn through ferti-fortification. *Indian Journal Fertilizers* 8: 48-55.
- FAO. 2002. Food barley improvement. (<http://www.fao.org/ag/AGP/AGPC/doc/field/other/act.htm>).
- Gebreslassie, H. B. and Demoz, H. A. 2016. A review on: Effect of phosphorus fertilizer on crop production in Ethiopia. *Journal of Biology, Agriculture and Healthcare*. 6: 117-120.
- Hossain, M.A, Jahiruddin, M. and Khatun, F. 2011. Response of maize (*Zea mays* L.) varieties to zinc fertilization. *Bangladesh Journal of Agricultural Research* 36: 437-447.
- Katyal, J.C. and Rattan, R.K. 1990. Micronutrient use in the nineties. In: Soil Fertility and Fertilizer Use, vol. IV (Ed. V. Kumar *et al.*), IFFCO, New Delhi pp. 119-135.
- Kumar S, Vivek, Rana NS, Kumar R, Naresh RK and Dhyani BP. 2019. Effect of weed and nutrient management on the growth and yield of barley (*Hordeum vulgare* L.) and associated weeds. *International Journal of Current Microbiology and Applied Sciences* 8(2): 993-1001.
- Meena, L.R., Mann, J.S., Jat, H.S., Chand, R. and Karim, S.A. 2011. Response of multi-cut fodder barley (*Hordeum vulgare* L.) to varying levels and N application under semi-arid condition of Rajasthan. *Indian Journal of Agronomy* 81: 344-347.
- Narolia, G.P. 2009. Response of malt barley (*Hordeum vulgare* L.) to levels and scheduling of nitrogen application under varying growing environments. Ph.D. Thesis, Department of Agronomy, SKRAU, Bikaner.
- Pervez, K., Yousuf, M., Imitas, M. and M. Islam. 2009. Response of wheat to foliar and soil application of urea at different growth stages. *Pakistan Journal of Agronomy*, 41: 1197-1204.
- Rajasthan Agricultural Statistics at a Glance. 2015-16. Commissionrate of Agriculture, Jaipur, Rajasthan
- Shafi, M., Bakht.J., Jalal, F., Khan, M.A. and khattak. S.G. 2011. Effect of nitrogen application on yield and yield components of barley (*Hordeum vulgare* L.) *Pakistan Journal of Botany* 43: 1471-1475.
- Shaktawat, R.P.S. and Shekhawat, P.S. 2010. Soil fertility status as affected with and without farmyard manure in kharif crops and fertilizer levels in barley (*Hordeum vulgare* L.). *Indian Journal of Agricultural Sciences* 80: 791-794.



Genetic Variability Studies for Yield and its Components in Indian Mustard (*Brassica Juncea* L.)

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Abstract

In the present investigation, variability for 11 agro-morphological traits were estimated among 68 genotypes (50 F₁ hybrids, 10 *mori* CMS, five restorers and three checks) of Indian mustard. Analysis of variance showed highly significant ($P = 0.01$) genotypic difference for all the studied traits. The values of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the studied traits, implying that environmental effects on the studied traits were prominent than genotypic effects. The maximum variability (9.61%) was recorded for number of secondary branches and minimum for days to maturity (0.30%). 1000-seed weight (96.08%) and seed yield per plant (93.49%) had very high broad sense heritability while, genetic advance was relatively high for seed yield per plant (38.98%), number of secondary branches per plant (25.50%) and test weight (20.57%). Principal component analysis revealed that the first six principal components with eigenvalues greater than unity explained 99% of the total variation. PC1, PC2, PC3 and PC4 explained 60.2%, 23.7%, 6.7% and 5% of the total variation, respectively. Three traits viz; number of secondary branches per plant, 1000-seed weight and seed yield per plant exhibited high heritability and high genetic advance indicated that high selection for these traits are effective for seed yield improvement in Indian mustard.

Key words : Genetic advance, coefficient of variance, principal component, variability, heritability.

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important oilseed crop of Indian sub-continent. It belongs to the plant family Brassicaceae (Cruciferae) or the mustard family. India mustard is a natural allotetraploid ($2n=4x=36$, AABB) evolved from natural hybridization between *B. rapa* ($2n=2x = 20$, AA) and *B. nigra* ($2n=2x=16$, BB) (Gaebelein & Mason, 2018). Among nine major oilseed crops grown in different agro-climatic environments of the country, brassica oilseeds is the third most widely grown oilseed crop next to soybean and groundnut. Rapeseed and mustard stands first in vegetable oil production and contribute ~23% to the total vegetable oil of the country (Jat *et al.*, 2019). The domestic demand for edible oils and fats has been increasing rapidly at the rate of 6% per annum, but domestic output has been increasing just by 2% per annum (Renjini & Jha, 2019). Low productivity of oilseed crops is the major reason behind such a huge imbalance between demand and supply of edible oils in India. To meet out the targeted oil requirements, there is an urgent need to further increase the yield potential of this crop. The development of varieties and hybrids with high seed yield and oil content has an important role to fill the gap between oil production and human population (Choudhary *et al.*, 2020). As a consequence of breeding research over a century in this crop, many varieties have been bred, however little information is available about extent of variability and diversity among these varieties. Selection of parents based on genetic diversity and variability estimates may be useful in the selection of suitable

parents for heterosis and pedigree breeding. Therefore, keeping the above background in view the present investigation was undertaken with the objective to estimate genetic variability studies for yield and its components in Indian mustard.

Materials and Methods

In this study, we used 68 Indian mustard genotypes, including 15 parental lines, 50 F₁ hybrids, three genotypes (two varieties; RH 0749/RH 30 and one hybrid; DMH-1) as standard checks (Table-1). All these 68 genotypes were raised in Randomized Block Design (RBD) with three replications during Rabi season, 2018-19 at Oilseeds Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. These genotypes were planted in paired rows plots of 5m length, with an inter-row spacing of 30 cm and an intra-row spacing of 10 cm. All the recommended package and practices were adopted to raise a healthy crop. The data were recorded on plot basis for two traits viz; days to 50% flowering and days to maturity while other nine phenotypic traits viz; plant height, number of primary branches per plant, number of secondary branches per plant, main shoot length, number of siliquae on main shoot, silique length, number of seeds per silique, test weight (g) and seed yield per plant (g) were recorded from the five randomly selected and tagged plants from the centre of each row.

Statistical analysis : The data recorded for each genotype were subjected to statistical analysis. An analysis of variance (ANOVA) was conducted to test

Table-1 : List of 68 Indian mustard genotypes (50 F1s, 3 checks, 10 mori CMS lines and 5 restores).

S.No.	Genotype	S.No.	Genotype	S.No.	Genotype	S.No.	Genotype
1.	MA-1-30 x MR-9	18.	MA-8701 x MR-38	35.	MA-9301 x MR-44	52.	RH-0749
2.	MA-1-30 x MR-31	19.	MA-8701 x MR-43	36.	MA-9518 x MR-9	53.	RH-30
3.	MA-1-30 x MR-38	20.	MA-8701 x MR-44	37.	MA-9518 x MR-31	54.	MA-1-30
4.	MA-1-30 x MR-43	21.	MA-8812 x MR-9	38.	MA-9518 x MR-38	55.	MA-023
5.	MA-1-30 x MR-44	22.	MA-8812 x MR-31	39.	MA-9518 x MR-43	56.	MA-270
6.	MA-023 x MR-9	23.	MA-8812 x MR-38	40.	MA-9518 x MR-44	57.	MA-8701
7.	MA-023 x MR-31	24.	MA-8812 x MR-43	41.	MA-9811 x MR-9	58.	MA-8812
8.	MA-023 x MR-38	25.	MA-8812 x MR-44	42.	MA-9811 x MR-31	59.	MA-9705
9.	MA-023 x MR-43	26.	MA-9705 x MR-9	43.	MA-9811 x MR-38	60.	MA-9301
10.	MA-023 x MR-44	27.	MA-9705 x MR-31	44.	MA-9811 x MR-43	61.	MA-9518
11.	MA-270 x MR-9	28.	MA-9705 x MR-38	45.	MA-9811 x MR-44	62.	MA-9811
12.	MA-270 x MR-31	29.	MA-9705 x MR-43	46.	MA-9702 x MR-9	63.	MA-9702
13.	MA-270 x MR-38	30.	MA-9705 x MR-44	47.	MA-9702 x MR-31	64.	MR-9
14.	MA-270 x MR-43	31.	MA-9301 x MR-9	48.	MA-9702 x MR-38	65.	MR-31
15.	MA-270 x MR-44	32.	MA-9301 x MR-31	49.	MA-9702 x MR-43	66.	MR-38
16.	MA-8701 x MR-9	33.	MA-9301 x MR-38	50.	MA-9702 x MR-44	67.	MR-43
17.	MA-8701 x MR-31	34.	MA-9301 x MR-43	51.	DMH – 1	68.	MR-44

Table-2 : Analysis of variance for yield and component traits in Indian mustard.

Source of variation	DOF	PH	NPB	NSB	MSL	NSMS	SL	NSS	DF	DM	TW	SYP
Replication	2	5.41	0.51	3.22	142.28	45.52	0.02	0.12	3.07	0.05	0.02	2.46
Genotypes	67	397.04**	0.92**	8.91**	162.29**	119.25**	0.47**	4.81**	27.85**	9.36**	0.84**	83.10**
Error	134	11.95	0.20	1.10	23.77	24.54	0.02	0.29	0.46	0.58	0.01	1.88

*Significant at $P = 0.05$ and **Significant at $P = 0.01$; DOF – Degree of Freedom; PH-Plant Height (cm); NPB-No. of Primary Branches; NSB-No. of Secondary Branches; MSL-Main Shoot Length (cm), NSMS-No. of Siliquae on Main Shoot; SL-Siliqua Length (cm); NSS-No. of Seeds/Siliqua; DF-Days to Flowering (50 %); DM-Days to Maturity; TW-1000-Seed Weight (g); SYP-Seed Yield/Plant (g).

significant differences among genotypes (Panse and Sukhatme, 1985). Genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), broad-sense heritability (H^2_{bs}) and genetic advance as percent of the mean (GAM) were calculated according to Singh & Chaudhary (1985). To better understand the correlation between all characters studied with seed yield, principal component analysis (PCA) was performed using a matrix generated from the mean morphological data. All the statistical analysis was performed using OPSTAT Statistical Package (CCS HAU, Hisar).

Results and Discussion

Analysis of variance : Analysis of variance showed highly significant ($P = 0.01$) genotypic difference for all the studied traits (Table-2). This indicated the presence of sufficient level of genetic variability among the evaluated genotypes for seed yield and its component traits, which could be exploited in mustard improvement programs in India. Pandey *et al.* (2020) reported similar findings of significant genetic variability for various yield and its component traits in the 40 Indian mustard genotypes.

Estimation of variance components, heritability and genetic advance : The following parameters, namely coefficient of variance (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance (GA) are usually used to measure genetic variability and to predict the gain under selection (Kingsolver *et al.*, 2001). Estimates of variance components, broad-sense heritability and

genetic advances for seed yield and its component traits are presented in table 3. The extent of variability was estimated in terms of coefficient of variation. The maximum variability (9.61%) was recorded for number of secondary branches and minimum for days to maturity (0.30%). Generally, the values of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all traits, implying that environmental effects on the studied traits were more prominent than genotypic effects. Similar to our study, Kumar *et al.* (2019), Rout *et al.* (2019) and Tripathi *et al.* (2019) were also reported higher PCV values than GCV for yield and its component traits in Indian mustard. Four traits viz; Number of siliquae on main shoot, main shoot length, number of primary branches and number of secondary branches had more differences for PCV and GCV which might be due to the more confounding effect of environment on these traits. Moreover, the GCV and PCV estimates do not confirm the full scope of heritable variation due to masking effect of environment and can be determined more accurately with heritability with genetic advance estimate (Manjeet *et al.*, 2021). Genetic gain or response to selection is depends upon heritability and genetic advances of particular trait. Singh (2001) classified heritability estimates (H^2_{bs}) as low (<40%), moderate (40-59%), moderately high (60-79%) and very high (>80%). In the present study, moderately broad sense heritability values was observed for number of primary branches (54.17%) and number of siliquae on main shoot (56.26%) while, moderately high broad sense

Table-3 : Estimates of different genetic parameters of variation in Indian mustard.

S. No.	Character	Range	CV	GCV	PCV	H ² (bs) %	GAM
1.	PH	150.58 – 216.0	1.70	5.58	5.84	91.47	11.01
2.	NPB	4.03 – 6.66	8.75	9.51	12.92	54.17	14.42
3.	NSB	5.95 – 14.0	9.61	14.76	17.62	70.25	25.50
4.	MSL	59.66 – 92.40	6.22	8.67	10.67	66.01	14.52
5.	NSMS	35.81 – 65.41	9.40	10.67	14.22	56.26	16.48
6.	SL	2.84 – 5.12	3.74	9.46	10.17	86.48	18.13
7.	NSS	8.21 – 14.52	4.39	9.87	10.80	83.48	18.58
8.	DF	37.33 – 54.33	1.49	6.63	6.80	95.18	13.33
9.	DM	137.33 – 145.33	0.54	1.21	1.33	83.43	2.29
10.	TW	4.04 – 6.95	2.05	10.19	10.39	96.08	20.57
11.	SY	11 - 35.25	5.16	19.57	20.24	93.49	38.98

CV – Coefficient of Variance; GCV - Genotypic Coefficient of Variability; PCV - Phenotypic Coefficient of Variability; H²bs - Broad-sense Heritability; GAM - Genetic Advance as 5% Percent of the Mean.

Table-4 : Total variance of different principal components.

Principal component	Eigen Value	Percent variability	Cumulative percent variability
1.	189.03	0.602	0.602
2.	74.18	0.236	0.838
3.	21.16	0.067	0.905
4.	15.78	0.050	0.955
5.	7.65	0.02	0.98
6.	2.71	0.01	0.99

heritability values were observed for number of secondary branches (70.25%) and main shoot length (66.01%). Remaining seven traits viz; plant height (91.47%), silique length (86.48%), number of seeds per silique (83.48%), days to 50% flowering (95.18%), days to maturity (83.43%), 1000-seed weight (96.08%) and seed yield per plant (93.49%) had very high broad sense heritability. This implies that the expected gain from selection would be high if these traits will use as selection criteria for improving seed yield. The high heritability estimates are also indicative of smaller environmental influence on these traits. Similar to present study, a number of previous studies reported moderate to high heritability for yield and its component traits in Indian mustard (Tiwari *et al.*, 2019; Ray *et al.*, 2019; Patel *et al.*, 2021).

Genetic gain under selection for yield and its component traits are depends on the extent of genetic advance as percent of 5% mean for particular trait. Johnson *et al.* (1955) classified genetic advance as percentage of mean (GAM) values as low (0-10%), moderate (10-20%) and high (>20%). Based on this classification, GAM ranged from 2.29% for days to maturity to 38.98% for seed yield per plant. Genetic advance was relatively high for seed yield per plant (38.98%), number of secondary branches per plant (25.50%) and test weight (20.57%). Traits with intermediate GAM included plant height (11.01%), number of primary branches per plant (14.42%), main shoot length (14.52%), number of siliques on main shoot (16.48%), silique length (18.13%), number of seeds per silique (18.58%) and days to 50% flowering (13.33%). Only days to maturity had low value for GAM. High values

for genetic advances indicate that there is a high potential for improvement of the trait under selection. High heritability along with moderate to high GAM show that yield-attributing trait under selection is predominantly conditioned by its genes and is less affected by environmental influences, and can be used to select for yield improvement (Mengistu *et al.*, 2020). A trait with low to moderate heritability and low genetic advances has a low response to selection (Taneva *et al.*, 2019). In the present study only one trait, days to maturity have low response to selection, given their low values for genetic advance. Therefore, the present genotypes should be further selected for dwarf plant height, high number of primary and secondary branches per plant, longer main shoot length, high number of siliques on main shoot, more number of seeds per silique, more 1000-seed weight, early flowering and maturity under multiple locations and years.

PCA analysis : Principal component analysis revealed that the first six principal components with eigenvalues greater than unity explained 99% of the total variation (Table-4). PC1, PC2, PC3 and PC4 explained 60.2%, 23.7%, 6.7% and 5% of the total variation, respectively. Plant height, main shoot length and number of siliques on main shoot were the major contributors to the variation explained by the first (PC1) principal component (Table-5). The highest contributor to PC2 were main shoot length and number of siliques on main shoot. Besides this, PC3 was major contributor for seed yield/plant while PC5 were chief contributor of days to 50% flowering and days to maturity. Our findings are consistent with preceding studies where Rao *et al.* (2017) reported that nine principal components contributed 77% variability for seed yield and its component traits among 43 Indian mustard genotypes and Avtar *et al.* (2017) noted 70.41% of total variation among 96 Indian genotypes for 20 morphological traits. The traits mostly associated with PC1 and PC2 accounted for most of the variation among the test genotypes and could be used as the basis for selection. In this population, the genotypes were differentiated by their differences in plant height, main shoot length and number

Table-5 : Factor loadings of characters with respect to different principal factors.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
PH	0.768	-0.601	-0.134	-0.097	-0.127	-0.004	0.072	-0.005	-0.015	-0.003	0.003
NPB	0.014	-0.002	0.052	-0.015	0.002	0.147	0.081	0.056	0.862	-0.471	0.017
NSB	0.026	0.064	0.231	-0.112	0.082	0.654	0.682	0.017	-0.137	0.102	0.003
MSL	0.412	0.65	-0.471	-0.385	0.189	0.027	-0.026	0.025	0	-0.024	-0.014
NSMS	0.422	0.399	0.231	0.763	-0.165	0.014	-0.002	-0.004	-0.001	0.015	0.002
SL	0.007	0.008	-0.009	-0.015	-0.008	-0.006	-0.021	0.175	0.179	0.374	0.892
NSS	0.028	0.009	0.133	-0.084	-0.114	0.142	-0.219	0.926	-0.07	0	-0.174
DF	0.056	-0.178	-0.027	0.241	0.821	0.327	-0.353	-0.006	-0.013	0.011	0.006
DM	0.002	-0.036	-0.028	0.137	0.439	-0.606	0.567	0.297	-0.017	-0.093	0
TW	0.002	-0.009	-0.038	0.01	0.039	-0.064	0.046	-0.012	0.447	0.786	-0.416
SY	0.24	0.14	0.794	-0.406	0.179	-0.226	-0.159	-0.137	0.014	0.021	0.01

of siliquae on main shoot because these traits had high PC1 and PC2 loadings.

Conclusions

High variability was observed among the evaluated 68 genotypes for all the studied traits. Number of secondary branches, 1000-seed weight and seed yield per plant exhibited high heritability and high genetic advance indicated that high selection for these traits are effective for seed yield improvement in Indian mustard. These results will be useful in understanding the genetic variability within a group of genotypes which can be put to a better use for well-defined breeding approach for evaluation and characterization of genetic variation in this crop.

References

1. Avtar, R., Manmohan, M., Jattan, M., Rani, B., Kumari, N., Thakral, N.K. and Sheoran, R.K. (2017). Evaluation and diversity analysis in Indian mustard [*Brassica juncea* (L.) Czern & Coss.] germplasm accessions on the basis of principal component analysis. *J. Appl. Nat. Sci.*, 9(4), 2485-2490.
2. Choudhary, R.R., Avtar, R.S.R. and Kumar, D. (2020). Heterosis studies based upon Mori CMS system in *Brassica juncea* L. *Journal of Oilseed Brassica*, 11(2), 116-120.
3. Gaebelein, R. and Mason A.S. (2018). Allohexaploids in the genus *Brassica*. *CRC Crit. Rev. Plant Sci.* 37, 422-437.
4. Jat, R.S., Singh, V.V., Sharma, P. and Rai, P.K. (2019). Oilseed brassica in India: Demand, supply, policy perspective and future potential. *OCL*, 26, 8.
5. Johnson H.W., Robinson H.F. and Comstock R.E. (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy journal* 47: 314-318.
6. Kingsolver, J.G., Hoekstra, H.E., Hoekstra, J.M., Berrigan, D., Vignieri, S.N., Hill, C.E., Hoang, A., Gibert, P. and Beerli, P. (2001). The strength of phenotypic selection in natural populations. *Am. Nat.*, 157(3), 245-261.
7. Kumar, R., Kaur, S., Bala, K., Kaur, S. and Sharma, L. (2019). Assessment of genetic variability, correlation and path analysis for yield traits in F_1 hybrids of Indian mustard (*Brassica juncea* L.). *Agric. Sci.*, 7(1), 1-7.
8. Mengistu, G., Shimelis, H., Laing, M., Lule, D. and Mathew, I. (2020). Genetic variability among Ethiopian sorghum landrace accessions for major agro-morphological traits and anthracnose resistance. *Euphytica*, 216(7), 1-15.
9. Pandey, S.K., Srivastava, K.K., Negi, S., Khan, N.A. and Singh, R.K. (2020). Variability, trait relationship and path analysis for seed yield and seed quality parameters in Indian mustard (*Brassica juncea* L.). *J. Oilseed Brassica*, 11(1), 69-76.
10. Panse V.G. and Sukhatme, P.V. (1967). *Statistical methods for Agriculture workers* (2nd ed.). Indian council of Agriculture, New Delhi.
11. Patel, P.B., Patel, P.J., Patel, J.R. and Patel, P.C. (2021). Elucidation of genetic variability and inter-relationship studies for seed yield and quality traits in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *Electronic Journal of Plant Breeding*, 12(2), 589-596.
12. Rao, P., Avtar, R., Kumari, N., Jattan, M., Rani, B. and Sheoran, R.K. (2017). Multivariate analysis in Indian mustard genotypes for morphological and quality traits. *Electron. J. Plant Breed.*, 8(2), 450-458.
13. Ray, J., Singh, O.P., Pathak, V.N. and Verma, S.P. (2019). Assessment of genetic variability, heritability, genetic advance and selection indices for yield contributing traits in Indian mustard [*Brassica juncea*]. *IJCS*, 7(4), 1096-1099.
14. Renjini, V.R. and Jha, G.K. (2019). Oilseeds sector in India: A trade policy perspective. *Indian J. Agric. Sci.*, 89(1), 73-80.
15. 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. *J. Pharmacog Phytochem*, 8, 4119-4123.
16. Singh B.D. (2001). *Plant Breeding: Principles and Methods*. Kalyani Publishers, New Delhi-Ludhiana, India 506 p.
17. Singh, M., Avtar, R., Singh, V.K., Mahavir, Kumari, N., Anu and Rathore, V. (2021). Genetic diversity in Indian mustard (*Brassica juncea*) genotypes for Sclerotinia stem rot (*Sclerotinia sclerotiorum*) using SSR markers. *Indian J. Agric. Sci.*, 91(6).
18. Singh, R.K. and Chaudhary, B.D. (1985). Line x Tester analysis. In *Biometrical Methods in Quantitative Genetic Analysis* (pp. 215-223). Kalyani Publishers, New Delhi, India.
19. Taneva, K., Bozhanova, V. and Petrova, I. (2019). Variability, heritability and genetic advance of some grain quality traits and grain yield in durum wheat genotypes. *Bulg. J. Agric. Sci.*, 25(2), 288-295.
20. Tiwari, V. K. (2019). Morphological parameters in breeding for higher seed yield in Indian mustard [*Brassica juncea* (L.) Czern. & Coss.]. *Electron. J. Plant Breed.*, 10(1), 187-195.
21. Tripathi, N., Kumar, K., Tiwari, R. and Verma, O.P. (2019). Assessing genetic variability in Indian mustard (*Brassica juncea* L. Czern and Coss.) for seed yield and its contributing attributes under normal and saline/alkaline condition. *J. Pharmacogn. Phytochem.*, 8, 1322-1324.



Knowledge and Adoption of Recommended Litchi Production Technology among the Farmers of Jashpur District of Chhattisgarh

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Abstract

The present investigation was conducted to study on knowledge and adoption level of litchi growers towards the litchi production technology among the farmers of Jashpur district of Chhattisgarh during 2020-21. In the present study, it was observed that 61.25 per cent of the litchi cultivators belonged to medium level of knowledge, whereas, 22.50 and 16.25 per cent of the litchi cultivators belonged to the low and high knowledge levels about recommended litchi production technology. With respect to adoption 63.75 per cent of litchi cultivators were had medium level of adoption, whereas, 25.00 and 11.25 per cent of the litchi cultivators belonged to low and high adoption level about recommended litchi production technology.

Key words : Knowledge and adoption level, litchi cultivators, litchi production technology.

Introduction

Litchi (*Litchi chinensis* Sonn.) belongs to the Sapindaceae family and it is commonly known as the “Queen of fruits”. Litchi was originated in near South China and North Vietnam in the year 1500 BC (Menzel, 2000; Rajwanshi *et. al.*, 2017). Litchi, one of the most environmentally sensitive subtropical tree fruit crops, is adapted to areas of the world characterized by warm subtropics and elevated tropics having cool dry winters and warm wet summers. India is the second country in the world in terms of production, which produces large quantity of litchi after China. The area of litchi production in India is 95000 ha and 727000 MT as of 2018-19 (Anonymous 2019). In India Bihar, Jharkhand, Assam and West Bengal accounts for 64.20 per cent of the country's total litchi production. The other litchi producing states of India are whereas in north western part of India Chhattisgarh, Uttarakhand, Punjab, Odisha, Tripura, Himachal Pradesh and Jammu & Kashmir. Bihar accounts for three-fourth of the litchi production of the country. The agro-climatic conditions of the state are ideal for this fruit cultivation. In Chhattisgarh, litchi crop is mainly grown in Surguja, Jashpur, Surajpur and Balrampur districts. Litchi is good for production in the Jashpur district. The area of Litchi cultivation in Jashpur district is 1520 hectares and production are 6840 MT, respectively, with an average yield of 4.5 MT per hectare (Anonymous, 2020). The increasing area under Litchi in Jashpur has brought a significant change in the social as economic condition of the farmer.

Litchi fruits are mainly eaten in fresh form, many types of preserves such as jamaes, beverages (juice, nectar, carbonated drinks) and canned fruits are made from its fruits. Litchi syrup is becoming popular for its taste

and aroma. Carbohydrate, vitamin C, vitamin A & B complex are found in abundance in litchi. A part from this, minerals like potassium, calcium, magnesium, phosphorous and iron are also found in it, but excessive consumption can also cause sugar. But consuming litchi in regular amounts can have many benefits or is most suitable for digestion.

It is therefore, felt necessary to find out the knowledge and adoption level of the litchi cultivators for developing new suitable strategy, to overcome the problems faced by them in adoption. Therefore, the present investigation was undertaken with the objective to study the knowledge and adoption level of litchi growers towards the litchi production technology.

Materials and Methods

The present study was undertaken in purposively selected Jashpur District. Jashpur and Bagicha blocks were selected purposively. From each selected blocks ten villages selected. From Jashpur block selected villages namely - Paiku, Pidi, Ameratoli, Portenga and Lokhandi, similarly from Bagicha blocks - Jhiki, Badupara, Tatkel, Bhitghara and Raikera villages were selected. Eight farmers from each selected village were selected randomly. The respondent farmers were interviewed with the help of pretested structured schedule prepared for the study. The statistical tools like Mean, Standard deviation, Frequency Percentage, correlation were used to analyse the data.

Knowledge of technology : The knowledge test included packages of all practices related to litchi production. A set of questions was developed from the respective package of practices to be asked to the litchi growers which were then finalized after discussions with the major guide and

Table-1 : Distribution of the litchi cultivators according to their practice wise level of knowledge regarding litchi cultivation. (n=80)

S. No.	Litchi Cultivation Practices	Knowledge Level			
		Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Litchi variety	69	86.25	11	13.75
2.	Spacing between two plants	63	78.75	17	21.25
3.	Propagation	38	47.50	42	52.50
4.	Intercropping	39	48.75	41	51.25
5.	Irrigation time	36	45.00	44	55.00
6.	Irrigation method	58	72.50	22	27.50
7.	Fertilizer application	42	52.50	38	47.50
8.	Pruning practices	43	53.75	37	46.25
9.	Insect-control	39	48.75	41	51.25
10.	Disease-control	34	42.50	46	57.50
11.	Harvesting	80	100.00	00	00.00

Table-2 : Over all knowledge level of litchi cultivators.

S. No.	Particulars	Litchi cultivators(n=80)	
		Frequency	Percentage
1.	Low (Up to 5 score)	18	22.50
2.	Medium (6 to 9 score)	49	61.25
3.	High (Above 9 score)	13	16.25

Mean = 6.76, S.D. = 2.04

Table-3 : Distribution of the litchi cultivators according to their practice wise adoption level regarding litchi cultivation. (n=80)

S. No.	Litchi Cultivation Practices	Adoption Level			
		Yes		No	
		Frequency	Percentage	Frequency	Percentage
1.	Litchi variety	55	68.75	25	31.25
2.	Spacing between two plants	51	63.75	29	36.25
3.	Propagation	20	25.00	60	75.00
4.	Intercropping	33	41.25	47	58.75
5.	Irrigation time	26	32.50	54	67.50
6.	Irrigation method	35	43.75	45	56.25
7.	Fertilizer application	37	46.25	43	53.75
8.	Pruning practices	31	38.75	49	61.25
9.	Insect-control	29	36.25	51	63.75
10.	Disease-control	27	33.75	53	66.25
11.	Harvesting	80	100.00	00	00.00

advisory committee, and finalising total eleven question to be asked from the respondents.

A tool was developed to measure the knowledge level of farmers about selected recommended techniques for litchi crop. Knowledge index was used along with the use of a scale made by the teacher with some modifications. Respondent's responses regarding knowledge were obtained in a two-point continuum.

Adoption technology : It is circulated as the degree of use of recommended practices. Adoption refers to the extent to which litchi growers use the recommended agricultural practices of litchi cultivation. The recommended package of practices for higher production of litchi in litchi cultivation was measured keeping in mind

the extent of adoption by the litchi cultivators. To measure the extent of adoption, the list of recommended important practices was prepared and responses for each practice was obtained into two-point continuum.

Results and Discussion

Knowledge level of recommended litchi production technology among the litchi cultivators : The data presented in Table-1 revealed that most of the litchi growers were aware of certain aspects of litchi production technology *i.e.*, harvesting (100.00%), litchi variety (86.25%), spacing between two plants (78.75%), irrigation method (72.50%), pruning (53.75%), fertilizer application (52.50%), intercropping and pest-control (48.75%), propagation (47.50%), irrigation time (45.00%)

and disease-control (42.50%). Whereas, majority of the respondents were had no knowledge regarding litchi production technology *i.e.*, disease-control (57.50%), irrigation time (55.00%), propagation (52.50%), intercropping and pest-control are same per cent (51.25%), fertilizer application (47.50%), pruning (46.25%), irrigation method (27.50%), spacing between two plants (21.25%) and litchi variety (13.75%).

Knowledge level of litchi cultivators : The data in Table-2 revealed that 61.25 per cent of litchi cultivators were had medium level of knowledge about litchi cultivation. Whereas 22.50 per cent of litchi cultivators were had low knowledge about litchi cultivation and 16.25 per cent were had high knowledge about litchi cultivation practices. Singh (2000), Katkar (2001) and Chavhan (2015) all found similar results.

Extent of adoption of recommended litchi production technology : The data presented in Table-3 revealed that most of the litchi growers were had adoption regarding selected practices of litchi production technology *i.e.*, litchi variety (68.75%), spacing between two plants (63.75%), propagation (25.00%), intercropping (41.25%), irrigation time (32.50%), irrigation method (43.75%), fertilizer application (46.25%), pruning (38.75%), insect-control (36.25%), disease-control (33.75%) and harvesting (100.00%). Whereas, majority of the litchi growers were had not adopted the recommended litchi production technology *i.e.*, litchi variety (31.25%), spacing between two plants (36.25%), propagation (75.00%), intercropping (58.75%), irrigation time (67.50%), irrigation method (56.25%), fertilizer application (53.75%), pruning (61.25%), insect-control (63.75%), and disease-control (66.25%).

Adoption level of litchi cultivators : The data in Table-4 revealed that 63.75 per cent of litchi cultivators were had medium level of adoption. Whereas 25.00 per cent of litchi cultivators were had low level of adoption and 11.25 per cent were in high level of adoption category. This observation is consistent with Singh's findings (2006).

Conclusions

Even though the above results related to adoption are good but still there is a vast gap in adoption of key practices such as propagation, pruning time, disease and pest management etc. The concerned agencies should conduct the training programmes related to importance of organic manure application, benefits of pruning in litchi and importance of pest management which is crucial in getting a good quality and quantity of crop. Even the extension agencies need to carry out educational activities like method, result demonstrations and other extension methods to educate and motivate the litchi cultivators for the adoption of recommended practices. The results of this research are very useful for the extension professionals and policy makers to plan the activities and development of strategies.

References

1. Anonymous 2019. Area and Production of Horticulture Crops - All India, National Horticulture Board. Ministry of Agriculture and Farmers Welfare. Government of India, Gurugram, Haryana.
2. Anonymous 2020. Area, Production and Productivity of Horticulture Crops in Chhattisgarh, Directorate Horticulture and Farm Forestry, Chhattisgarh. Department of Agriculture, Government of Chhattisgarh.
3. Chavhan, K.T. 2015. Knowledge and adoption of mango production technology. M. Sc. Thesis, Vasantrao Naik Marathwada Krishi Vidyapeeth, Prabhani (M.S.), India : 69-70.
4. Katkar, V.J. 2001. A study of adoption of mango production technology in Akole tehsil of Ahmednagar district. *M.Sc. Thesis, Mahatma Phule Krishi Vidyapeeth*, Rahuri, Ahmednagar, Maharashtra, India, : 54-58.
5. Menzel, C. 2000. The physiology of growth and cropping in lychee. *In 1st international symposium on litchi and longan*. 558: 175-184.
6. Rajwanshi, R., Kumar, M. and Lal, B. 2017. Pre-and postharvest management practices for litchi production in India. *In lychee disease management*. Springer, 45-66.
7. Singh, B. 2000. Adoption of recommended practices by the peach growers of Amritsar districts. *M.Sc. Thesis, Punjab Agricultural University*, Ludhiana, : 37-41.
8. Singh, M. 2006. Adoption and constraints in mango cultivation. *M.Sc. Thesis, Chaudhary Charan Singh Haryana Agricultural University*, Hisar : 50-63.



Stenting : A New Technique for Rapid Multiplication of Subtropical Plum (*Prunus salicina* Lindl.) in Respons of Different Concentration of IBA

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Abstract

The purpose of the present investigation was to standardize the stenting method of propagation in plum for production of quality plants in a short period of time. The experiment comprises of stents/cuttings of varieties Kala Amritsari, Satluj Purple and Kabuli Green Gauge and five IBA concentrations (Control, 500 ppm, 1000 ppm and 1500 ppm). For preparation of stents, cuttings of scion cultivar Kala Amritsari and Satluj Purple tongue grafted on rootstock Kabuli Green Gauge and after IBA treatment they were planted in second week of January. The result indicated that stents/cuttings treated with higher doses of IBA i.e. 1000 and 1500 ppm attained maximum success at the end of growing season with well-developed roots. Similarly, IBA application produced the maximum shoot length, root length, root girth, fresh and dry weight of roots in both stents and cuttings.

Key words : IBA, stenting, cutting, rooting, plum

Introduction

Plum (*Prunus salicina* Lindl.) is deciduous temperate fruit belonging to family Rosaceae. It is probably adopted temperate fruit to the warmer climate, where the high chilling requiring fruits like apple and cherry cannot be grown profitably. Plums are commercially propagated through T budding or Tongue grafting on seedling rootstock of peach, plum and apricot. The seeds from ripening fruits and cuttings from vigorously grown cultivars such as Kabuli Green Gauge and Alubukhara tree are used to raise the rootstock. The traditional method of nursery raising takes almost two years to produce a grafted plants of saleable size. During the first year the rootstock are raised through seeds or by cuttings and when these rootstock attain the size of pencil thickness (which almost takes 10-12 months), the grafting or budding operations are done and thus it takes another one year to produce grafted plants for planting in the field. Therefore, this method is laborious, time taking and costlier. On the other hand in stenting technique, grafting and rooting occurs simultaneously. Thus, stenting can be an innovative technique to reduce the duration of plant multiplication, where rooting of clonal rootstock is not a complex phenomenon. In stenting cutting and grafting is performed simultaneously (Von de pol and Breukelaar 1982). The scion is grafted onto non-rooted rootstock cuttings. The union and adventitious roots on the rootstock occurs simultaneously. In case of rose propagation, it has become popular among propagators

(Nazari *et al.* 2009) and also in the case of apple, pear and plum (Hartman *et al.* 2002). Stenting also provides the benefits of rootstock used. The rootstock shows the positive effect on a different aspect of scion ranging from tree size, productivity, uptake of nutrient, growth rate, time of defoliation, bloom date and tree survival. It is also known to affect the susceptibility of scion tree to a variety of disease and pest (Gill *et al.* 2014).

In stenting technique, hard wood plum cuttings are difficult to root, hence, the rooting hormone IBA is used to induce rooting of stents as IBA is associated with stimulation of cell division at the graft union. The stents prepared from semi-soft pear (*Pyrus communis* L. X *Pyrus pyrifolia* Burm F.) scion grafted on the cuttings of rootstock 'Kainth' (*Pyrus pashia* Hamilton) after third week of January using higher doses of IBA exhibited higher success using this technique (Brar and Gill, 2014). IBA application significantly affects all aspects viz., lateral shoots, internodes length, root length and root number in both non-rooted and rooted stocks in stents made from sweet cherry and Colt (Negi and Upadhyay 2016). Kaur *et al.* (2015) also reported similar findings in peach.

Materials and Methods

The experiment was conducted at Horticulture Research Center, Patharchatta and Department of Horticulture, G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand under open field condition. The planting material consist of

Table-1 : Effect of IBA concentration on plant height, fresh and dry weight of shoot.

Sl. No.	Stents/cuttings (S)	Plant height				Fresh weight of shoot				Dry weight of shoot			
		IBA concentrations (l)				IBA concentrations (l)				IBA concentrations (l)			
		Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)
1.	KG+KA (S ₁)	102.87	110.17	118.10	114.37	111.38	96.03	98.40	115.23	105.67	53.40	60.20	55.20
2.	KG+SP (S ₂)	100.53	108.73	116.17	113.00	109.61	91.20	92.55	95.90	94.90	46.80	47.50	47.10
3.	KG (S ₃)	79.50	80.37	82.33	80.53	80.68	68.00	69.17	70.50	69.33	34.93	35.20	34.77
4.	KA (S ₄)	84.63	86.47	94.07	88.97	88.53	82.17	84.75	86.75	85.87	42.93	43.57	42.71
5.	SP (S ₅)*	91.88	96.43	102.67	99.22	84.35	86.22	92.10	88.94	42.58	44.52	46.62	44.94
Mean		102.87	110.17	118.10	114.37	111.38	96.03	98.40	115.23	105.67	53.40	60.20	55.20

CD_{0.05}

S	2.49	2.37	1.69
I	2.49	2.37	1.69
SxI	4.97	4.75	3.38

KGG : Kabuli Green Gauge, KA: Kala Amritsari, SP: Satluj Purple, KGG+ KA: KA grafted on KGG, KGG + SP: SP grafted on KGG

Table-2 : Effect of IBA concentration on root girth, number of primary and secondary roots.

Sl. No.	Stents/cuttings (S)	Plant height				Fresh weight of shoot				Dry weight of shoot			
		IBA concentrations (l)				IBA concentrations (l)				IBA concentrations (l)			
		Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)
1.	KG+KA (S ₁)	4.45	5.8	7.29	6.55	6.02	10.58	13.33	14.8	13.78	20.28	24.57	23.41
2.	KG+SP (S ₂)	4.43	5.43	6.61	5.6	5.52	10.6	11.62	13.75	11.83	21.30	23.52	21.50
3.	KG (S ₃)	2.98	3.21	3.46	3.42	3.27	6.58	7	7.76	7.43	16.73	17.46	17.15
4.	KA (S ₄)	3.75	4.02	4.91	4.38	4.26	8.1	8.66	10.39	9.32	17.80	20.12	19.06
5.	SP (S ₅)*	3.90	4.62	5.56	4.99	8.97	8.97	10.15	11.68	10.59	18.87	21.42	20.28
Mean		4.45	5.8	7.29	6.55	6.02	10.58	13.33	115.23	105.67	21.77	24.57	23.41

CD_{0.05}

S	0.43	0.59	0.70
I	0.43	0.59	0.70
SxI	0.87	1.28	1.40

KGG : Kabuli Green Gauge, KA: Kala Amritsari, SP: Satluj Purple, KGG+ KA: KA grafted on KGG, KGG + SP: SP grafted on KGG

Table-1 : Effect of IBA concentration on plant height, fresh and dry weight of shoot.

Sl. No.	Stents/cuttings (S)	Plant height				Fresh weight of shoot				Dry weight of shoot			
		IBA concentrations (l)				IBA concentrations (l)				IBA concentrations (l)			
		Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)	Control (l ₀)	500 ppm (l ₁)	1000 ppm (l ₂)	1500 ppm (l ₃)
1.	KGG+KA (S ₁)	20.69	20.86	24.82	23.66	22.51	65.70	68.00	84.97	75.34	36.40	41.10	42.90
2.	KGG+SP (S ₂)	20.21	21.55	23.63	21.75	21.79	60.87	62.22	65.57	64.31	33.50	35.20	34.80
3.	KGG (S ₃)	16.19	16.98	17.71	17.40	17.07	39.34	43.37	44.84	44.00	21.77	22.90	22.57
4.	KA (S ₄)	18.05	18.61	20.37	19.31	19.08	49.84	54.42	56.42	55.54	29.43	31.27	30.41
5.	SP (S ₅)*	18.78	19.50	21.63	20.53	53.94	57.00	62.95	59.86	30.28	31.97	34.32	32.64
	Mean	20.69	20.86	24.82	23.66	22.51	65.70	68.00	84.97	75.34	36.40	41.10	42.90
CD _{0.05}													
	S					0.64							1.65
	I					0.64							1.65
	Sxl					1.27							3.30
KGG : Kabuli Green Gauge, KA: Kala Amritsari, SP: Satluj Purple, KGG+ KA: KA grafted on KGG, KGG + SP: SP grafted on KGG													

stents/cuttings of 20 cm long and 1.0 to 1.25 cm in diameter having 3-5 buds. Cuttings were prepared, from the middle basal portion of 9-10 month old dormant shoots from seven year old mother plants of Plum cvs Kabuli Green Gauge, Kala Amritsari and Satluj Purple in the first fortnight of January. While preparing the cutting a smooth straight cut was given just below the node at the basal portion and slanting cut was given one cm above the upper node. On the other hand during the preparation of stents cuttings of scion (Kala Amritsari and Satluj Purple) were tongue grafted on to the rootstock (Kabuli Green Gauge). Prepared cuttings/stents were stored in moist sphagnum moss for 24 hrs and then soaked in different concentrations of IBA (Control, 500 ppm, 1000 ppm and 1500 ppm) for 10 second before the planting.

After these treatments, stents/cuttings of all varieties were planted in plots with the spacing of 30x30 cm². After planting to the nursery, necessary standard agronomical operations i.e. irrigation, weeding etc. was carried out to promote their early establishment, quick growth and development. The data was collected from five tagged plants in each treatment on rooting and other plant attributes were recorded. Successful propagation was determined by taking the criteria such as formation of the graft union and rooting. For that, Plant height, fresh and dry shoot and root weight, number and length of primary and secondary roots and success percentage were recorded. The data were statistically analyzed by using Factorial Randomized Block Design. To compare the mean values of the treatment combinations critical difference (C.D) at the 5 per cent level of significance was calculated.

Results and Discussion

Plant height and fresh and dry weight of shoots : The stem stents/cuttings treated with IBA 1000 ppm recorded more plant height (118.10) compare to control (Table-1). This may be due to the fact that, IBA increases cell division which results in early rooting leading to efficient absorption and translocation of water and mineral nutrients to the above ground parts of the cuttings, and thus causing their rapid growth and multiplication. Furthermore, stents (KGG+KA and KGG+SP) shows more plant height as compare to cuttings (KGG, KA and SP). This might be due to, the steonic effect in stents or differential growth of plant in response to genetic differences in varieties from which stents/cuttings was taken. Similar results were recorded by Gill *et al.* (2014) and Brar and Khehra (2017) with the application of IBA in stents of peach causing increased plant height. Kaundal *et al.* (1993) reported the maximum plant height in peach cv. Floridasun, Shan-i-Punjab, Florida Red when treated

with 1000 ppm IBA. Brar and Gill (2014) also observed the positive effect of IBA on enhancing the plant height in pear cuttings grafted on Kainth. Similarly, Jawanda *et al.* (1990) also noticed the promoting effect of IBA on shoot length in plum cuttings.

It is evident from the table-1 that IBA treatment had a significant effect on shoot fresh and dry weight in plum stents/cuttings. In KGG+KA stents, maximum fresh and dry weight was recorded in 1000 ppm IBA i.e., 115.23 g and 60.20 g, respectively and it was significantly higher than all the other treatments. Similarly, Singh and Tomar (2015), Singh *et al.* (2015) found IBA to be most effective in increasing fresh and dry weight of shoot in phalsa. Shukla and Bist (1994) also reported in pear that higher concentration of IBA gives the higher fresh weight of shoot. The fresh and dry weight of shoot is interlinked with each other. The difference in fresh weight and dry weight of plant among different varieties possibly due to the variation in vegetative characters like shoot length, thickness and number of leaves, leaf chlorophyll content, total sugar and C/N ratio as stated by Purohit and Shekarappa (1985) in pomegranate. IBA also has their significant role in enhancing the fresh weight of shoot by the increasing vegetative growth of plants.

Number of primary and secondary roots, root length, root girth, fresh and dry weight of root : The data presented in table-2 shows that 1000 ppm IBA treatment resulted in significantly higher numbers of primary and secondary roots. Moreover, KGG+KA and KGG+SP stents gave more number of primary and secondary roots as compare to their respective cuttings. These results are supported by the findings of Chauhan and Reddy (1974) who found that 1000 ppm IBA treatment increases the number of root in 'Santa Rosa' plum. Ali *et al.* (2017) also reported the maximum number of primary and secondary roots in kiwi cuttings with IBA 3500 ppm + Paclobutrazol 500 ppm. Likewise, Singh *et al.* (2015) also proved the effect of IBA concentration on the number of roots, however, the optimum concentration was found to be 2000 ppm. The increased number of primary and secondary roots in stents/cuttings may be due to the fact that IBA promotes the differentiation of cambial initials into root primordia and increases the mobilization of reserve food material to sites of root initiation thereby increasing the number of roots per cutting (Ullah *et al.* 2005). Ryugo and Breen (1974) observed the principle role of IBA in synthesis of the specific proteins necessary for formation of root initials. Ray *et al.* (2001) noticed that rooting was accelerated with increase IBA level might be due to increased cell wall elasticity which further may affect the

cell division and internodes increased number of root to a certain level.

Similarly, 1000 ppm IBA significantly increased the length of primary and secondary roots, root thickness, fresh and dry weight of roots and these growth parameters are decrease with increase in IBA concentration above 1000 ppm (Table3). Moreover, stents performed better than the cuttings with respect to the overall root growth. The varying rooting parameter under different stents/cuttings and IBA levels might be attributed to rooting potential of varieties and steonic effects. In consistency to our results Gill *et al.* (2014) also reported the significant role of IBA on enhancing the root length of the peach stents. Wada *et al.* (1998) found that IBA promote root length by influencing the synthesis of enzymes that are involved in cell elongation. Alam *et al.* (2007) reported that IBA promote cell elongation which positively affect the root length and thickness and the increase in root mass is due to more vegetative growth and accumulation of carbohydrates. These results are in agreement with findings of Rathore (1984) who also reported increase in length and thickness of roots by the application of IBA on kiwi cuttings. The increase in root diameter may be due to more vegetative growth and accumulation of carbohydrates. Maximum root weight under IBA treatment was due to the fact that auxins significantly induced the rooting in stents/cuttings, which accumulates more stored carbohydrates for root initiation and growth and number of roots in each cutting are directly proportional to the fresh weight and dry weight of roots reported Singh and Tomar (2015) in phalsa. Our present findings are in support with the findings of Verma and Chauhan (2015) who reported greater amount of fresh and dry weight of roots in apple cuttings however, the ideal concentration was found to be 2500 ppm. Similarly, Dutra *et al.* (2002) in peach, Singh *et al.* (2015) in phalsa and Bhat (2000) in pomegranate found improvement in fresh and dry weight of root with the application of IBA.

The trend of superior outcome of observations at particular treatment may be due to the fact that the observations are interlinked with each other. Difference in rooting and vegetative growth among the stents/cuttings of various varieties may be due inherent capacity of the varieties to be rooted and survived. In stents, the nature of rootstock also effectively impacts the overall growth, which is obvious when rootstock had the well-developed adventitious roots. In a study using four rootstocks, viz. Sharbati peach, Kabul Green Gage, Kala Amritsari plum and wild apricot, IBA was found to enhance the rooting in the hardwood cutting of these rootstocks, while the

maximum was recorded in Kala Amritsari plum followed by Kabuli Green Gage (Bal *et al.* 2000). Application of natural or synthetic auxins induces the initiation of adventitious roots in cutting (Haissig 1986). Hence, exogenous application of IBA supplements the endogenous levels of the auxins leading to enhanced rooting and vegetative growth. This is possibly due to the fact that IBA concentrations have increased cell division and cell elongation simultaneously. Apart from ensuring optimal hormone concentration, the sensitivity of hormone to adventitious root formulation for a particular species has to be taken into account. It has been suggested that in plants the endogenous auxins level influence the impact of exogenously supplied IBA on rooting of *Prunus persica* (Tworkoski and Takeda, 2007).

Conclusions

Results of the present investigation revealed that, stents of Kala Amritsari and Satluj Purple grafted on Kabuli Green Gauge performed better than their respective cuttings. Satluj Purple do not responded to propagation by cutting, but when grafted on to the Kabuli Green Gauge it performed unexpectedly well. In the light of aforesaid experimental findings, it can also be concluded that stents/cuttings are performed well when treated with IBA, and thus can be practiced on plum cuttings. The propagation through stenting reduces the nursery duration time. Thus, it can be concluded that stenting perform better than the cuttings with respect to the overall growth and success. Therefore, the stenting of cuttings viz., Kala Amritsari (KGG+KA) stents along with application of 1000 ppm IBA is recommended for the production of quality plants of plum.

Acknowledgements

The authors are thankful to Department of Horticulture and Director Experiment Station, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand for providing support and necessary facilities to conduct the experiment.

References

1. Alam R, Rahman KU and Ilyas M, 2007. Effect of indole butyric acid concentration on the rooting of kiwi cuttings. *Sarhad J. Agric*, 23: 293-295.
2. Ali MT, Iqbal U, Mushtaq R, Parray EJ, Ibrahim A, Mohiuddin JS, Kundoo AA, Shah IS and Wani MA 2017. Effect of plant growth regulators on rooting of kiwifruit (*Actinidia deliciosa*) cuttings. *J Pharmacogn Phytochem*, 6(6): 514-516.
3. Bhat J D 2000. Effect of plant growth regulators and other chemicals on rooting of cuttings in pomegranate (*Punica granatum* L.) cv. Ganesh. *Thesis, M.Sc. Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, H.P, India.*
4. Brar JS and Gill MS 2014. Rapid propagation of pear through stenting. *Indian J Hortic*, 51(1): 33-35.
5. Brar JS and Khehra S 2017. Stenting: A technique for rapid multiplication of peach (*Prunus persica* L. Batsch) Plants. *Int J Curr Microbiol Appl Sci.*, 6(8): 1449-1453.
6. Chauhan KS and Reddy TS 1974. Effect of growth regulators and mist on rooting in stem cuttings of plum (*Prunus domestica* L.). *Indian J Hortic*, 31(3): 229-231.
7. Dutra LF, Kersten E and Fachinello JC 2002. Cutting time indole-3-butyric acid and tryptophan in rooting of peach tree cuttings. *Sci. Agric*, 59(2): 327-333.
8. Gill JK, Singh H, Thakur A and Jawanda SK 2014. Studies on simultaneous grafting and rooting of peach on Floridagourd rootstock. *Hort Flora Res*, 3(3): 259-262.
9. Haissig BE 1986. Metabolic processes in adventitious rooting of cuttings. In: Jackson M.B. ed. New root formation in plants and cuttings. *Dordrecht, Martinus Nijhoff Publishers*, 141-189.
10. HartmannTH, Kester ED, Davies TF and Geneve LR 2002. Plant Propagation: Principles and Practices. Prentice Hall, New Jersey. 770p.
11. Hiss CE 1968. Internal and external factors regulating root initiation. In : W. J. Whittington ed., Root Growth. *Proc. 15th Easter School in Agri. Sci. Nottingham*, pp. 4253.
12. Jwanda JS, Singh A and Singh S 1990. Effect of indolebutyric acid and shoot portion on the rooting of cuttings in Japanese plum. *Acta Hortic*, 283.
13. Kaur S 2015. Effect of different treatments of Indole-3-butyric acid (IBA) on the rooting and growth performance of hardwood cuttings of peach (*Prunus persica* L. Batch). *Agric Sci Digest*, 35 (1): 41-45.
14. Nazari F, Khosh-Khui M and Salehi H 2009. Growth and flower quality of four *Rosa hybrid* L. cultivars in response to propagation by stenting or cutting in soil-less culture. *Sci. Hortic*, 119 (3): 302-305.
15. Negi ND and Upadhyay SK 2016. Stenting-A new technique for sweet cherry and pear propagation under polyhouse conditions. *Indian J Hortic*, 73(2): 296-299.
16. Purohit AG and Shekharappa KE 1985. Effect of type of cutting and indolebutyric acid on rooting of hardwood cuttings of pomegranate (*Punica granatum* L.). *Indian J Hortic*, 42(1-2): 30-36.
17. Rathore DS 1984. Propagation of chinese gooseberry from stem cuttings. *Indian J Hortic*, 41(3-4): 237-239.
18. Ray RN, Diwedi AK, Rao PS and Jain BP 2001. Effect of indole butyric acid and coloured wrapping material on propagation of itchi cv. Purbi. *Haryana J. Hort. Sci*, 30: 170-172.
19. Ryugo K and Breen PJ 1974. Indole acetic acid metabolism in cuttings of plum (*Prunus ceracifera* x *P. mumsonia* cv. Marianna 2624). *J. Am. Soc. Hortic. Sci*, 99 (3): 247-51.
20. Shukla GS and Bist LD 1994. Studies on efficacy of IBA and NAA on clonal propagation by cutting in low chilling pear rootstock. *Indian J Hortic*, 51(4): 351-357.
21. Singh KK and Tomar YK 2015. Effect of planting time and indole butyric acid levels on rooting of woody cuttings of Phalsa (*Grewia asiatica* L.). *Hort Flora Res*, 4(1): 39-43.
22. Singh KK, Chauhan JS, Rawat JMS and Rana D K 2015.

- Effect of different growing conditions and various concentrations of IBA on the rooting and shooting of hardwood cutting of Phalsa (*Grewia asiatica* L.) under valley condition of Garhwal Himalayas. *Plant Arch*, 15(1): 131-136.
23. Tajbakhsh M, Korkan M and Ghiyasi M 2009. Effect of timing on callus formation and rooting ability in IBA treated hardwood stem cuttings of persian walnut, hazelnut and apple. *Not Bot Horti Agrobot Cluj Napoca*, 37(1): 103-107.
 24. Tworowski T and Takeda F 2007. Rooting response of shoot cuttings from three peach growth habits. *Sci. Hortic*, 115(1): 98-100.
 25. Ullah T, Wazir FU, Ahmad M, Analoui F, Khan MU and Ahmad M 2005. A breakthrough in guava (*Psidium guajava* L.) propagation from cutting. *Asian J. Plant Sci*, 4: 238-243.
 26. Verma P and Chauhan PS 2015. Effect of storage conditions (Growth chambers) and IBA treatments on rooting of cuttings of apple clonal rootstock Merton 793 in net house conditions. *Bioscan*, 10: 1049-1052.
 27. Wada S, Tanimoto E and Masuda Y 1998. Cell elongation and metabolic turnover of the cell wall as affected by auxin and cell wall degrading enzymes. *Plant Cell Physiol*, 9 (2): 369-376.
 28. Van de Pol PA and Breukelaar A 1982. Stenting of roses a method for quick propagation by simultaneously cutting and grafting. *Sci. Hortic*, 17(2): 187-196.



Effect of Growth Media and Plant Growth Regulators on Seed Germination of Papaya (*Carica papaya* L.)

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Abstract

The condition of different growth media (soil, vermicompost, vermiculite and cocopeat in 2:1 ratio) and two different plant growth regulators for papaya (*Carica papaya* L.) 'variety of Red Lady' in a field experiment during 2016 at Departmental nursery and back yard area, Department of Horticulture, S.K.N Collage of Agriculture, Jobner, Rajasthan. The experiment was laid out in Complete randomized design with ten treatments and three replications. Analysis of variance indicated significant effect of combination of Soil + Vermicompost + Seed soaking with GA₃ @ 150 ppm (T₂) on imbibition period, seedling emergence, germination percentage and germination index.

Introduction

The cultivated papaya (*Carica papaya* L.) one of the 22 accepted species, might have originated as a cross between two species of the genus *carica* of the family *caricaceae*, originated from tropics of America and it was introduced in India during 16th century from Malacca. The papaya in the genus *carica* Papaya occupies 2.0 per cent of the total fruit crop area and 5.3 per cent of total fruit production in India. It occupies a cultivated area of 132 thousand hectares with 5667 thousand MT of production with average productivity of 43 t/ha. It requires less area for tree fast growth, high yield, long fruiting period and nutritional value, so grown extensively as a filler plant in orchards, comes to fruiting in a year, is easy to cultivate and provides more income per ha next to banana. Papaya not only helps to improve the farm income but also serves as a cottage industry. In India, It is successfully grown all over the country and is available round the year. It is grown a 0.60 thousand hectares with annual production of 8.97 thousand tonnes in Rajasthan (Anonymus, 2015-16).

Papaya has also been used as vegetable and fruit processing. It is a very wholesome, refreshing and delicious fruit and rich in nutrient content and highly valued for its digestive properties papain a well known byproduct is prepared from dried latex of its immature fruits is used in meat tenderizing, manufacture of chewing gum, cosmetics, for degumming natural silk and to give shrink resistance to wool. Papaya fruit is a rich source of phyto-nutrients, 9.5 per cent carbohydrate, 0.5 per cent proteins, 0.1 per cent fat (cholesterol free), 4.0 per cent

calorific value 0.4 per cent minerals (0.01% calcium, 0.01% phosphorus, 0.4 mg iron), vitamins (2020 IU Carotene (Vit. A), 40 IU Thiamine (Vit. B), 250 IU riboflavin (vit. B2), 85 mg ascorbic acid (vit. C), 0.2 IU nicotinic acid) and 89.6 per cent moisture (Ram, 2007).

A good growing medium anchorage or support to the seed germination, growth of seedling and plant, serves as reservoir for nutrients and water allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate (Abad *et al.*, 2002). Due to awareness of multifold uses of papaya for table and extraction purposes, it is slowly emerging from the status form of a homestead crop to that of commercial crop. The major production constraint encountered in papaya is difficulty in maximizing yield with in unit time. Balanced nutrition plays a vital role on plant growth, yield and fruit quality. Therefore the applications of different growth media and inorganic fertilizers at nursery stage along with organic manures at later stage are the key factors to enhance the production. During seedling stage it requires a fertile soil or suitable growth media for better growth and development of the plants. The development of root system is suppressed and plants are more susceptible to soil borne diseases in heavy soils without drainage (Beattie and White, 1992). Therefore, the use of suitable growing media for sowing of seed plays an important role in seed germination and subsequent vegetative growth of seedlings (Srivastava *et al.*, 1998).

Similarly, the plant growth regulators are also profoundly influence the growth and differentiation of

plant cells, tissues and organs. The role of PGR's has been well recognized in agriculture production. Among the plant growth regulators auxins stimulate cell elongation and influence a host of other developmental responses, such as root initiation vascular differentiation tropic responses, apical dominance and the development of auxiliary buds, flowers and fruits (Das and Das 1996). Auxins are synthesized in stem or root apices and transported through the plant axis. The principal auxin present in the plants is indole-3 acetic acid (IAA). Several other indole derivatives all as precursors to IAA are known to express auxin activity probably by converting to IAA in the tissues. Furthermore, the other PGR's like gibberellins are also responsible to cause stem elongation and flowering of the plants. They are also prominently involved in mobilization of endosperm reserves during early embryo growth and seed germination (Shanmugavelu, 1985). Growth media and plant growth regulators both are an integral part of most of the horticultural production system. Hence, an experiment was conducted with the following objectives :

To study the effect of different growth media and plant growth regulators on germination of papaya

To work out the economic feasibility of the treatments.

Materials and Methods

The experiment was conducted at Departmental nursery and back yard area, Department of Horticulture, S.K.N Collage of Agriculture, Jobner, Rajasthan to study the effect of growth media and plant growth regulators on germination and seedling growth of papaya (*Carica papaya* L.) during *khariif* season of the year 2016. The experiment plot was geographically located at 75°28' longitude, 26°05' latitude and altitude of 427 m above mean sea level. Jobner is coming under Semi-Arid Eastern Plains Zone of Rajasthan. The climate of this region is characterized by extremes of temperature both in summer and winter, low rainfall and moderate relative humidity. There were ten treatment combinations consisting of different growth media and two different plant growth regulators. These were evaluated in complete randomized design with replicated thrice. The 10 (each of ten treatment consisted of 150 polybags and each polybag containing one seedling) different treatment combinations of growth media (soil, vermicompost, vermiculite and cocopeat in 2:1 ratio) and two different plant growth regulators (GA₃, NAA in 150, 50 ppm, respectively) involved Soil + Vermicompost (2:1) (T₁), Soil + Vermicompost (2:1) +Seed soaking with GA₃ @ 150ppm (T₂), Soil + Vermicompost (2:1) +Seed soaking with NAA @ 50ppm (T₃), Soil +Cocopeat (2:1) (T₄), Soil+ Cocopeat (2:1) + Seed soaking with GA₃ @ 150ppm (T₅), Soil+

Cocopeat (2:1) + Seed soaking with NAA @ 50ppm (T₆), Soil + Vermiculite (2:1) (T₇), Soil + Vermiculite (2:1) + Seed soaking with GA₃ @ 150ppm (T₈), Soil + Vermiculite (2:1) + Seed soaking with NAA @ 50ppm (T₉) and Control (Soil)(T₁₀) during experimentation. Among the different growth media, vermicompost was procured from college vermicompost unit and rest of the media like cocopeat and vermiculite were procured from departmental nursery unit and a mixture of growing media was prepared. Different growth media were used as single or mixture *i.e.* soil, vermicompost, cocopeat and vermiculite.

Cocopeat : Cocopeat is also known as coir pith, coir fiber pith, coir dust or simply coir, itself is waste coconut coir obtained by processing in the capture of fiber (ability to store water as 6 times more than its volume). The cocopeat can hold quantities of water, just like a sponge. It is used as a replacement for traditional peat in soil mixtures or as a soil less substrate for plant cultivation (Mason, 2003). The content of macro and micro nutrients contained in coconut fiber are potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (mg), Sodium (Na) and some other minerals. Being a good absorbent, dry cocopeat can be used as an oil absorbent on slippery floors. Cocopeat is hydrophilic unlike sphagnum moss and can quickly reabsorb water even when completely dry. Cocopeat is porous and cannot be over watered easily. Cocopeat generally has acidity in the range of pH 5.5 to 6.5 and chemical properties like 90-94 per cent total porosity, 20-30 per cent cellulose, 65-70 per cent lignin, 94-98 per cent organic matter on dry weight basis and 60-130 meq/100 g cation exchange capacity.

Vermicompost : Vermicompost is significantly proving as 'Miracle growth promoter and also a protector' from pests and diseases. Vermicompost, a product of a non thermophilic bio degradation of organic material through interactions between earthworms and microorganism, is a peat like material with high porosity, aeration, drainage, Water holding capacity and microbial activity. It contains most nutrients in available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium (Edward, 1998) and has large particular surface area that provides many micro sites for microbial activity strong retention of nutrients. The plant growth regulators and other plant growth influencing materials *i.e.* auxins, cytokinins, humic substances etc, produced by micro organisms have been reported from vermicompost (Atiyen, 2002).

Vermiculite : Vermiculite is limited expansion clay with a medium shrink – swell capacity. It has a high cation exchange capacity (CEC) at 100 - 150 meq/100 g. Vermiculite clay are weathered micas in which the potassium ions between the molecular sheets are

replaced by magnesium and iron ions. The presence of oxides of various metals (Magnesium, Potassium, Aluminium and Iron), which makes it ideal bio-stimulant plant growth regulator; its high water absorption (up to 500%), allows to keep an optimum soil moisture regime, even in condition of prolonged drought.

According to the results of field experiments established that the use of vermiculite improve the structure of both light and heavy soils, create the optimal air - water regime of soils, significantly stimulate the germination and the growth of plants. Reduce the acidity and salinity of soil up to 8 - 14%, increase the efficiency of fertilizers, reduce the incidence of diseases like root rot and ultimately increase the productivity of crops by 10 - 17%. Moreover, the use of vermiculite in agriculture is justified both on the stage of germination and seedling growth, production of grains and plants when grown in open fields. In green house condition good results are also achieved when it was applied with cocopeat. Vermiculite recorded a positive effect when it was entering into the composting mass.

Naphtelene Acetic Acid (NAA) : Naphtelene acetic acid (NAA) is an aromatic acid and a synthetic plant hormone in the auxin group, similar to naturally occurring indole acetic acid in its action on plants. NAA is responsible for stimulation of cell division, cell elongation, elongation of shoot, photosynthesis, RNA synthesis, membrane permeability, water uptake and involved in many physiological processes like plant growth, prevention of preharvest fruit drop, flower induction, fruit set, delayed senescence and prevention of bud sprouting, leaf chlorophyll content and increased yield in fruit crops. An exogenous application of naturally occurring or synthetic plant growth regulators affects the endogenous hormonal pattern of the plant either by supplementation of sub-optimal levels or by inter-action with their synthesis, translocation or inactivation of existing hormone levels.

Gibberellic Acid (GA₃) : Gibberellins are one of the important plant growth regulator involved in the natural process of breaking dormancy and other aspects of seed germination before the photosynthetic apparatus develops sufficiently in the early stages of germination, the stored energy reserves of starch nourish the seedling. Usually in germination, the breakdown of starch to glucose in the endosperm begins shortly after the seed is exposed to water. Gibberellins in the seed embryo are believed to signal starch hydrolysis through inducing the synthesis of the enzyme α -amylase in the aleurone cells.

All the treated and untreated seeds (one in each polybag, as per treatment) were sown in polybags of (20 X 10 cm size) at approximately 10 – 15 mm deep in different growing media on 28.08.2016. The polybags

were immediately irrigated after sowing and repeated light irrigation every day each polybag until seedling emergence takes place. After the completion of emergence of seedlings, the polybags were lightly irrigated twice in a day.

Sampling and Observation : The period of imbibition (*i.e.* the number of days after sowing of seed to the commencement of the germination) was recorded for each treatment until first sign of emergence was shown.

The rate of emergence (RE) in papaya seedlings was calculated through the technique suggested by the Islam *et al.* (2009) using the following formula-

$$RE = \frac{\text{No. of seedlings emerged in 5 days after soowing}}{\text{No. of seedlings emerged in 15 days after soowing}} \times 100$$

The germination percentage was calculated by dividing the total number of germinated seeds by the total number of seeds sown and multiplied by 100.

$$\text{Germination \%} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds own}} \times 100$$

The germination index was calculated by the method as described the association of official seed analysis (AOSA, 1983) as follows–

$$\text{Germination index} = \frac{\text{Number of germinating seeds}}{\text{Days of first count days}} + \frac{\text{Number of germinating seeds}}{\text{Days of final or last count}}$$

Seedling vigour was evaluated by dividing the total number of healthy seedlings by the total number of seedlings and multiplied by 100.

$$\text{Seedling vigour} = \frac{\text{Total number of healthy seedlings}}{\text{Total number of seedlings}} \times 100$$

The expenditure incurred on all operations and cost of materials and inputs applied to each treatment was taken into account to determine cost of cultivation while the gross returns were calculated by multiplying the number of plants of each treatment with sale price of papaya seedlings. The net returns was calculated by deducting cost of raising the 1000 seedlings from gross returns for respective treatment. The computation details of economics for each treatment are given in appendices at the end.

Data collected on different aspects of papaya *viz.* germination and seedling growth parameters were subjected to statistical analysis (Panse and Sukhatme, 1985). Significance of difference between means of data was tested through “F” test and critical difference (CD) was worked out wherever “F” value was found to be significant for treatment effect.

Table-1 : Effect of growth media and plant growth regulators on number of roots, root length, fresh weight of shoot, fresh weight of root, shoot:root ratio and survival per cent of papaya.

Treatments	Imbibition period (Days)	Rate of emergence (%)	Germination (%)	Germination index	Seedling vigour (%)	Net returns (?)
T ₁	12.84	73.67	83.50	1.58	76.67	11311
T ₂	09.32	90.57	92.00	2.28	94.27	11739
T ₃	12.00	78.04	85.00	1.94	90.00	12394
T ₄	13.67	66.00	82.00	1.68	87.20	11202
T ₅	09.92	87.17	89.00	2.13	92.17	11690
T ₆	11.00	63.75	84.00	1.81	89.32	11926
T ₇	14.20	60.77	72.00	1.65	81.06	9926
T ₈	13.00	63.49	80.00	1.90	86.05	10272
T ₉	13.72	62.39	74.00	1.72	81.65	10988
T ₁₀	16.00	54.17	65.78	1.54	71.29	8737
SEm+	0.34	1.37	1.48	0.08	2.28	366
CD (p=0.05)	1.00	4.04	4.36	0.23	6.71	1088

Results and Discussion

The result of present investigation revealed that use of different growth media and plant growth regulators reduced the imbibition period (Table 1). The data showed that application of soil + vermicompost + seed soaking with GA₃ @ 150 ppm (T₂) significantly reduced the imbibitions period as compared to other treatments except treatment T₅ (soil + cocopeat + seed soaking with GA₃ @ 150 ppm), which was found statistically at par. The findings clearly indicated that combination of growth media and plant growth regulators played a significant role for inducing early germination in papaya seeds. Growing medium (soil + vermicompost) had the best water holding capacity, porosity and nutrients which would have enhanced the availability of water, aeration and nutrition during germination of seed. Reducing in duration of imbibition period with application of soil + vermicompost + seed soaking with GA₃ @ 150 ppm (T₂) might be due to fact that vermicompost, not only provided plant nutrients but also improved the physical conditions of mixture in respect of granulation, friability and porosity which developed a balanced nutritional environment and water holding capacity favourable to seed and plant system (Edwards, 1998). This was also evident from reduced period of imbibition that combined applications of soil, vermicompost, along with 150 ppm GA₃ and soil, cocopeat along with GA₃ @ 150 ppm or NAA @ 50 ppm were more advantageous than all other combinations. Thus, the seedling grew well in a medium containing soil, vermicompost with GA₃ was suitable for propagation as reported by Pandit (2001), Yogeesh (2007), Abirami *et al.* (2010), Rajamanickam and Anbu (2010), Meena *et al.* (2012), Bhardwaj (2013) and Ramteke *et al.* (2015).

Findings of all the authors proved that, vermicompost is high in nutrients, when it mixed with soil

and GA₃ which break the dormancy and increase germination of papaya seeds, it also provide a balanced nutrition for improving early germination and plant establishment. Seed germination parameters of papaya (*Carica papaya* L.) as affected by different growth media and plant growth regulators are presented in Tables 1. Results indicated that application of soil + vermicompost + seed soaking along with GA₃ @ 150 ppm (T₂) was found to be the best among all the treatments but found statistically at par with T₅ (soil + cocopeat + seed soaking with GA₃ @ 150 ppm) with regard to germination behavior as these media have, high porosity, aeration, drainage, water holding capacity and microbial activity, Edwards (1998), Atiyeh (2000). These media contain most nutrients in available forms such as nitrates, phosphates, exchangeable calcium, soluble potassium (Edwards, 1998). The plant growth regulators and other plant growth influencing materials *i.e.* auxins, cytokinins, and humic substances *etc.*, produced by micro organisms have also been reported from vermicompost (Atiyeh, 2002 b).

Maximum germination percentage was recorded when seeds soaked in GA₃ might be due to the fact that GA₃ involved in the activation of cytological enzymes which stimulates α -amylase enzyme that converts insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks (Babu *et al.* 2010). GA₃ also plays an important role in leaching out of the inhibitors which in turn helps in breaking the seed dormancy. As per the results in dictated, the germination started at 9.32 days after sowing on soil + vermicompost + seed soaking with GA₃ @ 150 ppm (T₂) during experimentation this treatment recorded maximum rate of emergence (90.57%), highest germination per cent (92), maximum germination index (2.28) and maximum seedling vigour (94.27%) for Papaya seedlings. The soil + vermicompost (2:1) without plant growth

regulators (GA₃) showed the least results in most cases. Application of this treatment allowed increased germination parameters from the beginning to the end of experiment as compared to other media combination. The reason for the best performance of vermicompost and GA₃ might be having high organic matter content which preserve soil humidity, increase nutrient content and improve soil structure. It also increase water absorption and maintained the cell turgidity, cell elongation and increased respiration at optimum level, leading to favourable seed sprouting. In addition to this, it increases the nutrient holding capacity of the medium, which ultimately improve the utilization capacity of the plant (Joiner and Nell, 1982). The maximum germination index with GA₃ might be due to its influence in early germination and increased per cent germination. The results are in conformity with findings of Rajamanickam and Anbu (2010) in aonla.

Economics of the treatment : Application of soil : vermicompost (2:1) along with NAA @ 50 ppm for raising of papaya seedlings was found to be the best to make profitable and showed maximum net returns (? 12394/1000 seedlings). This might be due to fact that highest seedling vigour and survival percentage was obtained under this treatment. The higher net returns under this treatment could be ascribed to the lesser cost of treatments and higher healthy seedlings. Similar results have also been reported by Choudhari and Chakrawar (1981) and Anjanawe *et al.* (2012) in papaya.

References

1. A.O.S.A 1983. *Seed Vigour Testing Handbook*. Contribution No. 32 to Handbooks on seed testing. Association of Official Seed analysis, Ithaca, New York, USA.
2. Abad, M., Noguere, P., Puchades, R., Maquieira, A. and Noguera, V. 2002. Physio - chemical and chemical properties of some coconut dusts for use as a substitute for containerized ornamental plants. *Bioresource Technology*, 82: 241-245.
3. Abirami, K., Rema, P.A. and Mathew 2010. Effect of different propagation media on seed germination, seedling growth and vigour of nutmeg. *Journal of Medicinal plants Research*, 4 (19): 2054-2058.
4. Anjanawe, S.R., Kanpure, R.N., Kachouli, B.K. and Mandloi, D.S. 2012. Effect of plant growth regulators and growth media on seed germination and growth vigour of papaya. *Annals of Plant and Soil Research*, 15 (1): 31-34.
5. Anonymous, 2015. NHB. Database area and production of papaya. www. NHB.com.in.
6. Atiyeh, R.M., Arancon, N.Q., Edwards, C.A., and Metzger, J.D. 2000. Influence of earthworm - processed pig manure the growth and yield of green house tomatoes. *Bioresource Technology*, 75: 175-180.
7. Atiyeh, R.M., Lee, S.S., Edwards, C.A., Arancon, N.Q. and Metzger, J. 2002 b. The influence of humic acid derive from earthworm processes organic waste on plant growth. *Bioresource technology*, 84: (14).
8. Babu, K.D., Patel, R.K., Singh, A., Yadav, D.S., and Deka, B.C. 2010. Seed germination, seedling growth and vigour of papaya under North-East Indian condition. *Acta Horticulturae*, 851: 299-306.
9. Beattie, D.J. and White, J.W. 1992. Liliun. Hybrids and spices in: De Hortogh A.A. and Le Nard M. (edition), *The physiology of Flower Buds Elsevier, Amsterdam*, 423-454.
10. Bhardwaj, R.L. 2013. Effect of growing media on seed germination and seedling growth of papaya cv. Red Lady. *Indian Journal of Agriculture Research*, 47 (2): 163-168.
11. Choudhari, B.K. and Chakrawar, V.R. 1981. Note on the effect of some chemicals on the germination of Rangpur lime seeds. *Indian Journal of Agriculture Sciences*, 51 (3): 313-315.
12. Das, B.C, Das, T.K. 1996. Studies on the response of GA₃, NAA and Etherl on the vegetative growth and yield of pumpkin. *Orissa journal of Horticulture*, 24: 74-78.
13. Edwards, C.A. and Burrows, I. 1998. The potential of earthworm compost as plant growth media. *Earthworm Waste and Environmental Management*, 211-219.
14. Islam, A.K., Anuar, M.A. and Yaakob. 2009. Effect of genotypes and presowing treatment on seed germination behavior of *Jatropha*. *Asian Journal of Plant Science*, 8: 433-439.
15. Joiner, J.N. and Nell, T.A. 1982. Fired montmalillonite clay as a propagation and hydraulic growing medium. Proceeding. Florida state. *Horticulture Society*, 93: 214-215.
16. Mason, J. 2003. *Sustainable agriculture*. Landlinks Press. PP. 192 edition (2) ISBN 978-0-643-0687-6.
17. Meena, R.R, Jain, M.C. and Mukerjee, S. 2012. Effect of pre-sowing dip treatment with gibberellic acid on germination and survivability of papaya. *Annals of Plant and Soil Research*, 5 (1): 120-121.
18. Pandit, V.K, Nagarajan, S. and Sinha, J.P. 2001. Improving papaya (*Carica papaya* L.) seed germination and seedling growth by presowing treatments. *Indian Journal of Agriculture Science*, 71 (11): 704-705.
19. Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Method for agricultural workers*. Fourth edition. Indian Council of Agricultural Research, New Delhi. P1-381.
20. Ramteke, V., Paithanker, D.H., Kamatyanattii, M. and Baghel, M.M. 2015a Seed germination and seedling growth of papaya as Influenced by GA₃ and potting media, *Journal of progressive Agriculture*, 6 (1): 129-123.
21. Shanmugavelu, K.G. 1985. Studies on the effect of plant growth regulators, on Cashewnut. *Acta Horticulturae*, 10: 32-39.
22. Srivastva, R., Nanhorya, R. and Upadhyay, J.K. 1998. Selection of proper potting mixture for root trainer of Eucalyptus Hybrid. *Indian Forester*, 124: 503-510.
23. Yogeesh, H.S. Bhanuprakash, K. and Naik, L.B. 2007. Effect of temperature and chemical pre-treatment on seed germination in papaya. *Indian Journal of Agricultural Sciences*, 77 (10): 689-91.



Effect of Nitrogen and Potassium Fertilization on Performance of Sesame (*Sesamum indicum* L.) under Loamy Sand Soils of Jaipur District of Rajasthan

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Abstract

A field experiment was carried out during *summer* season, 2016 to study the effect of nitrogen and potassium fertilization on growth, yield and quality of sesame. The experiment was taken in Randomized block design with four nitrogen levels [0, 20, 40 and 60 kg N/ha] and four levels of potassium (0, 10, 20 and 30 kg K₂O/ha) with sixteen treatment combination and replicated three times. Results from data revealed that results indicated that progressive increase in level of nitrogen up to 40 kg/ha significantly increased the plant height and dry matter accumulation/plant at all the growth stages, number of branches/plant, yield (seed, stalk & biological), oil content and oil yield over preceding levels. Further increase in nitrogen level to 60 kg/ha could not enhance the above parameters significantly. Results further revealed that progressive increase in level of potassium up to 20 kg/ha significantly increased the above mentioned parameters over 10 kg K₂O/ha and control. The above treatment remained at par with 30 kg K₂O/ha.

Key words : Growth, potassium, nitrogen, quality, yield.

Introduction

Sesame (*Sesamum indicum* L.) commonly known as *til* also called as “queen of oilseeds” has been known to be one of the earliest domesticated edible oilseeds used by the mankind. The crop is grown in wide range of environments extending from semi-arid tropics and sub-tropics to temperate regions. Sesame is an edible oilseed crop next to groundnut and rapeseed-mustard. Its oil content generally varies from 46 to 52 per cent and protein content from 18-20 per cent. In India, sesame is cultivated on 15.98 lakh hectares with annual production of 8.20 lakh tonnes (Anonymous, 2014-15).

Despite of being such an important sesame growing state, the average productivity is very low in comparison to global as well as national level. Cultivation of crop on marginal and sub-marginal lands of poor fertility under rainfed condition, low and scanty rainfall, poor agronomic practices and inadequate or even no use of fertilizers are the major factors responsible for low productivity of the crop.

Poor nourishment especially of nitrogen, is another factor of low productivity of sesame. Nitrogen is universally deficient plant nutrient in most of the Indian soils, particularly the light textured ones where most of sesame growing areas are confined (Chhonkar and Rattan, 2000). Besides nitrogen, potassium is an essential macronutrient that is taken up by plants from soil in relatively large amounts. Currently nitrogenous and phosphatic fertilizer application is several times higher than that of K (6.8:2.8:1.0). This NPK use ratio when compared from a

generally proclaimed ideal ratio of 4:2:1 is typically unfavourable to potassium (Katyal, 2001). Potassium plays a key role in many metabolic processes in plants. Inspite of the enormous role of potassium in plant physiological and metabolic processes as well as activation of many enzymatic systems, its application to field crops is being ignored with the understanding that our soils are not deficient in potassium. Considering the above facts in view, the present investigation was conducted during *kharif*, 2016.

Materials and Methods

A field experiment was conducted during the *kharif* seasons of 2016 at SKN College of Agriculture, Sri Karan Narendra Agricultural University, Jobner. Geographically, jobner is situated 45 km west of Jaipur at 26° 05' North latitude, 75° 28' East longitude and at an altitude of 427 meters above mean sea level. The average annual rainfall of this tract varies from 400 mm to 500 mm and is mostly received during the months of July to September. Soils are loamy sand with 0.21% organic carbon, 126.3 kg ha⁻¹ N, 19.23 kg ha⁻¹ P₂O₅ and 150.26 kg ha⁻¹ K₂O. Experiment was laid out in a randomized block design with three replications comprising 16 treatment combination. The recommended dose of 25 kg P₂O₅/ha through SSP was drilled as basal 10 cm deep and N and K₂O were applied as per treatment through urea and MOP, respectively. The dose of sulphur @ 20 kg/ha was applied through sulphur dust. Different growth attributes studied viz., plant height and dry matter accumulation/plant at all the growth stages, number of branches/plant, were counted in five randomly selected one meter row length in each plot at

Table-1 : Effect of nitrogen and potassium on growth parameters, yield, oil content and oil yield of sesame.

Treatments	Growth parameters								Yield (Kg/ha)			Oil	
	Plant height (cm)			Dry matter accumulation (g)/plant			No. of branches/plant	Seed yield	Stalk yield	Biological yield	Oil Content	Oil Yield (kg/ha)	
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS						At harvest
Nitrogen (N kg/ha)													
0	28.2	107.5	130.9	1.54	9.83	10.28	3.02	3.14	642	1812	2454	43.29	279.84
20	34.3	118.5	143.5	1.68	10.75	11.18	3.37	3.49	881	2470	3351	46.11	406.78
40	40.2	125.8	151.7	1.82	11.63	12.04	3.64	3.78	983	2821	3735	48.86	482.68
60	40.8	127.8	153.2	1.87	11.90	12.44	3.75	3.87	1020	2893	3896	49.48	506.94
SEm±	1.03	2.14	2.51	0.04	0.24	0.27	0.08	0.09	24	65	78	0.95	14.49
CD	2.96	6.16	7.22	0.11	0.69	0.78	0.24	0.25	69	186	224	2.72	41.71
Potassium (K ₂ O kg/ha)													
0	33.5	111.3	134.8	1.62	10.02	10.38	3.11	3.22	711	2009	2753	44.67	321.64
10	35.9	118.1	143.0	1.74	10.83	11.26	3.38	3.50	877	2477	3330	46.41	407.18
20	36.5	124.3	150.4	1.76	11.60	12.10	3.63	3.77	958	2727	3630	47.72	463.67
30	37.5	125.9	151.2	1.79	11.66	12.20	3.66	3.80	980	2783	3722	48.94	483.75
SEm±	1.03	2.14	2.51	0.04	0.24	0.27	0.08	0.09	24	65	78	0.95	14.49
CD	2.96	6.16	7.22	0.11	0.69	0.78	0.24	0.25	69	186	22	2.72	41.71

physiological maturity of the sesame. The sesame RT-346 was sown at 30 cm row spacing on 16 July 2016 and harvested 20 October 2016. For calculating seed yield the total biomass harvested from each net plot was threshed, cleaned and dried. Seeds, thus obtained were weighed in terms of kg/plot and converted to kg/ha and stalk yield per plot was calculated by subtracting the seed yield from the biological yield and then expressed in kg/ha. Biological yield after thorough sun drying of harvested material, weight was taken for biological yield per plot and then converted to kg/ha. Oil content in seed was determined by Soxhlet's Ether Extraction Method (A.O.A.C., 1960).

Results and Discussion

Effect of Nitrogen : The results revealed that application of 40 kg N had favourable effect on growth and biomass production. All the growth parameters viz., plant height, dry matter accumulation per plant and branches per plant increased linearly with the corresponding increase in levels of N. This increment was, by and large, statistically significant over control and 20 kg N/ha (Table-1). It can be attributed to the better availability of nutrients in root zone for development of the crop. The increase in these components seems to have been brought about by increase in amount of growth substances and naturally occurring phytohormones with increased nitrogen supply. Probably the increase in auxin supply with higher levels of nitrogen brought about increase in the dry matter accumulation and biomass. The observed improvement might be due to an early and plentiful availability of

nitrogen leading to better nutritional environment in the root zone for growth and development as nitrogen is one of the major essential plant nutrients required for growth. Results of the present investigation are in conformity with those of Okpara *et al.* (2007) and Ogundare *et al.* (2015) in sesame.

Application of successive nitrogen upto 40 kg/ha significantly increased the seed, stalk and biological yield of sesame, however it remain at par with 60 kg/ha. As seed yield is primarily a function of cumulative effect of yield determining characters, significantly higher values of these characters might be ascribed as the most probable reason of getting higher seed yield of sesame. Increases in stalk yield and biological yield bear ample testimony to this effect that an increased supply of N was available which culminated in greater production of seeds and dry weight and contributed to greater yield. The results of present investigation are in line with those of Tripathi and Rajput (2007), Sarala and Jagannatham (2002) and Purushotham *et al.* (2009) in sesame, who obtained increased yield attributes, seed, stalk and biological yields with the application of nitrogen upto optimum level.

Result showed in table revealed that significant increase in oil percentage and oil yield with suitable dose of nitrogen i.e. 40 kg/ha was observed in the present investigation because of increased N content in seed which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen content might be due to increased activity of nitrate

reductase enzyme. These results are in close conformity with the findings of Mondal *et al.* (2001), Sujathamma *et al.* (2003) and Shehu *et al.* (2010) in sesame.

Effect of Potassium : The sesame crop responded favourably to potassium fertilization in terms of plant height, number of branches/plant, crop dry matter accumulation/plant at all the stages of observation. Significant response to applied K was noted up to 20 kg/ha in respect of these growth determining characters. However, it showed statistical equivalence with 30 kg/ha, wherein, the maximum values of most of the growth attributes were recorded. The result of this study were in close conformity as observed by Sarkar and Pal (2005), and Deshmukh *et al.* (2010) on sesame.

It is apparent from data presented in table-1 that seed yield of sesame increased significantly with successive increase in level of potassium upto 20 kg/ha. This level of potassium fertilization produced the seed yield of 958 kg/ha, thereby, registering a quantum increase of 81 and 247 kg/ha over 10 kg/ha and control, respectively. Stalk and biological yield also increase significantly with the above same level of potassium. These results are in close conformity with the findings with those of Sarkar and Pal (2005), Jadav *et al.* (2010) on sesame.

Results revealed that increasing levels of potassium significantly increases oil content and oil yield in sesame. Data in table 1 indicated that the application of potassium at 20 and 30 kg/ha significantly improved the oil content over control. The result are in agreement with those of Mollashahi *et al.* (2013), Viradiya *et al.* (2004) and Mondal *et al.* (1997).

References

1. A.O.A.C.1960. Official Method of Analysis. Association of Official Analytical Chemists, 1608 Broadnon Drive, Champaign, Illinois, USA.
2. Anonymous, 2014-15b. Rajasthan Economic Review. Commisionerate of Agriculture, Rajasthan, Jaipur pp. 48-56.
3. Chhonkar, P.K. And Rattan, R.K. 2000. Soil and fertilizer management for sustainable agriculture. *Indian Farming*, 2: 28.
4. Jadav, D.P., Padamani, D.R., Polara, K.B., Parmar, K.B. and Babaria, N.B. 2010. Interaction effect of sulphur and potassium on yield and nutrients uptake by sesame (*Sesamum indicum* L.). *An Asian Journal of Soil Science* 5: 144-147.
5. Katyal, J.C. 2001. Fertilizer use situation in India. *Journal of the Indian Society of Soil Science* 49: 570-592.
6. Mollashahi, M., Ganjali, H. and Fanaei H. 2013. Effect of different levels of nitrogen and potassium on yield, yield components and oil content of sunflower. *International Journal of Farming and Allied Sciences* 2 : 1237-1240.
7. Mondal, S. S., Pramanik, C.K. and Das, J. 2001. Effect of nitrogen and potassium on oil yield, nutrient uptake and soil fertility in soybean (*Glycine max*) - sesame (*Sesamum indicum*) intercropping system. *Indian Journal of Agricultural Sciences* 71(1): 44-46.
8. Mondal, S.S., Dasmahapatra, A.N., Chatterjee, B.N. and Maiti, P.K. 1997. Effect of potassium application on the yield and oil content of sesame, mustard and groundnut on a K-deficient soil. *Journal of Potassium Research* 13 : 153-158.
9. Ogundare ,S.K., Aydele F.G.and Oloniha, J.A. 2015. Effect of time of sowing and urea application rate on the growth and yield of two varieties of sesame (*Sesamum indicum*) in Ejiba Kogi state, Nigeria. *Nigerian Journal of Agricultural Food and Environment* 11(4): 118-123.
10. Okpara, D.A. Muoneke, C.O. and Ojikpong, T.O. 2007. Effect of nitrogen and phosphorus rates on growth and yield of sesame (*Sesamum indicum* L.) in the south eastern rainforest belt of Nigeria. *Nigerian Agricultural Journal* 38 :1-11.
11. Purushotham, G., Harsha K.N., Shashidhra, G.C., Krishnegowda, M., Tanveer, A. and Manjunath B.N. 2009. Integrated nutrient management in sesame (*Sesamum indicum* L.).*Journal of Oilseed Research* 26: 264-265.
12. Sarala, N.V. and Jagannatham, A. 2002.Effect of nitrogen and Azospirillum on yield attributes and yield of sesame under rainfed conditions. *Journal of Oilseeds Research* 19(1): 125-126.
13. Sarkar, R.K and Pal P.K 2005. Effect of crop geometry ,fertility level and nipping on physiological parameters in relation to productivity of sesame (*Sesamum indicum* L.). *Indian Journal of Agricultural Science* 75(3): 143-147.
14. Shehu, H.E., Kwari J.D. and Sandabe M.K. 2010. Effects of N, P and K Fertilizers on Yield, Content and Uptake of N, P and K by Sesame (*Sesamum indicum*). *International Journal of Agriculture and Biology* 12: 845–850.
15. Sujathamma, P., Reddy D.S. and Reddy B.S. (2003). Direct, residual and cumulative residual effect of nitrogen on yield parameters, yield and nitrogen uptake of sesame in rice-groundnut-sesame cropping system. *Annals of Agricultural Research* 24(3): 587-592.
16. Tripathi, M.L. and Rajput, R.L. (2007). Response of sesame (*Sesamum indicum*) genotypes to levels of fertilizers. *Advances in Plant Sciences* 20(2): 521-522.
17. Viradiya, M.B., Marsonia, P.J. and Golakiya, B.A. 2004. Response of summer groundnut (*Arachis hypogaea* L.) to potassium in the diverse soils of Saurashtra. *Advances Plant Sciences* 17: 615-618.



Effect of Solid and Liquid Forms of Organic Manure on Growth and Yield of Soybean (*Glycine Max* L. Merrill)

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Abstract

Field experiment was carried out during the kharif season of 2012-13 at the Crop Research Farm, Department of Agronomy (SHIATS Model Organic Farm, Block-E) Allahabad School of Agriculture, SHIATS, Allahabad (U.P.) to evaluate the effect of different solid and liquid forms of organic manure on growth and yield of soybean. The experiment was laid out in randomized block design with three replications. The treatment consisted of three sources of solid (Vermicompost 2.6 t ha⁻¹, Farmyard manure 16 t ha⁻¹ and Poultry manure 2.2 t ha⁻¹) and liquid (Panchgavya and Fish Amino Acid) forms of organic manures and two cultivars (JS 335 and JS 95-60). The experimental results revealed that FYM + Panchgavya + Variety JS 335 recorded at all stages (growth stages plant height (47.26) number of branches plant⁻¹(10.46), dry weight (21.33), crop growth rate (44.43) and stover yield (2876.66 kg ha⁻¹) there were significant difference between treatments, except relative growth rate (0.03) at 60-75 days interval and seed yield (2198.33 kg ha⁻¹).

Key words : Organic farming, farm yard manure, vermicompost, panchgavya, variety JS 335, CGR.

Introduction

Soybean (*Glycine max* L.) is considered as a wonder crop of 21st century which is the top oil seeds in the world production. It is an important oil seed crop in addition to source of food, feed, and nutrition. Imkongtoshi and Gohain (2009) .It is an excellent health food and contains about 44% good quality protein, 20% Cholesterol free oil, 20% Carbohydrate and 0.69% Phosphorus (Gahukar *et al.*, 1997). The major constraint affecting the productivity is the adequate availability of suitable genotype and nutrients (Venkateswarlu *et al.*, 1987). Choosing and cultivation of suitable genotype that adapts itself under the peculiar climatic condition of the Allahabad region is a necessity for soybean sustainability. Concomitantly, adoption of appropriate agronomic operations may result in acceptable phenotypical characteristics, viz., plant height number of branches plant⁻¹ dry matter production, nodulation and ultimate enhancement of productivity of the crop. One of the feasible solutions for addressing the imbalanced nutrient and related constraints, is the foliar spray of *Panchgavya*, which promote growth and vigour of plant and improves productivity (Pathak and Ram, 2002). The management of manures within a crop rotation can have large effects on yields and crop quality (Stein-Bachinger and Werner, 1997). Organic farming plays greater role in maintaining soil health and reducing the risk of soil erosion when compared to chemical farming (Reganold and Palmer, 1995). There is need to refining and standardized package of practice for important crop under organic farming system. evaluated the combined use of solid and liquid organic manure

(farmyard manure, Vermicompost, poultry manure, *Panchgavya* and Fish amino acid) on soybean. Nutrient imbalance is one of the important constraints of soybean productivity. Therefore in the present investigation effect of various of solid and liquid organic manure on growth and yield of soybean was carried out.

Materials and Methods

The soil of the experimental field was shallow in depth (30 cm) having 0.34% organic carbon, 13.50 kg ha⁻¹ available P₂O₅, 257.00 kg ha⁻¹ available K₂O, pH 7.5 and EC (0.13 dS m⁻¹). The experiment was laid out in Randomized Block Design with three replication. The treatment combinations in the experiment comprised of 3 sources of solid organic manures viz., Farmyard manure, Poultry manure and Vermicompost which were calculated on the basis of 40 kg ha⁻¹ phosphorus equivalency (Farmyard manure 16 t ha⁻¹, Poultry manure 2.2 t ha⁻¹ and Vermicompost 2.6 t ha⁻¹), 2 cultivars (JS 335, JS 95-60), and 2 sources of liquid manures (*Panchgavya* 3% and Fish amino acid 3%). These sources of foliar application were applied during grand growth (30 DAS), branching (45 DAS) and flowering (60 DAS). *Panchgavya* was prepared with a mixture of five components in the ratio of 5:4:3:2:1, viz., cow dung, cow urine, milk, curd, cow ghee and six ripe bananas respectively, which was fermented for 21 days. Fish amino acid was prepared with a mixture of two components in the ratio of 1:1, viz., fish waste and jaggery which was fermented for 21 days.

Results and Discussion

There was progressive increase plant height, number of

Table-1 : Effect of solid and liquid forms of organic manures on growth, yield attributes, economics and post-harvest soil status of phosphorus of two cultivars of soybean.

	Treatments	60 DAS		60-75 DAS				Stover yield (kg ha ⁻¹)	*Net return (Rs. ha ⁻¹)	*B:C ratio
		Plant height (cm)	Number of Branches plant ⁻¹	Dry weight	Growth interval		Seed yield (kg ha ⁻¹)			
					CGR (g m ⁻² Day ⁻¹)	RGR (g g ⁻¹ Day ⁻¹)				
T ₁	Vermicompost + Fish amino acid + Variety JS 335	44.26	9.33	19.00	12.58	0.01	1504.33	2314.33	36840.35	1.94
T ₂	Vermicompost + <i>Panchgavya</i> + Variety JS 335	45.20	10.06	14.66	37.76	0.05	1677.66	3240.00	45732.35	2.17
T ₃	Vermicompost + Fish amino acid + Variety JS 95-60	34.46	6.33	14.00	14.06	0.03	1157.33	1967.00	16263.66	1.41
T ₄	Vermicompost + <i>Panchgavya</i> + Variety JS 95-60	35.33	7.20	11.66	14.81	0.03	1214.66	2198.33	22239.00	1.57
T ₅	Poultry manure + Fish amino acid + Variety JS 335	43.33	9.46	17.00	30.36	0.04	1793.66	3009.00	51869.66	2.34
T ₆	Poultry manure + <i>Panchgavya</i> + Variety JS 335	44.13	8.86	16.00	17.02	0.09	1793.66	2198.66	52013.66	2.35
T ₇	Poultry manure + Fish amino acid + Variety JS 95-60	37.40	7.26	13.00	14.06	0.11	1446.33	2082.66	34209.66	1.88
T ₈	Poultry manure + <i>Panchgavya</i> + Variety JS 95-60	38.13	7.53	16.33	11.10	0.02	1909.33	2082.66	57685.00	2.49
T ₉	Farmyard manure + Fish amino acid + Variety JS 335	42.73	9.66	16.00	25.91	0.03	1851.33	2719.66	49450.35	2.12
T ₁₀	Farmyard manure + <i>Panchgavya</i> + Variety JS 335	47.26	10.46	21.33	44.43	0.03	2198.33	3876.66	72925.66	2.66
T ₁₁	Farmyard manure + Fish amino acid + Variety JS 95-60	35.33	7.66	12.00	21.47	0.15	1388.33	2320.66	25057.00	1.55
T ₁₂	Farmyard manure + <i>Panchgavya</i> + Variety JS 95-60	35.76	6.53	11.66	19.99	0.04	1562.00	2372.33	34849.00	1.79
	SED (±)	3.88	1.05	2.26	5.21	0.07	412.02	409.55	-	-
	CD (P= 0.05)	8.05	2.18	4.69	10.80	NS	NS	849.35	-	-
	CV (%)	11.80	15.41	18.19	29.04	152.20	31.06	19.81	-	-
Vermicompost (2.6 t ha ⁻¹), Farmyard manure (16 t ha ⁻¹), Poultry manure (2.2 t ha ⁻¹), <i>Panchgavya</i> (3%), Fish Amino Acid (3%).										

branches plant⁻¹ and dry weight at 60 DAS significantly higher values (47.26, 10.46 and 21.33 g respectively) observed in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). However, plant height and number of branches plant⁻¹ in treatment T₁ (Vermicompost + Fish Amino Acid + Variety JS 335), T₂ (Vermicompost + *Panchgavya* + Variety JS 335), T₅ (Poultry manure + Fish amino acid + Variety JS 335), T₆ (Poultry manure + *Panchgavya* + Variety JS 335), and T₉ (Farmyard manure + Fish amino acid + Variety JS 335), were found to be statistically at par with T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). Further dry weight in treatment T₁ (Vermicompost + Fish Amino Acid + Variety JS 335) and T₅ (Poultry manure + Fish amino acid + Variety JS 335), was found to be statistically at par with T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). Application of organic formulation may have supplied sufficient quantity of phosphorus and other essential nutrient. The phosphorus has specific role to play in root development which result in shoot biomass and hence the number of branches plant⁻¹ and ultimately affecting the crop growth. Similar finding were reported by Abbas *et al.* (1994) and Chiezey *et al.* (1992).

Another aspect is the increase of microbial population in soil because of the application of organic matter, which might have improved biological nitrogen fixation, greater release of phosphorus and synthesis of growth promoting hormones (Dubey, 1997 and Baskar *et al.*, 2000).

Significantly higher crop growth rate (CGR 21.33) recorded in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). However crop growth rate in T₂ (Vermicompost + *Panchgavya* + Variety JS 335) was to be found statistically at par with T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). Organic manures gradually release nitrogen and other essential nutrients in a slow pattern. Further, organic matter and ammonium ions are released after their decomposition and these are inhibitory to

the Nitrate Reductase (NR) activity, which is highly desirable. Similar finding was reported by Claussen and Lenz (1999). Thus the results clearly showed that all the organic manures used in the study played an important role to increase biomass of soybean crop.

Significantly higher stover yield recorded in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). The maximum seed yield, net return and B: C ratio (2198.33 kg ha⁻¹, 72925.66 ha⁻¹ and 2.66 respectively) were recorded in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). The beneficial effects to regulate balanced supply of nutrient including primary, secondary and micronutrients, tilting microbial dynamics and modifying soil environment favorably for crop growth is another phenomenon worthwhile mentioning (Nehra *et al.*, 2001). Further, it was also observed that *Panchgavya* besides supplying N, P and K also possessed insecticidal property and controlled *Spodoptera litura*. Application of organic sources releases essential macro and micronutrients over a long period, leading to increased vegetative growth and thus augmented stover yield (Patel *et al.*, 2007).

References

1. Abbas, Mohd, Singh, M.P., Nigam, K.B. and Kandalkar, V.S. 1994. Effect of P, plant densities and plant types on different growth and physiological parameter of soybean. *Indian Journal of Agronomy* 39(2): 246-268.
2. Baskar, M., Solaimalai, A., Sivakumar, C.G., Sankaranarayanan, K. and Sudhakar, G. 2000. Effect of phosphorus, zinc and phosphobacteria on soybean: a review. *Agricultural Reviews* 21(1): 60-65
3. Chiezy, U.F., Yayock, J.Y. and Shebayan, Jay 1992. Respnce of soybean (*Glycine Max* (L) Merrill) to nitrogen and phosphorus fertilizer lavel. *Tropical science* 32: 361-368.
4. Claussen, W. and Lenz, F. 1999. Effect of ammonium or nitrate nutrition on net photosynthesis, growth and activity of the enzymes nitrate reductase and glutamine synthetase in bluberry, raspberry and strawberry. *Plant Soil* 208: 95-102.
5. Dubey, S.K. 1997. Co-inoculation of phosphorus-solubilizing bacteria with *Bradyrhizobium japonicum* to increase phosphate availability to rainfed soybean on vertisol. *Journal of Indian Society of Soil Science* 45(3): 506-509
6. Gahukar, R.T. 1997. Soybean lagwadiche Adhunik Tantradnyan. Agri.-Horticultural publishing House, Nagpur, pp 5-7.
7. Nehra, A.S., Hooda, I.S. and Singh, K.P. 2001 Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum*). *Indian Journal of Agronomy* 46(1): 112-17.
8. Patel, B.T., Patel, J.J. and Patel, M.M. 2007. Response of groundnut (*Arachis hypogaea*) to FYM, sulphur and micronutrients and their residual effect on wheat (*Triticum aestivum*). *Journal of Soil and Crop* 17(1): 18-23.
9. Pathak. R.K. and Ram, R.A. 2002. Approaches for organic Production of vegetables in India Report of central Institute for Subtropical Horticulture. Rehmankhera Lucknow: 1-13
10. Reganold, J.P. and Palmer, A.S. 1995. Significance of gravimetric and volumetric measurements of soil quality under biodynamic, conventional and continuous grass management. *J. Soil Water Conserv.* 50: 298-305.
11. Venkateswarlu, J. 1987. Efficient resource management system for dry lands of India. *Advances in Soil Science* 7: 165-221.
12. Stein-Bachinger, K. and Werner, W. 1997. Effect of manure on crop yield and quality in an organic agricultural system. *Biology, Agriculture and Horticulture* 14: 221-35
13. Imkongtoshi and Gohain, T. 2009. Integrated nutrient management in Soybean (*Glycine max* L.) under terrace cultivation of Nagaland. *Crop Research.*, 8 (1,2 & 3) : 39-42.



Yield and Quality of Mustard (*Brassica juncea*) and Lentil (*Lens esculenta*) Intercropping System Influenced by Different Fertility Levels

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Abstract

A field experiment was conducted in Split Plot Design with five intercropping systems [sole mustard, sole lentil, mustard + lentil (1:3), mustard + lentil (2:2) and mustard + lentil (2:3)] and four fertility levels (0, 75, 100 and 125% RDF) and replicated thrice during *rabi* season, 2017-18 at Agronomy farm, S.K.N. College of Agriculture, Jobner. The results revealed that planting of mustard in 2:2 row ratio, being at par to sole mustard, gave significantly higher seed yield (2234 kg/ha) as compared to 1:3 and 2:3 row ratios. The 1:3 row ratio, remaining at par to sole lentil, recorded significantly higher seed yield of lentil as compared to 2:2 and 2:3 row ratio. The 1:3 row ratio, recorded significantly higher nitrogen concentration in seed of mustard. Planting of mustard in 2:2 and planting of lentil in 1:3 row ratio, recorded significantly highest total uptake of nitrogen and phosphorus. Application of fertility levels up to 125% RDF significantly increased the seed yield of mustard and lentil and nitrogen concentration in seed of mustard and straw of lentil, total nitrogen and phosphorus uptake of mustard and lentil. Whereas, RDF up to 100% significantly increased nitrogen concentration in stover and seed of lentil, phosphorus concentration in seed and stover/straw of mustard and lentil, oil content in seed of mustard and protein content in seed of lentil.

Key words : Mustard, lentil, intercropping, RDF, protein, oil.

Introduction

Oilseed crops are main source of energy in the diet of Indians. Though, India has become self-reliant with respect to food grains but still lagging behind in the production of oilseeds. Indian mustard (*Brassica juncea*) is one of the major edible oil seed crop, maximizing mustard production and productivity is crucial for reducing edible oil import burden for the country. While, lentil is the good supplier of protein and has a high nutritional value, its production and productivity enhancement is vital for achieving food and nutritional security. Hence, maximizing the productivity of Indian mustard (*Brassica juncea*) + lentil (*Lens esculenta*) cropping systems is crucial for the country. Intercropping is one of the most important techniques which, involves growing of crops under different plant geometry. To avoid the risk of sole crop failure, adoption of intercropping is more safe and profitable cropping system for increasing the total production and net profit per unit area. Intercropping offers to farmers an opportunity to utilize diverse resources available at his farm (Ghosh, 2004)^[7]. Legumes offer excellent compatible combination for mixing with oilseeds to minimize the competition and to confer symbiotic association to achieve the prime aim of maximum use of available resources. The productivity of crop is largely influenced by fertility management. The dose of fertilizer depends on the initial soil fertility status

and moisture availability conditions. Exploitation of genetic yield potentiality of new plant types of mustard although depends on the extent of fertilizer application, the balance and compatible composition of all the major nutrients is a must to obtain greater fertilizer use efficiency. Among the commonly applied major nutrients, nitrogen is the key element in mustard production, which is a structural components of protein molecules, amino acids, chlorophyll and other constituents. Its adequate supply promotes higher photosynthesis activity and vigorous vegetative growth. A higher nitrogen supply favours the conversion of carbohydrates into protein. Phosphorus plays an important role in improving water use efficiency due to its favourable effect on crop growth root development and high seed yield production per unit of water use. Its conspicuous role in hastening crop maturity is of still more interest to us in the age of intensive cropping system.

Materials and Methods

The experiment was conducted at Agronomy farm (Plot No. 1-C) S.K.N. College of Agriculture, Jobner (Rajasthan) during *rabi* season 2017-18. The experiment comprising twenty treatment combinations replicated thrice in Split Plot Design (SPD) with five intercropping systems [sole mustard, sole lentil, mustard + lentil (1:3), mustard + lentil (2:2) and mustard + lentil (2:3)] in main plot and four fertility levels (0, 75, 100 and 125% RDF) in

sub plot. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), poor in organic carbon (0.14%), low in available nitrogen (130.0 kg/ha) and medium in phosphorus (16.52 kg P₂O₅/ha) and potassium (151.8 kg/ha) content. The seeds of mustard variety T-59 @ 5 kg/ha and Lentil variety RLG-255 @ 40 kg/ha were used for sowing in the experiment. The sowing was done on 09.11.2017. Mustard seeds were sown at a spacing of 45 x 15 cm² and lentil was spaced at an intra-row spacing of 10 cm with 30 cm inter-row spacing. In 1:3 row ratio, three rows of lentil was planted after replacing one row of mustard in replacement series. In 2:2 and 2:3 row ratios, two and three rows of lentil were planted in between paired rows of mustard as additive series. Half dose of nitrogen through urea and full dose of phosphorus through DAP were incorporated in the soil before sowing in plots as per treatments and remaining half dose of nitrogen was applied 40 DAS. 60 kg N and 30 kg P₂O₅/ha for mustard sole and 20 kg N and 40 kg P₂O₅/ha for sole crop of lentil were applied. In intercropping systems, the RDF of mustard was applied. Yield of mustard and lentil were computed from the plants of net plot in each treatment. Oil percent in the mustard was determined by Soxhlet apparatus using petroleum ether (60-80°C) as an extractant and protein content in seed of lentil crop was calculated by multiplying the per cent N content in seed with the factor of 6.25 (A.O.A.C., 1960)⁽¹⁾.

The uptake of nitrogen by crop was calculated by following formula (Snell and Snell, 1949) :

$$\text{N uptake (kg/ha)} = \frac{\text{Per cent N in seed} \times \text{Seed yield (kg/ha)} + \text{Per cent N in stover/straw} \times \text{stover/straw yield (kg/ha)}}{100}$$

The uptake of phosphorus by crop was calculated by following formula (Jackson, 1967)^[8]:

$$\text{P uptake (kg/ha)} = \frac{\text{Per cent P in seed} \times \text{Seed yield (kg/ha)} + \text{Per cent P in stover/straw} \times \text{stover/straw yield (kg/ha)}}{100}$$

$$\text{Total uptake (kg/ha)} = \frac{\text{Nutrient conc. in seed} \times \text{Seed yield (kg/ha)} + \text{Nutrient conc. in stover/straw} \times \text{stover/straw yield (kg/ha)}}{100}$$

Results and Discussion

Effect of intercropping

Yield : Results indicated that planting of mustard in 2:2 row ratio with lentil obtained significantly highest seed yield (2234 kg/ha) of mustard as compared to 1:3 and 2:3 row ratios, whereas it remained statistically at par with sole planting of mustard. The 2:2 row ratio also improved

the seed yield of mustard by 77.2 and 16.1 per cent over 1:3 and 2:3 row ratios, respectively. It may be due to 100% population and beneficial effect of lentil as evidenced by increased growth and yield attributes. These findings are in close conformity with those of Meena *et al.* (2008), Singh *et al.* (2014) and Das *et al.* (2017).

A significant reduction in seed yield of lentil was recorded in 2:2 (739 kg/ha) and 2:3 (980 kg/ha) row ratios as compared to 1:3 (1441 kg/ha) row ratio and 1:3 row ratio remained at par with sole lentil (1400 kg/ha). The reduction in seed yield of lentil in 2:2 and 2:3 row ratios over sole lentil was primarily due to low plant population of lentil in 2:2 row ratio and significant reduction in yield attributes (pods/plant and seeds/pod). This might also be due to adverse effect of mustard as mustard was planted in paired row with 100% population and lentil was added between pair as additive series. Similar results were also found by Yadav *et al.* (2014) and Das *et al.* (2017).

Nutrient concentration, uptake and quality : A significant increase in nitrogen concentration in seed of mustard was recorded in 1:3 row ratio as compared to 2:3 row ratio, sole mustard and 2:2 row ratio. This was probably due to comparatively greater availability of nutrients to mustard in 1:3 row ratio as compared to 2:3 row ratio, sole mustard and 2:2 row ratio. This might be due to complementary effect of intercropping. The results are in close conformity with those of Devi *et al.* (2014). Among different intercropping systems, the planting of mustard in 2:2 row ratio gave significantly higher total nitrogen and phosphorus uptake as compared to 1:3 and 2:3 row ratio as well as sole crop. Further, sole mustard and 2:3 row ratio also gave significantly higher total nitrogen and phosphorus uptake as compared to 1:3 row ratio.

Similarly, planting of lentil in 1:3 row ratio also gave significantly higher total nitrogen and phosphorus uptake by lentil crop as compared to rest of intercropping treatments and remained at par with sole crop of lentil. Because nutrient uptake is a function of its concentration in crop plant and seed and stover/straw yields of the crop. The results are in close conformity with those of Meena *et al.* (2008) and Abraham and Thenua (2015). Oil content in seed of mustard and protein content in seed of lentil were not improved significantly by different systems of intercropping.

Effect of fertility levels

Yield : Application of Increasing levels of fertility up to 125% RDF recorded significant improvement in seed (2129 kg/ha of mustard and 1309 kg/ha of lentil), stover/straw (6428 kg/ha of mustard and 3663 kg/ha of

Table-1 : Effect of intercropping system and fertility levels on yields, nitrogen and Phosphorus concentration in seed and stover and total nitrogen and Phosphorus uptake and oil content in seed of mustard.

Treatment	Yields (kg/ha)		Nitrogen Concentration (%)		Total nitrogen uptake (kg/ha)	Oil content (%)	Phosphorus concentration (%)		Total phosphorus uptake (kg/ha)
	Seed	Stover	Seed	Stover			Seed	Stover	
Intercropping system									
Mustard sole	2050	6214	3.18	0.748	113.01	35.33	0.660	0.256	29.76
Mustard + Lentil (1:3)	1261	3776	3.91	0.787	79.99	37.29	0.700	0.268	19.15
Mustard + Lentil (2:2)	2234	6823	3.58	0.772	134.25	36.64	0.692	0.262	33.70
Mustard + Lentil (2:3)	1924	5795	3.09	0.733	103.06	35.05	0.648	0.253	27.43
SEm+	53	177	0.09	0.019	2.61	0.88	0.017	0.006	0.65
CD (P=0.05)	185	612	0.31	NS	9.02	NS	NS	NS	2.26
Fertility level									
Control	1557	4688	2.90	0.648	74.92	32.92	0.573	0.223	19.32
75% RDF	1800	5458	3.33	0.742	99.62	35.73	0.657	0.254	25.62
100% RDF	1983	6035	3.64	0.811	120.14	37.82	0.722	0.278	31.01
125% RDF	2129	6428	3.89	0.839	135.62	37.85	0.748	0.284	34.09
SEm+	36	102	0.06	0.014	2.07	0.60	0.013	0.005	0.54
CD (P=0.05)	118	334	0.21	0.047	6.76	1.97	0.042	0.016	1.75

NS = Non significant

Table-2 : Effect of intercropping system and fertility levels on yields, nitrogen and Phosphorus concentration in seed and straw and total nitrogen and Phosphorus uptake and protein content in seed of lentil.

Treatment	Yields (kg/ha)		Nitrogen Concentration (%)		Total nitrogen uptake (kg/ha)	Protein content (%)	Phosphorus concentration (%)		Total phosphorus uptake (kg/ha)
	Seed	Straw	Seed	Straw			Seed	Straw	
Intercropping system									
Lentil sole	1400	3901	3.51	1.59	112.41	21.94	0.342	0.214	13.31
Mustard + Lentil (1:3)	1441	4021	3.57	1.62	117.89	22.31	0.345	0.218	13.92
Mustard + Lentil (2:2)	739	2060	3.42	1.53	57.43	21.38	0.328	0.209	6.82
Mustard + Lentil (2:3)	980	2730	3.37	1.49	74.53	21.06	0.321	0.203	8.80
SEm+	33	97	0.08	0.04	2.84	0.52	0.008	0.005	0.34
CD (P=0.05)	113	335	NS	NS	9.82	NS	NS	NS	1.18
B. Fertility level									
Control	937	2604	3.11	1.31	63.63	19.44	0.281	0.176	7.26
75% RDF	1097	3054	3.41	1.50	83.71	21.31	0.324	0.205	9.87
100% RDF	1217	3391	3.66	1.65	101.10	22.88	0.357	0.226	12.08
125% RDF	1309	3663	3.69	1.77	113.82	23.06	0.374	0.237	13.65
SEm+	23	68	0.07	0.03	1.91	0.43	0.007	0.004	0.23
CD (P=0.05)	76	221	0.23	0.10	6.24	1.41	0.022	0.014	0.74

lentil) and biological (8557 kg/ha of mustard and 4972 kg/ha of lentil) yields of mustard and lentil. The increase in seed and stover/straw yields might be due to better nutritional status in the soil, which was low in N and P. The increased supply of NPK and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and led to increased growth and yield parameters and ultimately resulted in higher seed and stover/straw yields. The biological yield is a function of seed and stalk yields. Thus, significant increase in biological yield with the application of N and P could be ascribed due to increased seed and stover/stalk yields.

The results of present investigation are in line with those of Meena et al. (2013), Sharma et al. (2013), Singh et al. (2014), Balai et al. (2017b) and Keerthi et al. (2017).

Nutrient concentration, uptake and quality : The significant increase in N concentration in seed of mustard and straw of lentil and total nitrogen and phosphorus uptake of mustard and lentil were recorded with increased application of RDF up to 125%. The nitrogen concentration in stover of mustard and in seed of lentil, phosphorus concentration in seed and stover/straw, oil content in seed of mustard and protein content in seed of lentil were recorded significantly higher with increased

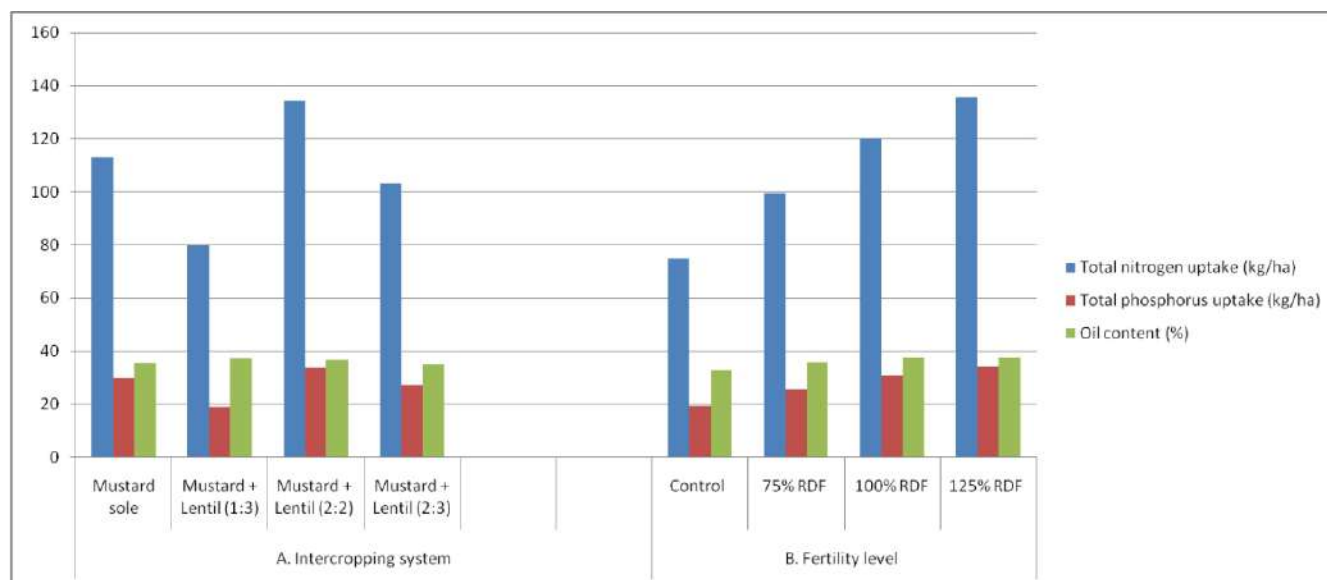


Fig.-1 : Effect of intercropping system and fertility levels on total nitrogen and phosphorus uptake and oil content in seed of mustard.

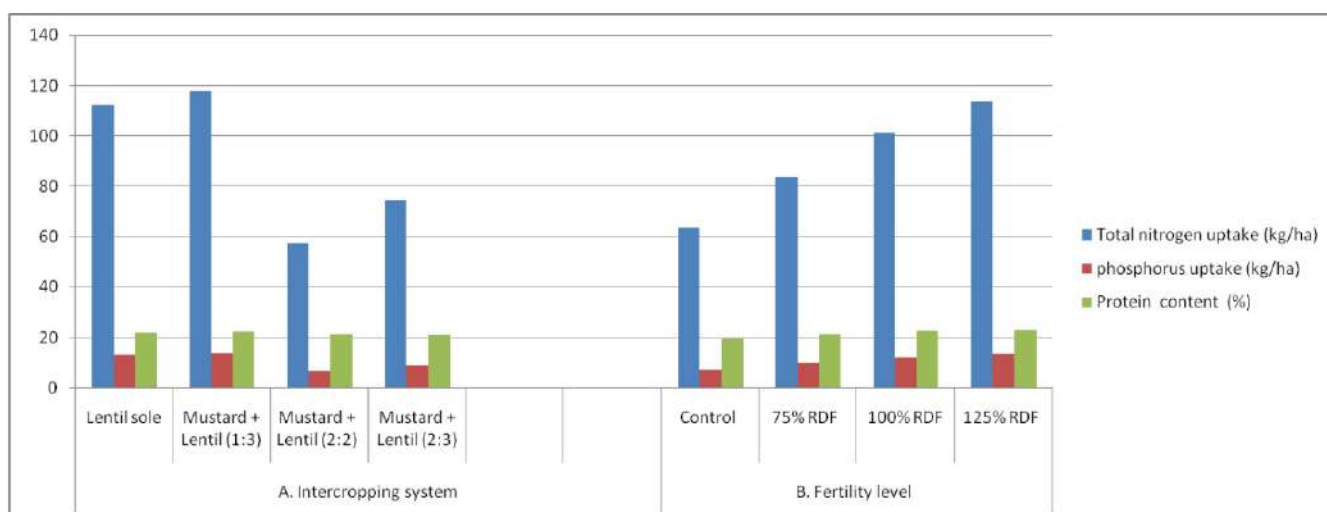


Fig.-2 : Effect of intercropping system and fertility levels on total nitrogen and phosphorus uptake and protein content in seed of lentil.

application of 100% RDF over lower levels. This might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N and P in plant parts. Since the nutrient uptake is a function of its content in crop plant and seed and stover/straw yields of the crop. The increase in these parameters due to N and P fertilization led to an increased uptake of nutrients in the present study. Significant increase in protein content and oil percentage because of increased N content in seed which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in seed is directly responsible for higher protein

because it is a primary component of amino acids which constitute the basis of protein. These results are in close conformity with the findings of Parihar *et al.* (2009), Trivedi *et al.* (2013), Pandey *et al.* (2016) and Balai *et al.* (2017a).

References

1. A.O.A.C. 1960. Official method of analysis, 18 edition. Association of Official Agricultural Chemists, Washington.
2. Abraham, T. and Thenua, O.V.S. 2015. Impact assessment of different irrigation and fertilizer levels on mustard + chickpea intercropping systems over sole cropping. *International Journal of Modern Chemistry and Applied Sciences* 2(4): 266-272.
3. Balai, K., Jajoria, M., Verma, R., Deewan, P. and Bairwa, S.K. 2017a. Nutrient content, uptake, quality of chickpea

- and fertility status of soil as influenced by fertilization of phosphorus and zinc. *Journal of Pharmacognosy and Phytochemistry* 6(1): 392-398.
4. Balai, K., Sharma, Y., Jajoria, M., Deewan, P., and Verma, R. 2017b. Effect of phosphorus and zinc on growth, yield and economics of chickpea (*Cicer arietinum* L.). *International Journal of Current Microbiology and Applied Sciences* 6(1): 1174-1181.
 5. Das, S., Devi, K.N., Athokpam, H.S., Lungdim, J. and Longjam, M. 2017. Chickpea (*Cicer arietinum* L.) based intercropping system with rapeseed (*Brassica juncea* L.) on growth, yield and competition indices. *Environment and Ecology* 35(1B): 470-430.
 6. Devi, K.N., Shamurailatpam, D., Singh, T.B., Athokpam, H.S., Sing, N.B., Singh, N.G., Singh, L.N., Singh, A.D., Chanu, O.P., Singh, S.R., Devi, P.D. and Devi, L.S. 2014. Performance of lentil (*Lens culinaris* M.) and mustard (*Brassica juncea* L.) intercropping under rainfed conditions. *Australian Journal of Crop Science* 8(2): 284-289.
 7. Ghosh, P.K. 2014. Growth, yield, competition and economics of groundnut/cereal fodder intercropping systems in the semi-arid tropics of India. *Field Crops Research* 88: 227-237.
 8. Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall Enc. N.J. USA.
 9. Keerthi, P., Pannu, R.K., Dhaka, A.K., Daniel, J. and Yogesh, 2017. Yield, nitrogen uptake and nutrient use efficiency in Indian mustard (*Brassica juncea* L.) as effected by date of sowing and nitrogen levels in western Haryana, India. *International Journal of Current Microbiology and applied sciences* 6(4): 1168-1177.
 10. Meena, D.S., Meena, V.R. and Meena, A.K. 2013. Fertilizer management studies on growth and productivity of hybrid Indian mustard (*Brassica juncea* L.). *Journal of Oilseed Brassica* 4(1): 39-42.
 11. Meena, S.L., Shamsudheen, M. and Dayal, D. 2008. Impact of row ratio and nutrient management on performance of clusterbean (*Cyamopsis tetragonoloba*) + sesame (*Sesamum indicum*) intercropping system. *Indian Journal of Agronomy* 53(4): 285-289.
 12. Pandey, M.K., Verma, A. and Kumar, P. 2016. Effect of integrated phosphorus management on growth, yield and quality of lentil (*Lens culinaris*). *Indian Journal of Agricultural Research* 50(3): 238-243.
 13. Parihar, C.M., Rana, K.S. and Parihar M.D. 2009. Crop productivity, quality and nutrient uptake of pearl millet (*Pennisetum glaucum*) and Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and residual effect of nutrient management. *Indian Journal of Agricultural sciences* 79(11): 927-30.
 14. Sharma, P. 2013. Response of mustard (*Brassica juncea*) varieties to fertility levels in alluvial soils of Madhya Pradesh. *A Journal of Multi-disciplinary Advance Research* 2(2): 47-49.
 15. Singh, T., Rana, K.S., Satapathy, B.S. 2014. Productivity, compatibility and economics of mustard (*Brassica juncea*) and (*Lens esculenta*) intercropping system as influenced by moisture conservation practices and fertility levels under rainfed conditions. *Indian Journal of Agricultural sciences* 84(6): 770-3.
 16. Snell, P.D. and Snell, G.T. 1949. Colorimetric methods of analysis, 3rd Edn. Vol. II D. Nostrand Co., Inc., New York.
 17. Trivedi, S.K., Pachauri, R.K., Sharma, G., Joshi, B.S. and Rajput, B. 2013. Effect of moisture Regimes, NPK and zinc levels on growth, yield, quality, nutrient uptake and economics of mustard (*Brassica juncea*). *Journal of Soils and Crops* 23(1): 78-85.
 18. Yadav, R.K., Shivran, A.C., Jakhar, P., Jagetiya A. and Puniya, M.M. 2014. Performance of rainfed moth bean and sesame as influenced by intercropping systems and sulphur fertilization. *Annals of Arid Zone* 53(2): 87-90.



Behavioral Response of Ladybird Beetles, *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. to Synthetic Herbivore-Induced Plant Volatiles (HIPV's) in a Y-tube Olfactometer

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Abstract

Five synthetic herbivore-induced plant volatiles (HIPV's) and their mixtures were tested for their ability to attract two coccinellid species viz. *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. in a Y-tube olfactometer under laboratory conditions. The both sexes of *C. septempunctata* Linn. were attracted to Methyl salicylate (MeSA) at (5 ppm and 10 ppm) and Cis-3-hexenyl acetate (5 ppm). Whereas, females of *C. septempunctata* Linn. also attracted to Methyl salicylate (1 ppm), Cis-hexanol (5 ppm) and -caryophyllene (5 ppm). On the contrary, male and female of *C. transversalis* Fab. were attracted to Methyl salicylate at 10 ppm and 5 ppm respectively. Similarly, Cis-hexanol at 10 ppm concentration also attracted both sexes of *C. transversalis* Fab. Among the HIPV's mixtures, significantly higher responses of both sexes of *C. septempunctata* Linn. and *C. transversalis* Fab. were recorded from Methyl salicylate (MeSA) + -caryophyllene + Cis-hexanol (1:1:1) at almost all concentrations tested (viz., 1, 5, 10 and 15 ppm). Whereas, combination of -caryophyllene + Cis-hexanol (1:1) failed to attract any sex of both species except 10 ppm concentration, that attracted male of *C. septempunctata* Linn. Results of present study clearly indicated that the mixture of herbivore-induced plant volatiles gave higher responses of *C. transversalis* Fab. and *C. septempunctata* Linn. adults than compounds tested singly. This is the first report of *C. transversalis* Fab. attraction to Methyl salicylate in a Y-tube olfactometer.

Key words : HIPV's, *Coccinella septempunctata* Linn., *Coccinella transversalis* Fab., Methyl salicylate (MeSA), Cis-hexanol

Introduction

The ladybird beetles (Coleoptera: Coccinellidae) are potential predators of soft-bodied insects i.e., aphids, scale insects, mealy bugs, phytophagous mites, whiteflies, nymphs of pentatomid bugs, etc., in agro-ecosystem. Thus, coccinellids have great economic importance as natural enemies to contain insect pests problems in agriculture crops. Coccinellids widely distributed in India with two hundred sixty one predaceous coccinellids species belonging to fifty seven genera (Omkar and Pervez 2004). Herbivore damage to the plants results in production of plant volatiles and these volatile compounds refer to as "herbivore-induced plant volatiles". Herbivore-induced plant volatiles mediate relationships between plants and insects through the attraction of natural enemies and the repulsion of herbivores (Takabayashi and Dicke 1996; Drukker *et al.*, 2000; Kessler and Baldwin, 2001; de Boer and Dicke, 2004; Uefune *et al.*, 2012; Aartsma *et al.*, 2017; Ray *et al.*, 2019). It is anticipated that site specific application of herbivore-induced plant volatiles can be used to increase natural enemy's populations within an area of interest, which will consecutively result in reduced insect pest population. In recent years, studies have shown that synthetic HIPVs attract beneficial insects and increase

predation by predators in the field conditions (Zhu and park, 2005; Rodriguez-Saona *et al.*, 2011; Kessler and Baldwin, 2001; James and Price, 2004; James, 2005; Salamanca *et al.*, 2017). In the present study, behavioral response of Ladybird beetle, *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. to synthetic HIPVs was investigated in laboratory conditions.

Materials and Methods

Behavioural responses of both Lady Bird beetle species viz., *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. were recorded in a Y-tube olfactometer, made up of transparent Plexiglas (3 cm ID; stem 10 cm, arms 8 cm; stem-arms angle 130°) with each arm connected to a glass tube holding the odor source. Filtered air at the rate of 1.0 liters/min was drawn through the olfactometer by a pump during the experimentation. Adult male and females of *Coccinella sp.* were directly collected from experimental field at I.A.R.I. New Delhi and starved for 24 hours before bioassay. Synthetic herbivory induced plant volatile's were selected to find out their possible effects on *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab., on the basis of literature accounts suggesting that each might have some attractive properties to some natural enemies in different agro-ecosystems. Test compounds were obtained from

commercial sources (Table-1). Selected synthetic compounds, singly, and as different mixtures were dissolved in a solvent (hexane) at different concentrations viz. 1 ppm, 5ppm, 10 ppm and 15 ppm. For the odor source whatman filter paper (2x2 cm) impregnated with 10 µl of test solution was used and before introducing it into one arm of Y-tube olfactometer, left to dry for 10s. Whereas, untreated whatman filter paper (control) of the same size was introduced into another arm of olfactometer. Directional bias excluded by rotating the apparatus 180° after five runs. Time to respond for *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. standardized to record maximum activity for the test compound. Male and female were allowed for 15 minutes to respond to the test compound and each insect was used only once. When insects traveled at least 4 cm along arm connected to test compound responses were considered positive. The olfactometer disconnected from the glass tube and thoroughly washed with water, rinsed in 70% ethanol, and dried in an oven at 120°C after every three runs. All experiments were conducted in day light at 28±2°C and 60% relative humidity.

Results and Discussion

The responses of *Coccinella septempunctata* Linn., male and female to synthetic HIPVs presented in Table 2. *C. septempunctata* Linn., male attracted significantly higher to methyl salicylate (MeSA) at 5 ppm (N= 20, P = 0.02) and 10 ppm (N = 20, P = 0.004), respectively over the control. Whereas, Cis-3-hexenyl acetate at 5 ppm elicited significantly higher responses (N = 20, P = 0.004) among all concentrations tested. On the contrary, the other volatile compounds at all concentration tested failed to elicit significant responses in male. Similarly, methyl salicylate (MeSA) at 1 ppm (N= 20, P = 0.02) 5 ppm (N = 20, P = 0.001) and 10 ppm (N = 20, P = 0.004) elicited significantly higher responses in *C. septempunctata* Linn., female over the control. *C. septempunctata* Linn., female also responded to Cis-3-hexenyl acetate at 5 ppm (N= 20, P = 0.02), Cis-hexanol at 5 ppm (N= 20, P = 0.02) and -caryophyllene at 5 ppm (N= 20, P = 0.02), respectively, while the other concentrations of these volatile compounds and all concentration of limonene tested, failed to elicit significant responses (Table-2, fig.-1).

The responses of *C. septempunctata* Linn., male and female to different combinations of synthetic HIPVs are presented in Table 3. Significantly higher responses of *C. septempunctata* Linn., male were recorded from methyl salicylate (MeSA)+ -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm (N = 20, P = 0.004), 5 ppm (N = 20, P = 0.001), 10 ppm (N = 20, P = 0.0004), -caryophyllene + Cis-hexanol (1:1) at 10 ppm (N = 20, P = 0.02), methyl

salicylate + Cis-hexanol (1:1) at 5 ppm (N = 20, P = 0.02), 15 ppm (N = 20, P = 0.004) and methyl salicylate (MeSA) + -caryophyllene (1:1) at 10 ppm (N= 20, P= 0.02), respectively. In contrast, -caryophyllene + Cis-hexanol (1:1) at 1 ppm (N = 20, P = 0.186), 5 ppm (N = 20, P = 0.384), 15 ppm (N = 20, P = 0.07), methyl salicylate + Cis-hexanol (1:1) at 1 ppm (N = 20, P = 0.186), 10 ppm (N = 20, P = 0.186), methyl salicylate (MeSA) + -caryophyllene (1:1) at 1 ppm (N = 20, P = 0.384), 5 ppm (N = 20, P = 0.186), 15 ppm (N = 20, P = 1.00) and methyl salicylate (MeSA)+ -caryophyllene + Cis-hexanol (1:1:1) at 15 ppm (N = 20, P= 0.07) failed to elicit significant responses (Table-3, Fig.-2). Similarly, among the different combinations of HIPVs tested, methyl salicylate + Cis-hexanol (1:1) at 5 ppm (N = 20, P = 0.02), 10 ppm (N = 20, P = 0.004) and methyl salicylate (MeSA)+ -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm (N = 20, P = 0.02), 5 ppm (N = 20, P = 0.0004), 10 ppm (N = 20, P = 0.0004), 15 ppm (N = 20, P = 0.02) elicited significantly higher responses over the control in *C. septempunctata* Linn., female. On the contrary, -caryophyllene + Cis-hexanol (1:1) at 1 ppm (N = 20, P = 1.00), 5 ppm (N = 20, P = 0.384), 10 ppm (N = 20, P = 0.07), 15 ppm (N = 20, P = 0.07), methyl salicylate + Cis-hexanol (1:1) at 1 ppm (N = 20, P = 0.666), 15 ppm (N = 20, P = 0.07), methyl salicylate (MeSA) + -caryophyllene (1:1) at 1 ppm (N = 20, P = 0.666), 5 ppm (N = 20, P = 0.186), 10 ppm (N = 20, P = 0.384) 15 ppm (N = 20, P = 1.00) failed to elicit significant responses (Table 3, Fig 2).

Our findings revealed that, *C. septempunctata* Linn., male attracted significantly higher to methyl salicylate (MeSA) at 5 ppm and 10 ppm over the control. Whereas, Cis-3-hexenyl acetate at 5 ppm elicited significantly higher responses over the control among all concentrations tested. On the contrary, the other volatile compounds at all concentration tested failed to elicit significant responses. Similarly, methyl salicylate (MeSA) at 1, 5 and 10 ppm elicited significantly higher responses in *C. septempunctata* Linn., female over the control. *C. septempunctata* Linn., female also responded to Cis-3-hexenyl acetate at 5 ppm, Cis-hexanol at 5 ppm and -caryophyllene at 5 ppm respectively, while the other concentrations of these volatile compounds and all concentration of limonene tested, failed to elicit significant responses (fig.-2). Whereas, significantly higher responses of *C. septempunctata* Linn., male over the control were recorded from methyl salicylate (MeSA)+ -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm, 5 ppm, 10 ppm, -caryophyllene + Cis-hexanol (1:1) at 10 ppm, methyl salicylate + Cis-hexanol (1:1) at 5, 15 ppm, and methyl salicylate (MeSA) + -caryophyllene (1:1) at 10 ppm, respectively. In contrast, -caryophyllene + Cis-hexanol (1:1) at 1 ppm, 5 ppm, 15 ppm, methyl

Table-1 : Details of synthetic HIPV's used in the present study.

S. No.	Compound	Purity	Supplier
1.	Methyl salicylate	> 99%	Sigma-Aldrich
2.	Cis-hexanol	> 98%	Sigma-Aldrich
3.	-caryophyllene	> 80%	Sigma-Aldrich
4.	D-Limonene	97%	Sigma-Aldrich
5.	Cis-3-Hexenyl acetate	=98%	Sigma-Aldrich

Table-2 : Behavioral responses of *Coccinella septempunctata* Linn. in a Y-tube olfactometer to synthetic HIPVs.

Synthetic HIPVs	Concentration	Male response (mean $\pm$ SE)				Female response (mean $\pm$ SE)			
		N	Source	Control	P value	N	Source	Control	P value
Methyl salicylate	1ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	5ppm	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	20	18 $\pm$ 0.07 ^a	2 $\pm$ 0.07 ^b	<0.001
	10ppm	20	16 $\pm$ 0.00 ^a	4 $\pm$ 0.09 ^b	0.004	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004
	15ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
Limonene	1ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666
	5ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	10ppm	20	6 $\pm$ 0.1 ^a	14 $\pm$ 0.1 ^a	0.07	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
	15ppm	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666	20	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186
Cis-3-Hexenyl acetate	1ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	5ppm	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	10ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	15ppm	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
Cis-hexanol	1ppm	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	5ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	10ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
	15ppm	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384
- caryophyllene	1ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	5ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	10ppm	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
	15ppm	20	6 $\pm$ 0.1 ^a	14 $\pm$ 0.1 ^a	0.07	20	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186

*For each odour source, different letters indicate significant differences from control (Paired t test).

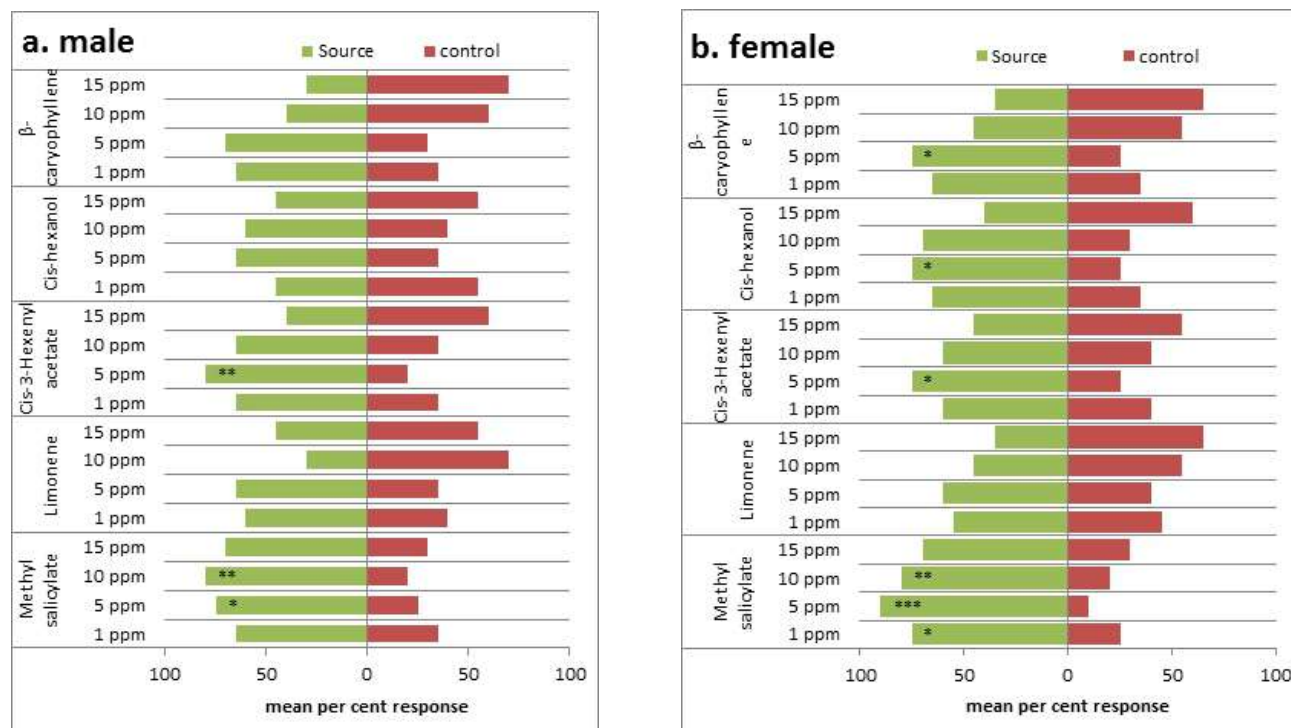


Figure-1 : Behavioral responses (mean per cent response) of *Coccinella septempunctata* Linn (a) male and (b) female to synthetic HIPVs in Y-tube olfactometer. Asterisks indicate significant differences over the control (Paired t test: N = 20, *P = 0.05, **P = 0.01, ***P = 0.001, ****P = 0.0001).

Table-3 : Behavioral responses of *Coccinella septempunctata* Linn. in Y-tube olfactometer to different combinations of synthetic HIPVs.

Synthetic HIPVs	Concentration	Male (mean % $\pm$ SE response)				Female (mean % $\pm$ SE response)			
		N	Source	Control	P value	N	Source	Control	P value
-caryophyllene + Cis-hexanol (1:1)	1ppm	20	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00
	5ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	10ppm	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
	15ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
Methyl salicylate+ Cis-hexanol (1:1)	1ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	11 $\pm$ 0.11 ^a	09 $\pm$ 0.11 ^a	0.666
	5ppm	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	10ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004
	15ppm	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
Methyl salicylate+ -caryophyllene (1:1)	1ppm	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	20	9 $\pm$ 0.11 ^a	11 $\pm$ 0.11 ^a	0.666
	5ppm	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	10ppm	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	15ppm	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00
-caryophyllene + Cis-hexanol + Methyl salicylate (1:1:1)	1ppm	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	5ppm	20	18 $\pm$ 0.07 ^a	2 $\pm$ 0.07 ^b	<0.001	20	17 $\pm$ 0.8 ^a	3 $\pm$ 0.8 ^b	0.0004
	10ppm	20	17 $\pm$ 0.8 ^a	3 $\pm$ 0.8 ^b	0.0004	20	17 $\pm$ 0.8 ^a	3 $\pm$ 0.8 ^b	0.0004
	15ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02

* For each odour source, different letters indicate significant differences from control (Paired t test).

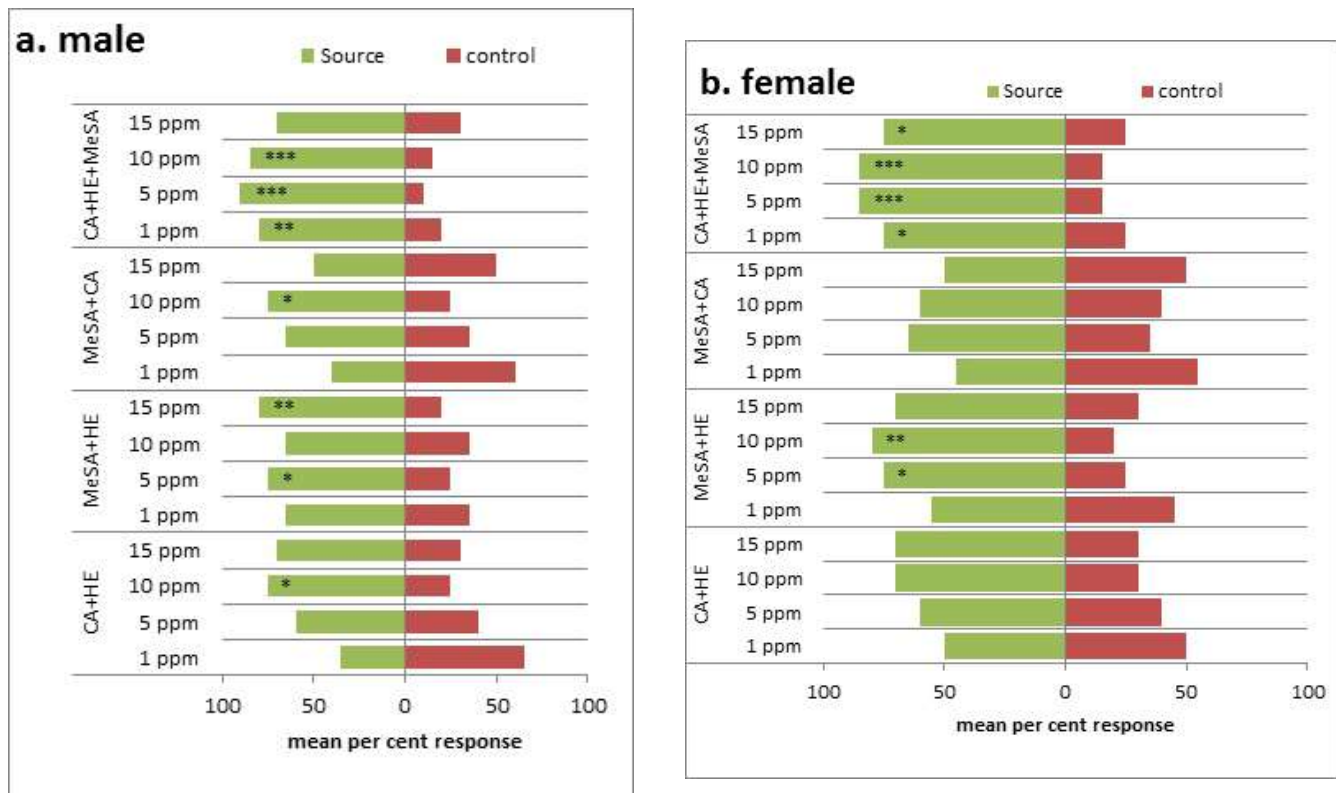


Figure-2 : Behavioral responses (mean per cent response) of *Coccinella septempunctata* Linn. (a) male and (b) female to different combinations of synthetic HIPVs in Y-tube olfactometer. Code for treatments: CA+HE, α -caryophyllene + Cis-hexanol (1:1); MeSA+HE, Methyl salicylate+ Cis-hexanol (1:1); MeSA+CA, Methyl salicylate+ α -caryophyllene (1:1); CA+HE +MeSA, α -caryophyllene + Cis-hexanol + Methyl salicylate (1:1:1). Asterisks indicate significant differences over the control (Paired t test: N = 20, *P < 0.05, **P < 0.01, *P < 0.001, ****P < 0.0001).**

Table-4 : Behavioral responses of *Coccinella transversalis* Fab. in Y-tube olfactometer to synthetic HIPVs.

Synthetic HIPVs	Concentration	Male response (mean $\pm$ SE)				Female response (mean $\pm$ SE)			
		N	Source	Control	P value	N	Source	Control	P value
Methyl salicylate	1ppm	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
	5ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02
	10ppm	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	15ppm	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
Limonene	1ppm	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666
	5ppm	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666
	10ppm	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384
	15ppm	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	20	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186
Cis-3-Hexenyl acetate	1ppm	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00
	5ppm	20	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
	10ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666
	15ppm	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00
Cis-hexanol	1ppm	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	5ppm	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	20	14 $\pm$ 0.1 ^a	6 $\pm$ 0.1 ^a	0.07
	10ppm	20	17 $\pm$ 0.8 ^a	3 $\pm$ 0.8 ^b	0.0004	20	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004
	15ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
-caryophyllene	1ppm	20	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666
	5ppm	20	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	20	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^a	0.186
	10ppm	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666	20	11 $\pm$ 0.09 ^a	9 $\pm$ 0.09 ^a	0.666
	15ppm	20	9 $\pm$ 0.09 ^a	11 $\pm$ 0.09 ^a	0.666	20	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384

* For each odour source, different letters indicate significant differences from control (Paired t test).

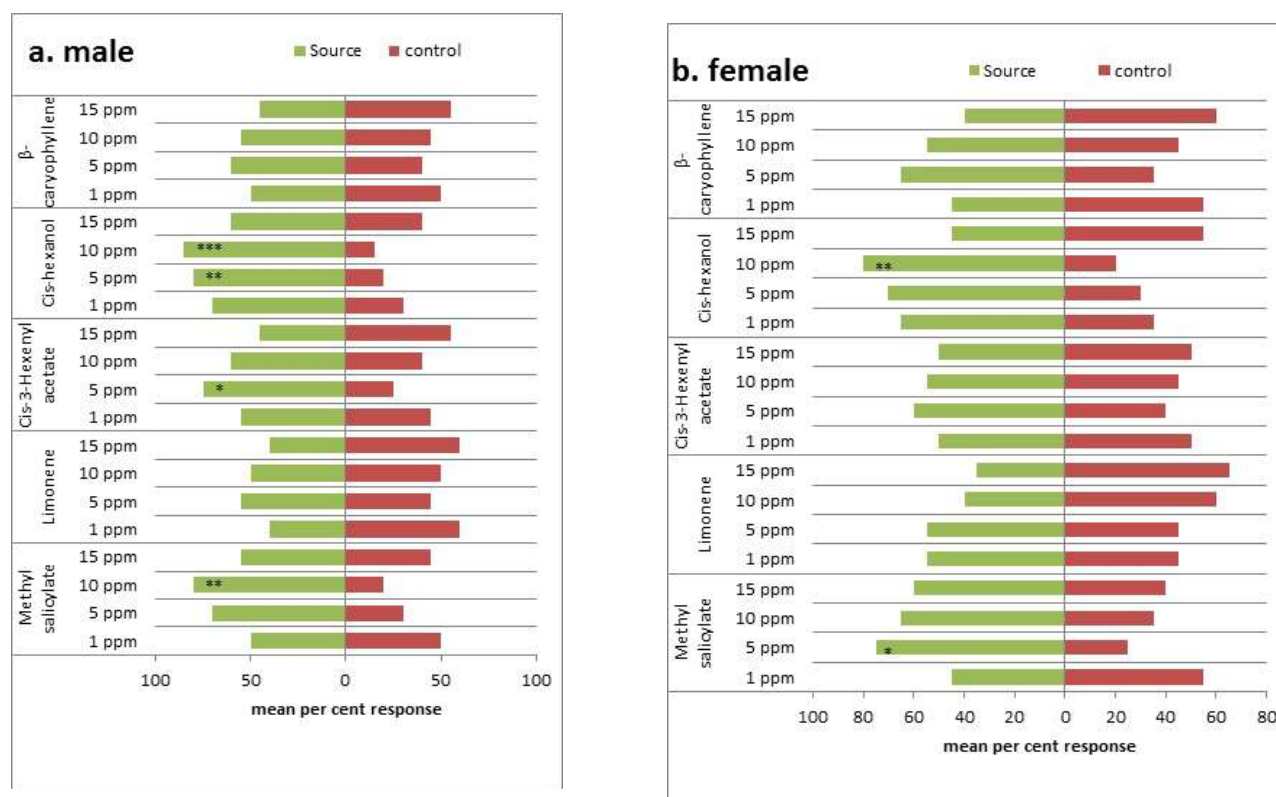


Figure-3 : Behavioral responses (mean per cent response) of *Coccinella transversalis* Fab (a) male and (b) female to synthetic HIPVs in Y-tube olfactometer. Asterisks indicate significant differences over the control (Paired t test: N = 20, *P = 0.05, **P= 0.01, ***P= 0.001, ****P =0.0001).

Table-5 : Behavioral responses of *Coccinella transversalis* Fab. in Y-tube olfactometer to different combinations of synthetic HIPVs.

Synthetic HIPVs	Concentration	Male (mean %±SE response)				Female (mean %±SE response)			
		N	Source	Control	P value	N	Source	Control	P value
-caryophyllene + Cis-hexanol (1:1)	1ppm	20	8±0.11 ^a	12±0.11 ^a	0.384	20	9±0.11 ^a	11±0.11 ^a	0.666
	5ppm	20	10±0.11 ^a	10±0.11 ^a	1.00	20	13±0.11 ^a	7±0.11 ^a	0.186
	10ppm	20	13±0.11 ^a	7±0.11 ^a	0.186	20	13±0.11 ^a	7±0.11 ^a	0.186
	15ppm	20	10±0.11 ^a	10±0.11 ^a	1.00	20	14±0.1 ^a	6±0.1 ^a	0.07
Methyl salicylate+ Cis-hexanol (1:1)	1ppm	20	12±0.1 ^a	8±0.1 ^a	0.186	20	11±0.11 ^a	09±0.11 ^a	0.666
	5ppm	20	14±0.1 ^a	6±0.1 ^a	0.07	20	14±0.1 ^a	6±0.1 ^a	0.07
	10ppm	20	15±0.10 ^a	5±0.10 ^b	0.02	20	16±0.09 ^a	4±0.09 ^b	0.004
	15ppm	20	16±0.09 ^a	4±0.09 ^b	0.004	20	15±0.10 ^a	5±0.10 ^b	0.02
Methyl salicylate+ - caryophyllene (1:1)	1ppm	20	9±0.11 ^a	11±0.11 ^a	0.666	20	9±0.11 ^a	11±0.11 ^a	0.666
	5ppm	20	12±0.1 ^a	8±0.1 ^a	0.384	20	14±0.1 ^a	6±0.1 ^a	0.07
	10ppm	20	15±0.10 ^a	5±0.10 ^b	0.02	20	16±0.09 ^a	4±0.09 ^b	0.004
	15ppm	20	15±0.10 ^a	5±0.10 ^b	0.02	20	10±0.11 ^a	10±0.11 ^a	1.00
-caryophyllene + Cis-hexanol + Methyl salicylate (1:1:1)	1ppm	20	14±0.1 ^a	6±0.1 ^a	0.07	20	15±0.10 ^a	5±0.10 ^b	0.02
	5ppm	20	15±0.10 ^a	5±0.10 ^b	0.02	20	15±0.10 ^a	5±0.10 ^b	0.02
	10ppm	20	17±0.8 ^a	3±0.8 ^b	0.0004	20	16±0.09 ^a	4±0.09 ^b	0.004
	15ppm	20	18±0.07 ^a	2±0.07 ^b	<0.001	20	17±0.8 ^a	3±0.8 ^b	0.0004

* For each odour source, different letters indicate significant differences from control (Paired t test).

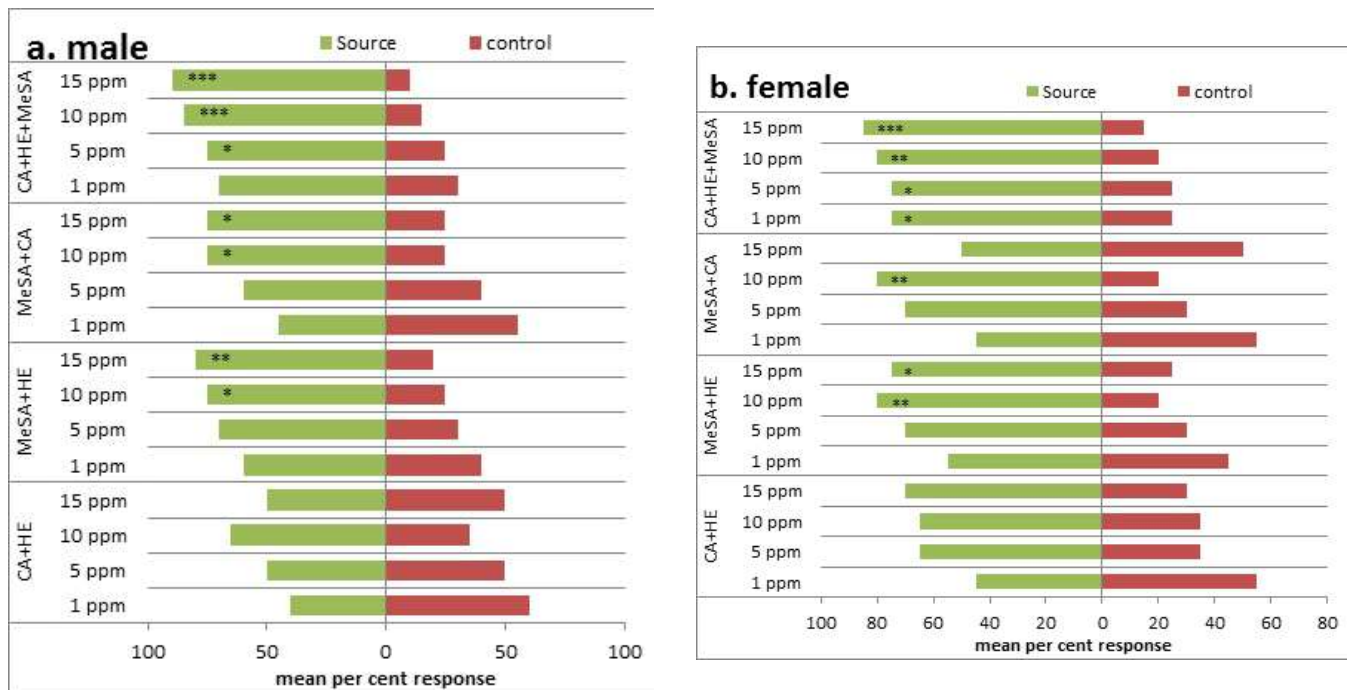


Figure-4 : Behavioral responses (mean per cent response) of *Coccinella transversalis* Fab. (a) male and (b) female to different combinations of synthetic HIPVs in Y-tube olfactometer. Code for treatments: CA+HE, -caryophyllene + Cis-hexanol (1:1); MeSA+HE, Methyl salicylate+ Cis-hexanol (1:1); MeSA+CA, Methyl salicylate+ -caryophyllene (1:1); CA+HE + MeSA, - caryophyllene + Cis-hexanol + Methyl salicylate (1:1:1). Asterisks indicate significant

salicylate + Cis-hexanol (1:1) at 1 ppm, 10 ppm, methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1 ppm, 5 ppm, 15 ppm and methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 15 ppm failed to elicit significant responses (Fig.-2). Similarly, among the different combinations of HIPVs tested, methyl salicylate + Cis-hexanol (1:1) at 5 ppm, 10 ppm and methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm, 5 ppm, 10 ppm and 15 ppm elicited significantly higher responses over the control in *C. septempunctata* Linn., female. On the contrary, α -caryophyllene + Cis-hexanol (1:1) at 1 ppm, 5 ppm, 10 ppm, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 1 ppm, 15 ppm, methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1 ppm, 5 ppm, 10 ppm and 15 ppm failed to elicit significant responses (Fig.-2). The present findings conform to those made by Zhu and Park (2005) and James (2005), who reported methyl salicylate as highly attractive to adults of *C. septempunctata* Linn.

The responses of *C. transversalis* Fab., male and female to synthetic HIPVs presented in Table-4. *C. transversalis* Fab., male was attracted by methyl salicylate 10 ppm (N = 20, P = 0.004), Cis-3-hexenyl acetate 5 ppm (N = 20, P = 0.02) and Cis-hexanol 5 ppm (N = 20, P = 0.004), 10 ppm (N = 20, P = 0.0004). Methyl salicylate at 1, 5, 15 ppm, Cis-3-hexenyl acetate at 1, 10, 15 ppm, Cis-hexanol at 1, 15 ppm, while limonene and α -caryophyllene at all concentrations tested, failed to attract significantly higher *C. transversalis* Fab., males over the control. Similarly, *C. transversalis* Fab., female responded to methyl salicylate at 5 ppm (N = 20, P = 0.02) and Cis-hexanol at 10 ppm (N = 20, P = 0.004), while methyl salicylate at 1, 10, 15 ppm and Cis-hexanol at 1, 5, 15 ppm failed to elicit significant responses. Similarly, all concentrations of limonene and α -caryophyllene also failed to elicit significant responses over the control (Table-4, Fig.-3). The responses of *C. transversalis* Fab. male and female to different combinations of synthetic HIPVs are presented in Table 5. Interestingly, significantly higher responses of *C. transversalis* Fab. male over the control were recorded from methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 5 ppm (N = 20, P = 0.02), 10 ppm (N = 20, P = 0.0004), 15 ppm (N = 20, P = 0.001), methyl salicylate + Cis-hexanol (1:1) at 10 ppm (N = 20, P = 0.02), 15 ppm (N = 20, P = 0.004) and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 10 ppm (N = 20, P = 0.02), 15 ppm (N = 20, P = 0.02). In contrast, α -caryophyllene + Cis-hexanol (1:1) at 1, 5, 10, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 1, 5 ppm, methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1, 5 ppm and Methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm failed to elicit significant responses (Table-5, Fig.-4). Similarly, significantly higher responses

of *C. transversalis* Fab. female over the control were recorded from methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm (N = 20, P = 0.02), 5 ppm (N = 20, P = 0.02), 10 ppm (N = 20, P = 0.004), 15 ppm (N = 20, P = 0.0004), methyl salicylate + Cis-hexanol (1:1) at 10 ppm (N = 20, P = 0.004), 15 ppm (N = 20, P = 0.02) and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 10 ppm (N = 20, P = 0.004). Conversely, α -caryophyllene + Cis-hexanol (1:1) at 1, 5, 10, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 1, 5 ppm and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1, 5, 15 ppm were failed to elicit significant responses (Table-5, Fig.-4). Our findings revealed that, *C. transversalis* Fab. male was attracted by methyl salicylate 10 ppm, Cis-3-hexenyl acetate 5 ppm and Cis-hexanol 5, 10 ppm. Methyl salicylate at 1, 5, 15 ppm, Cis-3-hexenyl acetate at 1, 10, 15 ppm, Cis-hexanol at 1, 15 ppm, while limonene and α -caryophyllene at all concentrations tested, failed to attract significantly higher *C. transversalis* Fab. males over the control. Similarly, *C. transversalis* Fab. female responded to methyl salicylate at 5 ppm and Cis-hexanol at 10 ppm, while methyl salicylate at 1, 10, 15 ppm and Cis-hexanol at 1, 5, 15 ppm failed to elicit significant responses. Similarly, all concentrations of limonene and α -caryophyllene also failed to elicit significant responses over the control (Fig. 3). Interestingly, significantly higher responses of *C. transversalis* Fab. male over the control were recorded from methyl salicylate + α -caryophyllene + Cis-hexanol (1:1:1) at 5 ppm, 10 ppm, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 10 ppm, 15 ppm, and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 10 ppm, 15 ppm. In contrast, α -caryophyllene + Cis-hexanol (1:1) at 1, 5, 10, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 1, 5 ppm, methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1, 5 ppm and methyl salicylate (MeSA) + α -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm failed to elicit significant responses (Fig. 4). Similarly, significantly higher responses of *C. transversalis* Fab. female over the control were recorded from methyl salicylate + α -caryophyllene + Cis-hexanol (1:1:1) at 1 ppm, 5 ppm, 10 ppm, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 10 ppm, 15 ppm and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 10 ppm. Conversely, α -caryophyllene + Cis-hexanol (1:1) at 1, 5, 10, 15 ppm, methyl salicylate + Cis-hexanol (1:1) at 1, 5 ppm and methyl salicylate (MeSA) + α -caryophyllene (1:1) at 1, 5, 15 ppm were failed to elicit significant responses (Fig.-4). Maeda *et al.*, 2015 also reported that the mixtures of synthetic herbivore induced plant volatiles are attractive to *Stethorus punctum picipes* (Casey) than the signal volatile compound tested. As per our knowledge a detailed survey of the literature shows that no previous study on the response of herbivore induced plant

volatile's components on *C. transversalis* Fab. has been reported. Methyl salicylate has been demonstrated to be attractive predatory bug *Anthocoris nemoralis* as well as minute pirate bugs, *Orius tristicolor*; bigeyed bugs, *Geocoris pallens* and lady beetle *stethorus punctum* (Drukker et al., 2000; James, 2003). In an another study Salamanca et al. 2017 reported attraction of predatory coccinellid ladybeetle *Hippodamia convergens* to Methyl salicylate under laboratory and greenhouse conditions.

References

1. Takabayashi, J. and Dicke, M. 1996. Plant-carnivore mutualism through herbivore-induced carnivore attractants. *Trends Plant Sci.* 1:109–113.
2. Drukker, B., Bruin, J., Jacobs, G., Kroon, A., Sabelis, M. W. (2000). How predatory mites learn to cope with variability in volatile plant signals in the environment of their herbivorous prey. *Experimental and applied Acarology*, 24(12): 881- 895.
3. Kessler, A. and Baldwin, I. T. (2001). Defensive function of herbivore-induced plant volatile emissions in nature. *Science*, 291: 2141–2144.
4. Boer, D. J. G. and Dicke, M. (2004). The role of methyl salicylate in prey searching behavior of the predatory mite *Phytoseiulus persimilis*. *Journal of Chemical Ecology*, 30: 255-271.
5. Uefune M, Choh Y, Abe J, Shiojiri K, Sano K, Takabayashi J. 2012. Application of synthetic herbivore-induced plant volatiles causes increased parasitism of herbivores in the field. *Journal of Applied Entomology*, 136: 561–567.
6. Ray, S., Helms, A.M., Matulis, N.L., Davidson-Lowe, E., Grisales, W., and Ali, J. G. (2019). Asymmetry in herbivore effect or responses: Caterpillar frass effectors reduce performance of a subsequent herbivore. *Journal of Chemical Ecology*, 46 (1), 76– 83.
7. Aartsma, Y., Bianchi, F., van der Werf, W., Poelman, E. H., & Dicke, M. (2017). Herbivore-induced plant volatiles and tritrophic interactions across spatial scales. *New Phytologist*, 216 (4), 1054–1063.
8. Salamanca J., Brígida Souza, Jonathan G. Lundgren, Cesar Rodriguez-Saona, 2017. From laboratory to field: electro-antennographic and behavioral responsiveness of two insect predators to methyle salicylate. *Chemoecology* 27(2): 1-13.
9. Zhu, J. and Park, K.C. (2005). Methyl salicylate, a soybean aphid-induced plant volatile attractive to the predator *Coccinella septempunctata*. *Journal of Chemical Ecology*, 31: 1733–1746.
10. Rodriguez-Saona, C., Kaplan, I., Braasch, J., Chinnasamy, D., Williams, L. (2011). Field responses of predaceous arthropods to methyl salicylate: a meta-analysis and case study in cranberries. *Biological control*, 59(2): 294-303.
11. James, D.G. and Price, T.S. (2004). Field-testing of methyl salicylate for recruitment and retention of beneficial insects in grapes and hops. *Journal of Chemical Ecology*, 30: 1613–1628.
12. James, D. G. (2005). Further Field evaluation of synthetic herbivore-induced plant volatiles as attractants for beneficial insects. *Journal of Chemical Ecology*, 31: 481-495.
13. Drukker, B., Bruin, J., Jacobs, G., Kroon, A., Sabelis, M.W. (2000). How predatory mites learn to cope with variability in volatile plant signals in the environment of their herbivorous prey. *Experimental and applied Acarology*, 24 (12): 881-895.
14. James, D.G. (2003). Synthetic herbivore-induced plant volatiles as field attractants for beneficial insects. *Environmental Entomology*, 32: 977–982.
15. Omkar and Pervez A. 2000. Biodiversity in predaceous Coccinellidae in India - A review. *Journal of Aphidology*, 14 : 41-66.
16. Maeda, T., Kishimoto, H., Wright, L.C., David J.G. 2015. Mixture of Synthetic Herbivore-induced Plant Volatiles Attracts More *Stethorus punctum picipes* (Casey) (Coleoptera: Coccinellidae) than a Single Volatile. *Journal of Insect Behaviour*, 28, 126–137.



Correlation and Path Analysis of Yield and its Components Plant Traits in Ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi]

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Abstract

Forty ricebean genotypes were evaluated for different quantitative traits in RBD design at the experimental farm of the Department of Organic Agriculture, CSKHPKV, Palampur. The objective of the present study was to estimate the extent of association between pairs of characters at genotypic and phenotypic levels and thereby compare the direct and indirect effects of the characters. Correlation studies revealed that seed yield had significant positive correlation with days to maturity, plant height, pods/plant, pod length, seeds/pod, 100-seed weight, clusters/plant and pods/cluster indicating that selection through these traits would be effective. Path studies revealed clusters/plant, pods/cluster and plant height as important traits for direct selection for yield as these traits have high direct effects. Days to maturity have high indirect effect via plant height which contributed to the positive and significant correlation with seed yield/plant.

Key words : Ricebean, correlation, path analysis and seed yield.

Introduction

Rice bean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] is one of the underutilized warm season annual vine legume with diploid chromosome number ($2n=2x=22$) which belong to subgenus *Ceratotropus* in the genus *Vigna* is widely cultivated in India, China, Korea, Japan, Myanmar, Malaysia, Indonesia, Philippines, Java, Fiji, Bangladesh, Sri Lanka and Nepal. In India its distribution is mainly confined to tribal region of the North- Eastern hills, Western and Eastern Ghats in peninsular region and the Western peninsular tract particularly-temperate hilly region in Himachal Pradesh. It is important crop of Mid-Himalayan region and has emerged as a good alternative to other pulse crops such as black gram and green gram which do not flourish in this region due to their susceptibility to cold temperate stress and high rainfall. It is a potentially valuable but underutilized multipurpose grain legume, which gives satisfactory grain yield even in marginal lands and adverse growing conditions. It is an important food legume in niche environments and has a pivotal role as a pulse in supporting the food security of the rural poor people.

Correlation analysis is a handy technique which provides information that selection for one character results in progress for other positively correlated characters. The importance of correlation studies in selection programmes is appreciable when highly heritable characters are associated with the important character like yield. Correlation coefficients, although, very useful in quantifying the size and direction of trait associations can be misleading if the high correlation

between two traits is a consequence of the indirect effect of other traits (Bizeti *et al.*, 2004). Path coefficient is an excellent means of studying direct and indirect effects of inter-related components of a complex trait which measures the direct influence of one variable on another. Each correlation coefficient between a predictor variable and the response variable is partitioned into its component parts: the direct effect or path coefficient (a standardized partial regression coefficient) for the predictor variable and indirect effects which involve the product of a correlation coefficient between two predictor variables with the appropriate path coefficient in the path diagram (Dewey and Lu, 1959). By determining the inter-relationships among seed yield components, a better understanding of both the direct and indirect effects of the specific components can be attained (Chaudhary and Joshi, 2005).

Materials and Methods

The experimental material for the present study consisted of 40 ricebean genotypes. These genotypes were evaluated for different quantitative traits in RBD design during kharif 2015 with plot size of 3 m x 0.6 m with row to row and plant to plant distance of 30 cm and 10 cm, respectively with 3 replications. The crop was raised following standard package of practices. Data pertaining to various quantitative traits except days to flowering and maturity was recorded on ten randomly taken plants. Days to flowering and maturity were computed on plot basis. For computing phenotypic, genotypic and environmental correlation coefficients, analysis of co-variance was carried out in all possible pairs of combinations of the

characters following Al-Jibouri *et al.*, (1958). The genotypic correlation coefficients and phenotypic correlation coefficients were used in finding out their direct and indirect contribution towards yield/plant as proposed by Wright (1921). The direct and indirect paths were carried out by following Dewey and Lu (1959).

Results and Discussion

In the present study, the estimates of phenotypic and genotypic correlation coefficients were computed for different characters and same have been presented in Table-1. The estimates of genotypic correlations, in general, were higher than their respective phenotypic correlations for most of the traits indicating strong inherent relationship between the traits.

Perusal of the data showed significant positive correlation of seed yield/plant with days to maturity, plant height, pods/plant, pod length, 100-seed weight, seeds/pod, clusters/plant and pods/cluster indicating that selection through these traits will lead to increase in yield. Days to maturity were significantly positively correlation with pod length, 100-seed weight and plant height. Plant height in turn showed significant positive correlation with pods/plant, pod length, 100-seed weight and seeds/pod.

Pods/plant showed positive correlation with pod length, 100-seed weight, seeds/pod and clusters/plant. Pod length showed positive correlation with 100-seed weight, seeds/pod, clusters/plant, pods/cluster. 100-seed weight showed positive correlation with seeds/pod which in turn showed positive correlation with clusters/plant while clusters/plant showed positive and significant correlation with pods/clusters.

Gupta *et al.*, (2014) also observed that seed yield was positively correlated with all the characters except days to maturity in ricebean. Similarly Dash (2012) and observed positive and significant correlation for green fodder yield with days to flowering, main stem length, branches/plant, branch length, leaves/plant, leaf weight and stem weight both at phenotypic and genotypic level in this crop.

Dodake and Dahat (2011) also studied characters association in ricebean which revealed that the seed yield/plant exhibited significantly positive correlation with number of pods/plant, number of seeds/pod and pod length, which is in agreement with the present study.

Seed yield is within great influence of environmental conditions, has complex mode of inheritance and low heritability (Bocanski *et al.*, 2010). On the contrary most of the yield components are less complex, and because of this by using some other trait which is highly correlated with seed yield and has higher heritability, should make

the selection of the best progenies more reliable (Vasic *et al.*, 2001, Bekavac *et al.*, 2008). Study of yield components and their inter relationship along with yield and their direct and indirect contributions towards yield is of immense importance.

The phenotype of a plant is the result of interaction of a large number of factors. Hence, the final yield is the sum total of effects of several component factors. Therefore, it is important to know the extent and nature of inter-relationship between seed yield and its contributing characters and also among themselves. Grafius (1956) had also opined that the improvement of complex characters such as seed yield might be accomplished better through component breeding. Therefore, it is also important to gather information on association of yield with other characters and among themselves, and their basis to identify characters for increasing the efficiency of both direct and indirect selection and thereby defining an ideal plant type. Correlation coefficients are quite helpful in determining the components of a complex trait like seed yield but an exact picture of the relative importance of direct and indirect influence of each component trait which is not provided by such studies as these estimates provide nature and magnitude but not its cause. Path coefficient (Wright 1921; Dewey and Lu 1959) under such circumstances plays an important role in partitioning the correlations into direct and indirect effects of a specific causal factor.

The values of path analysis at the phenotypic and genotypic levels are presented in Table 2. The significant positive correlation of seed yield with clusters/plant, pods/cluster, plant height and pods/plant was because of high direct effects of these traits indicating importance of direct selection of these traits. Days to maturity showed positive correlation with seed yield/plant via high indirect effects of plant height followed by pods/plant and branches/plant while plant height showed positive correlation with seed yield/plant via high indirect effects of clusters/pod, pods/plant and days to maturity.

On the other hand, pods/plant showed positive correlation with seed yield/plant via high indirect effects of clusters/plant, pods/cluster and plant height whereas, pod length showed positive correlation with seed yield/plant via highest indirect effects of clusters/plant followed by plant height and pods/cluster. 100-seed weight showed positive correlation with seed yield/plant via high indirect effects of plant height followed by clusters/plant and pods/plant and; seeds/pod showed positive correlation with seed yield/plant via high indirect effects of clusters/plant followed by plant height and pods/plant.

Clusters/plant showed positive correlation with seed

Table-1 : Estimates of phenotypic and genotypic correlation coefficient among various yield and morphological traits in ricebean.

Traits	Days to flowering	Days to maturity	Plant Height	Branches/plant	Pods /plant	Pod length	100-seed weight	Seeds /pod	Clusters /plant	Pods /cluster	Seed yield/plant
Days to flowering	P	0.44*	0.46*	0.17	0.13	0.34*	0.21	0.18	0.12	0.05	0.13
	G	0.60*	0.63*	0.49*	0.44*	0.47*	0.35*	0.88*	0.18	0.07	0.32*
Daysto maturity	P		0.67*	0.15	0.15	0.33*	0.36*	0.22	0.03	0.01	0.20*
	G		0.94*	0.35*	0.69*	0.68*	0.44*	1.16*	0.19	-0.06	0.33*
Plant height	P			0.03	0.24*	0.45*	0.39*	0.35*	0.13	0.00	0.28*
	G			0.22	0.77*	0.81*	0.61*	1.23*	0.33*	0.04	0.43*
Branches/plant	P				-0.00	0.06	0.13	0.05	-0.03	-0.02	0.09
	G				0.43*	0.21	0.12	0.72*	0.29*	0.02	0.21*
Pods/plant	P					0.34*	0.31*	0.36*	0.24*	0.17	0.34*
	G					1.36*	0.94*	2.20*	1.06*	0.45*	1.33*
Pod length	P						0.44*	0.32*	0.30*	0.27*	0.33*
	G						0.98*	1.63*	0.64*	0.40*	0.81*
100-seed weight	P							0.38*	0.18	0.14	0.27*
	G							1.61*	0.45*	0.22	0.74*
Seeds/pod	P								0.40*	0.21	0.29*
	G								0.87*	0.87*	1.77*
Clusters/plant	P									0.28*	0.46*
	G									0.70*	0.96*
Pods/cluster	P										0.43*
	G										0.73*

*significant at 5% level of significance.

Table-2 : Estimates of direct and indirect effects on seed yield at genotypic level and phenotypic level for different traits in ricebean.

Traits		Days to flowering	Days to maturity	Plant Height	Branches per plant	Pods per plant	Pod length	100-seed weight	Seeds/ pod	Cluster s/plant	Pods/cl uster	Correl ation with yield
Days to flowering	P	-0.08	0.02	0.10	0.02	0.02	0.00	0.01	-0.01	0.04	0.02	0.13
	G	0.28	-0.27	-0.46	-0.02	0.30	1.27	-0.53	-0.17	-0.08	0.01	0.32*
Days to maturity	P	-0.03	0.04	0.14	0.02	0.02	0.00	0.01	-0.01	0.01	0.00	0.20*
	G	0.17	-0.45	-0.68	-0.02	0.46	1.82	-0.68	-0.22	-0.08	-0.01	0.33*
Plant height	P	-0.04	0.03	0.21	0.00	0.04	0.00	0.02	-0.02	0.04	0.00	0.28*
	G	0.17	-0.42	-0.72	-0.01	0.51	2.19	-0.92	-0.23	-0.14	0.01	0.43*
Branches/plant	P	-0.01	0.01	0.01	0.11	-0.00	0.00	0.01	-0.00	-0.01	-0.00	0.09
	G	0.13	-0.16	-0.16	-0.05	0.29	0.58	-0.18	-0.14	-0.12	0.00	0.21*
Pods/plant	P	-0.01	0.01	0.05	-0.00	0.16	0.00	0.01	-0.02	0.08	0.05	0.34*
	G	0.12	-0.31	-0.55	-0.02	0.67	3.66	-1.43	-0.42	-0.45	0.06	1.33*
Pod length	P	-0.03	0.01	0.09	0.01	0.06	0.00	0.02	-0.02	0.10	0.08	0.32*
	G	0.13	-0.31	-0.59	-0.01	0.91	2.70	-1.50	-0.31	-0.27	0.05	0.81*
100-seed weight	P	-0.02	0.01	0.08	0.01	0.05	0.00	0.04	-0.02	0.06	0.04	0.27*
	G	0.10	-0.20	-0.44	-0.01	0.63	2.65	-1.52	-0.30	-0.19	0.03	0.74*
Seeds/pod	P	-0.01	0.01	0.07	0.01	0.06	0.00	0.01	-0.05	0.13	0.07	0.29*
	G	0.24	-0.52	-0.89	-0.03	1.48	4.38	-2.46	-0.19	-0.37	0.12	1.77*
Clusters/plant	P	-0.01	0.00	0.03	-0.00	0.04	0.00	0.01	-0.10	0.33	0.09	0.46*
	G	0.05	-0.09	-0.24	-0.01	0.71	1.72	-0.69	-0.16	-0.43	0.10	0.96*
Pods/cluster	P	-0.00	0.00	0.00	-0.00	0.03	0.00	0.01	-0.01	0.09	0.32	0.43*
	G	0.02	0.02	-0.03	-0.00	0.30	1.07	-0.34	-0.16	-0.30	0.14	0.73*

*significant at 5% level of significance.

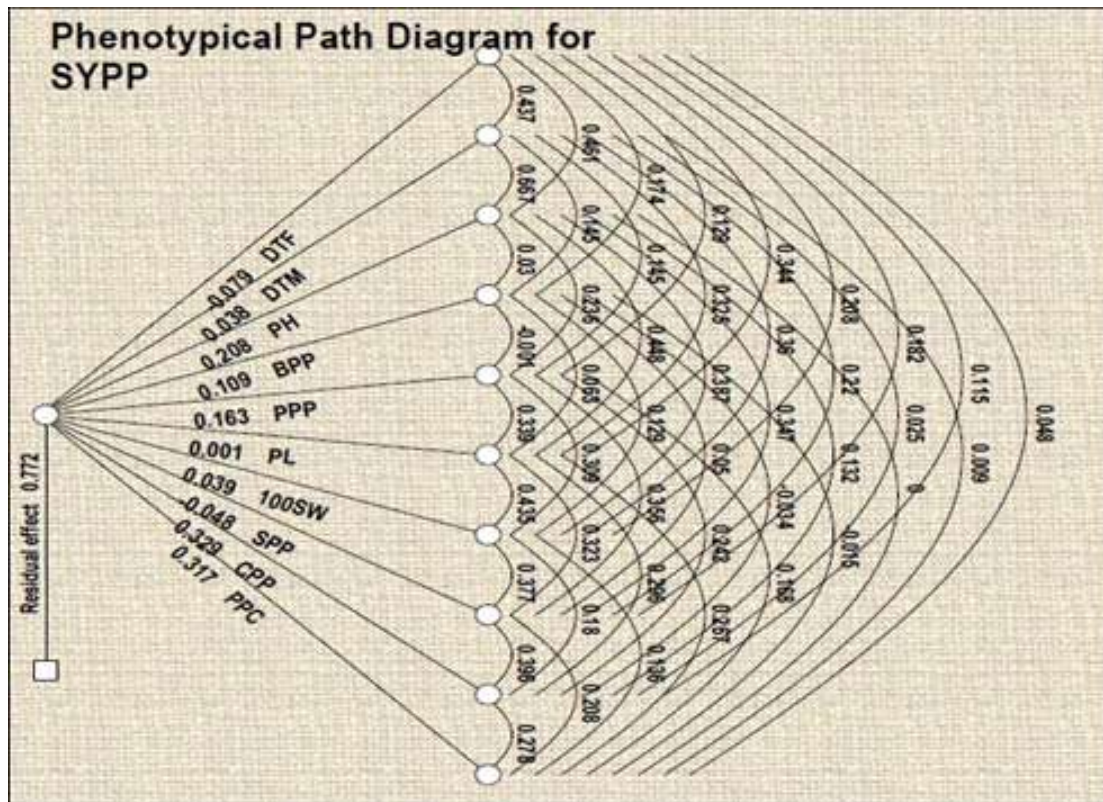


Fig.-1 : (a) Phenotypic path diagram representing cause and effect relationships among quantitative traits and seed yield per plant (SYPP) in ricebean germplasm lines.

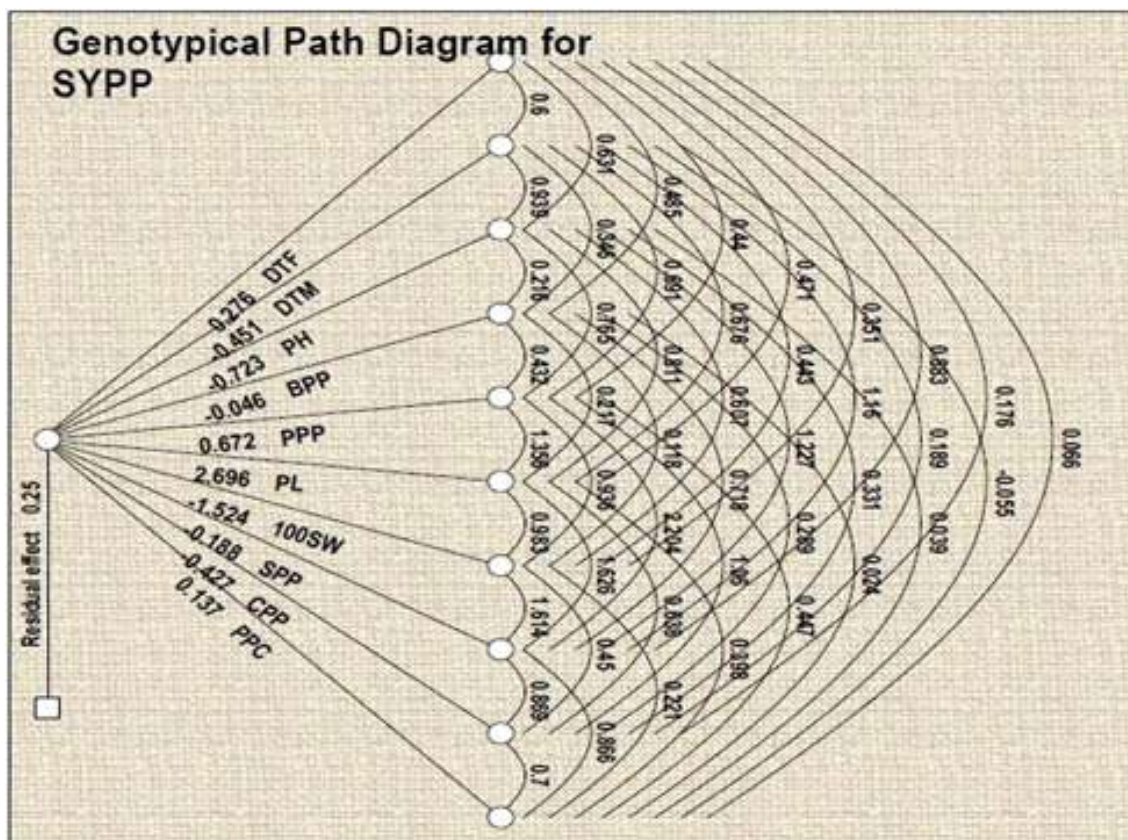


Fig.-1 : (b) Genotypic path diagram representing cause and effect relationships among quantitative traits and seed yield per plant (SYPP) in ricebean germplasm lines.

yield/plant via high indirect effects of pods/cluster followed by pods/plant and plant height while pods/cluster showed positive correlation with seed yield/plant via high indirect effects of cluster/plant followed by pods/plant and 100-seed weight. High indirect effects of these traits indicate indirect selection for increased yield via these traits. Phenotypic and genotypic path diagrams representing cause and effect relationships among quantitative traits and seed yield per plant (SYPP) in ricebean germplasm lines are shown in figure 1(a) and 1(b). Since clusters/plant, pods/cluster, plant height and pods/plant showed high direct effects can be considered for direct selection for high seed yield in comparison to rest of the traits which are useful in indirect selection towards yield.

Similar results were obtained by various workers. Dash (2012) did analysis of path coefficient analysis and revealed that leaves/plant and days to flowering had high positive direct effect on fodder yield while branches/plant and branch length had moderate direct effect. Similarly, Dodake and Dahat (2011) studied characters association and path coefficient analysis in ricebean and revealed that number of pods/plant had the highest direct effect and contributed towards yield.

Correlation studies revealed that seed yield had significant positive correlation with days to maturity, plant height, pods/plant, pod length, seeds/pod, 100-seed weight, clusters/plant and pods/cluster indicating that selection through these traits would be effective. Path studies revealed that clusters/plant, pods/cluster and plant height as important traits for direct selection for yield as these traits have high direct effects. Days to maturity have high indirect effect via plant height which contributed to the positive and significant correlation with seed yield/plant.

Other indirects effects that have shown positive and significant correlation with seed yield/plant comprised of pods/plant by pod length, pod length by plant height, 100-seed weight by pod length, seeds/pod by

branches/plant, clusters/plant by pod length and pods/cluster by clusters/plant.

References

1. Al-Jibouri, H.A., Miller, P.A., and Robinson, H.F., (1958). Genotypic and environment variances and covariance in upland cotton cross of interspecific origin. *Agronomy Journal*, 50: 633-636.
2. Bekavac, G., Purar, B., and Jockovic, D., (2008). Relationships between line per se and testcross performance for agronomic traits in two broad-based populations. *Euphytica*, 162: 363-369.
3. Bizeti H.S., deCarvalho, C.G.P., deSouza, J.R.P., Destro D., (2004). Path Analysis under Multicollinearity in Soybean. *Agron. J.*, 47(5): 669-676.
4. Bocanski, A., Sreckov, Z., Natasic, I., Alovic, and Vukosavjev, M., (2010). Correlation and path coefficient analysis of morphological traits of maize (*Zea mays* L.). *Research Journal of Agricultural Sciences* 42: 292-296.
5. Chaudhary, R.R., and Joshi, B.K., (2005). Correlation and Path Coefficient Analyses in Sugarcane. *Nepal Agric. Res. J.*, 6: 24-28.
6. Dash, G.B., (2012). Variability and character association studies among micromutants of forage ricebean. *Forage Research* 38: 119-121.
7. Dewey, D.R., and Lu, K.H., (1959). Correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal* 51: 510-515.
8. Dodake, M.M., and Dahat, D.V., (2011). Association of characters and path coefficient analysis studies in ricebean [*Vigna umbellata* (Thunb) Ohwi and Ohashi]. *International Journal of Agricultural Sciences*, 2: 359-361.
9. Grafius, J.E., (1956). Components of yield in oats-a geometrical interpretation. *Agronomy Journal*, 48: 419-423.
10. Gupta, S., Pandey, A., Kumar, A., and Pattanayaka, (2014). Evaluation of genotypic variation and suitability of ricebean genotypes for mid-altitudes of Meghalaya, India. *Legume Research*, 37: 56-58.
11. Vasic, Mirjana, Varga, Jelica, and Takac, A., (2001). Selekcija pasulija (Dry bean breeding) Savremena poljoprivreda. *Contemporary Agriculture* 2: 237-245.
12. Wright, S., (1921). The method of path coefficient. *Annals of Mathematical statistics* 5: 160-169.



Effect of STCR Based Fertilizers and Manure Application on Soil Chemical Properties and Rice (*Oryza sativa* L.) Yield in Vertisol of Central India

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Abstract

The field experiment was laid out to assess the effect of STCR based fertilizers and manure application on the chemical properties of the soil and yield of direct-seeded rice. Application of different STCR- yield targeted fertilizers with or without farmyard manure affect the chemical properties of soil, dry matter production and yield of the rice. The experiment was consisting six treatments comprised of different levels of NPK alone or in combination with FYM in a randomized block design with four replications. The results showed that application of NPK fertilizers as per STCR with FYM @ 5t ha⁻¹ for targeted yield 60 q ha⁻¹ resulted in maximum soil organic carbon (5.57 and 5.41 g kg⁻¹ at 60 DAS and at harvest, respectively), and it also reduces the soil pH from 7.57 to 7.47. The maximum dry matter content was also recorded in T₆ (157:125:70 kg N, P₂O₅ and K₂O with 5 t FYM ha⁻¹) at all the growth stages. Seed yield (5725 kg ha⁻¹) and straw yield (7623 kg ha⁻¹) were found to be maximum in the same treatment (T₆), whereas, the least was recorded in absolute control (T₁).

Introduction

Rice (*Oryza sativa* L.) is the staple food and main source of energy for more than three billion people around the globe, mostly consisting of South Asia and India whereas, it is the main source of dietary carbohydrate for 65% of the Indian population (IRRI 2009; Nalley *et al.* 2017; Pandey *et al.* 2018). Moreover, rice accounts for more than 40% of food-grain production in India (Baishya *et al.* 2015; FAO 2017), providing direct employment to 70% of people in rural areas. Rice cultivation accounts for more than 80% of the North–Eastern Himalayan region's total cultivated area (7.8% of India's total rice cultivation area) and contributes significantly to domestic rice production (Yadav *et al.* 2019). Being the staple food for more than 50% of the people, global food security hinges on the growth and stability of its production.

The success of the green revolution has been followed by declining soil health due to imbalanced use of fertilizers for a longer period and this degradation has led to the wide gap between crop removal and fertilizer application (Kumar *et al.*, 2007). To narrow down this gap, the balanced use of fertilizers is the most crucial approach. Conventionally, fertilizer application based on soil testing is being commended throughout the world to know the nutrients status and their imbalances in the soil and apply the required amount of the nutrients accordingly to overcome those imbalances (Gautam *et al.*, 2013). Soil testing and use of crop nutrient uptake and removal information are important in determining the actual rates of nutrients. The practice of adequate rate

and timing of fertilizer application can increase rice yield. Nitrogen (N), phosphorus (P), and potassium (K) are applied as fertilizers in large quantities to rice fields, and a deficiency of either of the nutrient leads to yield losses. However, in the conventional soil testing method, the fertilizer recommendations are usually given by categorizing soil into low, medium and high fertility classes taking into consideration only the available nutrient status of soil before raising the crop. But for an efficient fertilizer recommendation, the available nutrient status of the soil as well as requirements of particular crop needs to be considered before applying the fertilizer (Tegegnetwork *et al.*, 2015). Therefore, in this context, STCR approach which considers every bit of nutrient present in soil for achieving the targeted yield of crops under a particular agro-climatic situation is the most suitable one. This approach is crop as well as variety specific. It provides a scientific base for balanced fertilization not only between the fertilizer nutrients but also the available nutrients present in the soil (Ramamoorthy *et al.*, 1967). The targeted yield concept focuses on a balance between 'fertilizing the crop and fertilizing the soil'. Integrating organic and inorganic fertilizers enhances the growth parameters and yields of rice. The balanced use of fertilizers improves crop productivity and soil fertility in a sustainable manner without any environmental damage. Therefore, this investigation was carried out to evaluate the effect of STCR approach-based fertilizer application on the soil chemical properties and yield of direct-seeded rice.

Materials and Methods

The field experiment was laid out in the year 2016 at the soil science research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. Geographically, the experimental field is located at 23° 13' North latitude, 79° 57' East longitudes and at an altitude of 393 meter above mean sea-level. Taxonomically, the soils of the study fall in the order "Vertisol" and sub group "Typic *Haplusterts*" as per the taxonomic system of soil classification. The soils was slightly alkaline in nature having pH 7.57. The initial soil properties of the experimental soil is presented in table-1.

The field experiment was conducted in Randomized Block Design (RBD) with six treatments and four replications. The details about field experiment are shown in table-2.

STCR equations for rice crop :

$$FN = 4.25 T - 0.45 SN$$

$$FP_2O_5 = 3.55 T - 4.89 SP$$

$$FK_2O = 2.10 T - 0.18 SK$$

Where, FN - Fertilizer nitrogen (kg ha⁻¹), FP₂O₅ - Fertilizer phosphorus (kg ha⁻¹), FK₂O - Fertilizer potassium (kg ha⁻¹), T - Desired yield target (q ha⁻¹), SN - Available soil nitrogen (kg ha⁻¹), SP - Available soil phosphorus (kg ha⁻¹), SK - Available soil potassium (kg ha⁻¹)

Treatment's detail:

T₁: Control

T₂: General recommended dose (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹)

T₃: Targeted Yield 50 q ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹)

T₄: Targeted Yield 60 q ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹)

T₅: Targeted Yield 50 q ha⁻¹ with 5 t FYM ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O with 5 t FYM ha⁻¹)

T₆: Targeted Yield 60 q ha⁻¹ with 5 t FYM ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O with 5 t FYM ha⁻¹)

In treatments comprising of STCR with manure was applied at the rate of 5 tonnes FYM/ ha⁻¹ in addition to inorganic fertilizers. Plotwise composite soil samples were collected after harvesting of rice crop in *Kharif* 2016 upto 0-15 cm from the experimental plots. Collected soil samples were left for drying under shade. After that, soil samples were processed using wooden pestle and mortar and passed through 2mm sieve and properly stored in polythene bags for further analysis. Methods for analysis of different soil properties are depicted in Table 1. To

determine dry matter accumulation, five plants from the central row were harvested starting from 30 days after sowing each at an interval of 30, 60 and 90 days. Dry matter accumulation was determined three times (30, 60 and 90 DAS) and was calculated after oven drying at 70°C till constant weight.

The rice crop was harvested and bundles were made plot wise and allowed to dry in the plot for 2-3 days and then weighted. Threshing was done plot wise and grain and straw yields were recorded.

The data pertaining to each character of the rice crop were tabulated and analyzed statistically by applying the standard technique. Analysis of variance for randomized block design was worked out and the significance of treatments was tested to draw valid conclusions as described by Gomez and Gomez (1984). Critical differences were worked out at 5 percent level of probability where 'F' test was significant. If the variance ratios (F-test) were found significant at 5% level of significance, the standard error of the mean (SEm) and critical differences (CD) was calculated accordingly.

Results and Discussion

Effect of different treatments on dry matter accumulation : Dry matter per hill was recorded at 30, 60, and 90 days after sowing to observe growth parameters. The dry matter production of rice was significantly affected by different treatments (Table-3). The higher dry matter (2.46, 17.24 and 22.03 g hill⁻¹ at 30, 60 and 90 DAS, respectively) at all the stages was recorded under treatment T₆ with the application of 157:125:70 kg N, P₂O₅ and K₂O with 5 t FYM ha⁻¹ which was significantly superior to T₁ (control), T₂ (GRD) and T₃ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹). However, it was statistically at par with T₄ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹) and T₅ (115:90:49 kg N, P₂O₅ and K₂O with 5 t FYM ha⁻¹). The minimum dry matter accumulation (1.72, 10.82, and 12.86 g hill⁻¹ at 30, 60 and 90 DAS, respectively) was obtained in T₁ (control). The dry matter production is the cumulative effect of all the growth characters and the increasing NPK fertilizer levels incorporated with FYM increased leaf area which are indicators of higher chlorophyll per unit area improving accumulation and transport of nutrients which in turn resulted in higher dry matter accumulation of plants. A similar result on dry matter performance was recorded by Naing Oo *et al.* (2010), Samsul *et al.* (2012), Srivastava *et al.* (2013), Khidrapure *et al.* (2015) and Vidya *et al.* (2015).

Effect of different treatments on chemical properties of soil : Effect of fertilizers levels with and without FYM on soil chemical properties (pH, electrical conductivity and

Table-1 : Initial soil properties of the experimental soil.

S. No.	Parameter	Value	Unit	Method	Reference
1.	pH	7.57	-	Soil: Water (1:2.5)	Jackson, 1973
2.	Electrical Conductivity	0.321	dS m ⁻¹	Soil: Water (1:2.5)	Jackson, 1973
3.	Organic Carbon	5.41	g kg ⁻¹	Wet digestion method	Walkley and Black, 1934
4.	Available Nitrogen	217.83	kg ha ⁻¹	Alkaline potassium perman- ganate method	Subbiah and Asija, 1956
5.	Available Phosphorus	21.45	kg ha ⁻¹	Olsen's method	Olsen <i>et al.</i> , 1954
6.	Available Potassium	311.57	kg ha ⁻¹	Neutral ammonium acetate method	Hanway and Heidel, 1952

Table-2 : The details of the layout plan and treatment.

Experimental site	Research Farm, JNKVV, Jabalpur (M.P.)
Experimental Design	Randomized Block Design (R.B.D.)
Number of treatments	06
Number of Replications	04
Total number of plots	24
Gross plot size	5 m x 5 m (25 m ²)
Crop	Rice
Variety	Kranti
Season	Kharif 2016
Seed rate	100 kg ha ⁻¹
Row to row spacing	25 cm
Plant to plant spacing	10 cm
Sources of Fertilizers	Urea, SSP and MOP as per affixed targeted yield

organic carbon) at 60 DAS and at harvest of rice crop soils were studied.

Soil Ph : Data pertaining to effect of different treatments on pH of surface (0-15 cm) soil at 60 DAS and at harvest of rice crop has been given in Table 4. It was clear from the data that increasing levels of NPK with and without organic manure to decreased soil pH as compared to without inorganic fertilizers. Data further showed that the effect of various treatments on soil pH at both interval did not differ significantly. It was also evident from the data that soil pH under different treatments varied from 7.47-7.56 against the initial soil pH values of 7.57. The results showed that numerically maximum values of pH (7.56 at 60 DAS and 7.55 at harvest) were recorded in control, whereas the addition of inorganic nutrients along with FYM in 157:125:70 kg N:P₂O₅:K₂O with 5 t FYM ha⁻¹ (T₆) slightly reduced the pH in soil. No significant change in soil pH due to treatments at both the stages was observed might be due to higher buffering capacity of Vertisols. Continuous application of manure and fertilizers indicated that the possibility of alteration in pH being relatively high when fertilizers were used alone than conjoint use of fertilizer with organic manure. Similar results were also reported by Dwivedi *et al.* (2007) and Habtamu (2015). Dwivedi *et al.* (2007) reported that the variations in soil pH may occur due to various factors which include application of fertilizers, manure and

intensive cropping over a long period of time. In relation to this, from the perusal of literature it is clear that the pH of soil may decrease if fertilizers having residual acidity are continuously used in acid soil while, it may remain almost unchanged if fertilizer are used in normal soil due to high buffering capacity. Further, it also appears that use of organic manure (FYM) may act as a stabilizing factor.

Electrical conductivity : Data on electrical conductivity (EC) of surface soil (0-15 cm) at 60 DAS and at harvest of rice varied significantly due to different treatments are presented in Table-4. It is evident from the data that the EC of surface soil at both stages was varied in between 0.195-0.315 dS m⁻¹. It was also observed that significantly higher values of EC (0.315 and 0.303 dS m⁻¹) were obtained under T₆, which was statistically at par with T₅, while minimum values of EC (0.243 and 0.195 dS m⁻¹) were recorded under control. The EC almost slightly higher if balanced fertilizers were used along with organic manure (FYM) might be due to stabilizing effects of FYM. It was also observed that the FYM might have accelerated the dissolution of sparingly soluble salts thereby increasing the electrical conductivity of soil. Grewal *et al.* (1999) have reported that continuous use of inorganic fertilizer over a long period of time have no marked influence on EC of the soil and conjoint use of FYM and fertilizer may cause change which could be due to addition

Table-3 : Effect of different treatments on dry matter production.

Treatments	Dry matter (g hill ⁻¹)		
	30 DAS	60 DAS	90 DAS
T ₁ : Control	1.72 ^d	10.82 ^d	12.86 ^e
T ₂ : GRD	2.00 ^{cd}	13.08 ^c	16.60 ^d
T ₃ : T.Y. 50 q ha ⁻¹	2.11 ^{bc}	14.20 ^{bc}	18.32 ^{cd}
T ₄ : T.Y. 60 q ha ⁻¹	2.34 ^{ab}	15.90 ^a	20.58 ^{ab}
T ₅ : T.Y. 50 q + 5 t FYM ha ⁻¹	2.28 ^{abc}	15.64 ^{ab}	19.98 ^{bc}
T ₆ : T.Y. 60 q + 5 t FYM ha ⁻¹	2.46 ^a	17.24 ^a	22.03 ^a
CD (p=0.05)	0.30	1.61	1.94

*T.Y.- Targeted Yield

Table-4 : Effect of different treatments on chemical properties of soil.

Treatments	PH		EC (dS m ⁻¹)		Oxidizable Organic Carbon (g kg ⁻¹)	
	60 DAS	At Harvest	60 DAS	At Harvest	60 DAS	At Harvest
T ₁ : Control	7.56	7.55	0.243	0.195	5.33	5.11
T ₂ : GRD	7.55	7.54	0.269	0.237	5.49	5.29
T ₃ : T.Y. 50 q ha ⁻¹	7.55	7.53	0.281	0.251	5.51	5.27
T ₄ : T.Y. 60 q ha ⁻¹	7.54	7.51	0.297	0.273	5.55	5.35
T ₅ : T.Y. 50 q + 5 t FYM ha ⁻¹	7.52	7.49	0.293	0.279	5.53	5.33
T ₆ : T.Y. 60 q + 5 t FYM ha ⁻¹	7.51	7.47	0.315	0.303	5.57	5.41
CD (p=0.05)	NS	NS	0.019	0.016	0.22	0.20

*T.Y.- Targeted Yield

of organic manure which increased the buffering capacity of the soil.

Oxidizable organic carbon : Data of organic carbon (OC) has been presented in Table-4 clearly revealed that the organic carbon content increased under different treatments and the values ranged from 5.33 to 5.57 g kg⁻¹ at 60 DAS and 5.11 to 5.41 g kg⁻¹ at harvest soil, respectively. The data clearly indicated that OC content was affected by different fertilizers levels with and without FYM which brought about significant improvement in OC content at both stages. Maximum OC contents (5.57 and 5.41 g kg⁻¹ at 60 DAS and at harvest, respectively) were obtained under T₆ (157:125:70 kg N:P₂O₅:K₂O with 5 t FYM ha⁻¹) over rest of the treatments, while minimum OC contents (5.33 and 5.11 g kg⁻¹) were registered under control at both the stages, respectively. The improvement of OC content might be due to organic manures, which is a storehouse of nutrients and contributes to improved soil fertility. It was also farmyard manure increased organic carbon content by adding organic matter directly and also by improving crop yield, resulting in increased left over of root and plant biomass in the soil. The findings are in good agreement to those reported by Kalhapure *et al.* (2013) and Habtamu (2015). Earlier, Chesti *et al.* (2015) reported that three years of conjoint use of 10 t FYM ha⁻¹ with 100% NPK significantly improved the organic carbon content over the chemical fertilizers alone.

Effect of different treatments on yield of rice : The data of grain and straw yields as well as harvest index of the rice as influenced by various treatments are presented in Figure-1.

Grain yield : A glance of grain and straw yield of rice given in figure-1 indicated significant variation due to different treatments which was found significantly higher over control. An examination of the data revealed that each increment of NPK levels caused significant variation in grain yield of rice. Higher targeted yield of T₆ (60 q + 5 t FYM ha⁻¹) could not be achieved and deviated by $\pm 4.58\%$ negatively, whereas the targeted yield of T₅ (50 q + 5 t FYM ha⁻¹) was obtained comfortably. The grain yield target was achieved only in treatment T₅ which was significantly increased over control. Maximum grain yield of 5725 kg ha⁻¹ was recorded with application of 157:125:70 kg N:P₂O₅:K₂O + 5 t FYM ha⁻¹, which was statistically significant with other treatments except for T₄ and T₅, whereas minimum grain yield of 2781 kg ha⁻¹ was found under control. The improvement in yield under higher level nutrients might be due to higher absorption of nutrients responsible for the increased photosynthetic accumulation and high biomass production and finally resulting in an increase in the yield. Similar findings were also reported by Kumar *et al.* (2014) and Mahmud *et al.* (2016). Earlier, Chesti *et al.* (2015) reported that significantly higher grain yield of 5.36 t ha⁻¹ with the

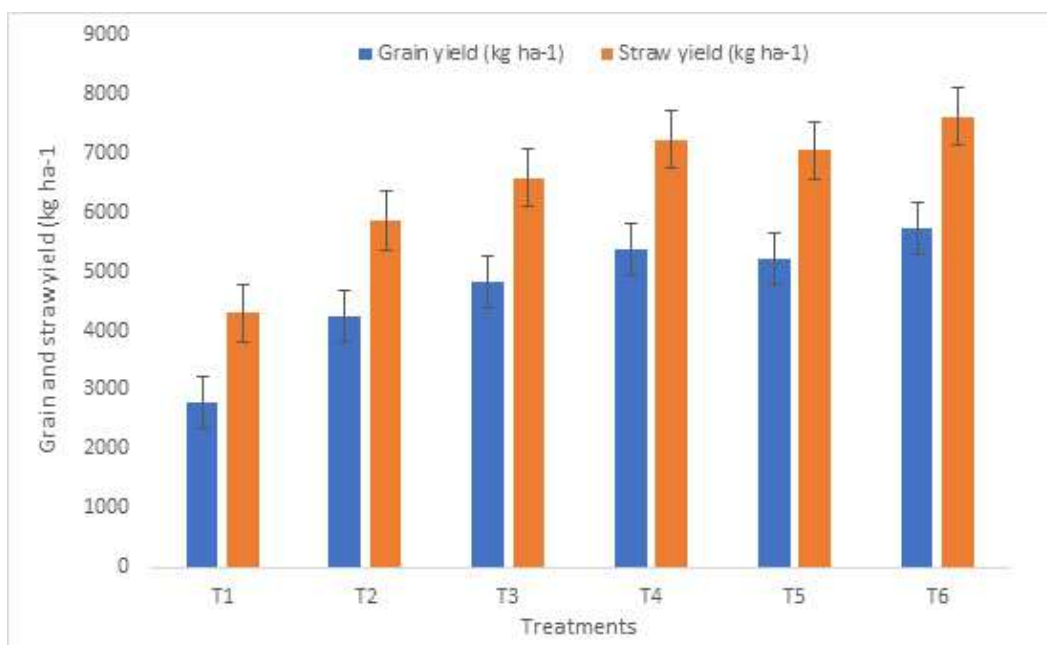


Figure-1 : Effect of different treatments on grain and straw yield.

application of 100% NPK+10 t FYM ha⁻¹ as compared to the grain yield of 4.96 t ha⁻¹ with the 100% NPK alone.

Straw yield : Data on straw yield of rice was significantly affected by different treatments are presented in Figure-1. The effect of treatments on straw yield also followed a similar trend as that of grain yield. The higher yield of straw (7623 kg ha⁻¹) was obtained with a higher level of inorganic fertilizers along with FYM (T₆), which was significantly superior to T₁ (control), T₂ (GRD) and T₃, respectively. However, it was statistically at par with T₄ and T₅. The minimum straw yield of 4295 kg ha⁻¹ was obtained in T₁ (control). The improvement in straw yield under higher level nutrients might be due to higher absorption of nutrients and increased photosynthesis activity lead to higher accumulation of biomass. Similar findings were also reported by Naing Oo *et al.* (2010).

Conclusions

From the experimental study, it is concluded that the STCR based fertilizer recommendation along with 5 tonnes FYM ha⁻¹ not only produced the targeted yield of rice but also improved the soil fertility as increases in soil organic carbon as compared to the application of chemical fertilizer alone. Thus, STCR based fertilizer along with FYM can play a vital role in exploiting the high yield potential of rice crops and sustaining soil health.

References

- Baishya, L.K., Rathore, S.S., Singh, D., Sarkar, D., Deka, B.C., (2015). Effect of integrated nutrient management on rice productivity, profitability and soil fertility. *Ann Plant Soil Res.* 17: 86–90.
- Chesti, M.H., Kohli, A., Mujtaba, A., Sofi, J.A., Nazir, Q., Tabasum Peer, Q.J.A., Dar, M.A. and Bisati, I.A., (2015). Effect of integrated application of inorganic and organic sources on soil properties, yield and nutrient uptake by rice (*Oryza sativa*L.) in Intermediate Zone of Jammu and Kashmir. *Journal of the Indian Society of Soil Science* 63(1), 88-92.
- Dwivedi, A.K., Singh, M., Kauraw, D.L., Wanjari, R. H. and Chauhan, S.S., (2007). Research bulletin on impact of fertilizer and manure use for three decades on crop productivity and sustainability and soil quality under soybean-wheat cropping system on a Vertisol in Central India. IISS (ICAR), Bhopal 224-235.
- FAO., (2017). The state of food security and nutrition in the world. Rome: Building resilience for peace and food security. FAO.
- Gautam, P., Srivastava, A., Singh, S., Saxena, A.K., (2013). STCR approach for optimizing integrated plant nutrient supply of pea in Mollisols of Uttarakhand. *Pantnagar. Journal of Research* 11(1):100-104.
- Gomez, A.A. and Gomez, K.A., (1984). Statistical procedures for Agricultural Research. 2nd Edn. John Wiley and Sons, New York.
- Habtamu, A.D., (2015). Effects of organic and inorganic fertilizers on selected soil properties after harvesting maize at Antra Catchment, Northwestern Ethiopia. *International Inv. Journal of Agriculture Soil Science* 3(5), 68-78.
- Hanway, J.J. and Heide, H., (1952). Soil Analysis Methods, as used in Iowa State. College Soil Testing Laboratory, Iowa, Agriculture 57, 1-31.
- IRRI., (2009). Rough rice production by country and geographical region. Trend in the rice economy. In: World rice statistics. www.irri.org/science/ricestat.
- Jackson, M.L., (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.
- Kalhapure, A.H., Shete. B.T. and Dhonde, M.B., (2013).

- Integrated nutrient management in maize (*Zea mays* L.) for increasing production with sustainability. *International Journal of Agriculture and Food Science Technology* 4(3), 195-206.
12. Khidrapure, G., Uppar, D.S., Maruti, K., Tejagouda, M.B. and Shankrayya, (2015). Effect of integrated nutrient management on plant Growth and seed yield in hybrid maize (arjun). *An International Journal of Life Science* 10(1): 369-371.
 13. Kumar, A., Meena, R.N., Yadav, Lalji, and Gilotyia, Y.K., (2014). Effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice. *The Bio-scan* 9(2): 595-597.
 14. Kumar, A., Tripathi, H.P., Yadav, D.S., (2007). Correcting nutrient for sustainable crop production. *Indian Journal of Fertilisers* 2(11): 37-44.
 15. Mahmud, A.J., Shamsuddoha, A.T.M., Nazmul, H.M., (2016). Effect of Organic and Inorganic Fertilizer on the Growth and Yield of Rice (*Oryza sativa* L.). *Nature and Science* 14(2): 45-54.
 16. Naing, Oo, A., Banterng, P., Polthanee, A. and Trela-Ges, V., (2010). The effect of different fertilizers management strategies on growth and yield of upland Black Glutinous rice and soil property. *Asian Journal of Plant Sciences* 9: 414-422.
 17. Nalley, L., Tack, J., Durand, A., Thoma, G., Tsiboe, F., Shew, A., Barkley, A., (2017). The production, consumption, and environmental impacts of rice hybridization in the United States. *Agron J.* 109:193–203.
 18. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A., (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U.S. Deptt. Of Agriculture. 19.
 19. Pandey, H.P., Pathak, R.K., Sachan, A.K., Tripathi, V.K., Kumari, A., (2018). Response of inorganic fertilizer and biofertilizer on biological yield and quality of hybrid rice (*Oryza sativa* L.) in Indo-Gangetic plain of central Uttar Pradesh. *J Pharmacognoc Phytochemistry* 7: 1403–1408.
 20. Ramamoorthy, B., Narasimhan, R.L., Dinesh, R.S., (1967). Fertilizer application for specific yield targets of Wheat, Sonara 64. *Indian farming* 17:43-45.
 21. Samsul, H., Partha, S.P. and Ashok, S., (2012). Growth attributes, cob yield and economics of maize (*Zea mays* L.) cultivars as affected by integrated nutrient management under Terai Region of West Bengal. *Indian Journal of Agricultural Research* 46(1): 42-47.
 22. Srivastava, O.P., (2013). Integrated nutrient management for sustained fertility of soil. *Indian journal of agricultural chemistry* 31(1): 1-12.
 23. Subbiah, B.V. and Asija, G.L., (1956). A rapid method for the estimation of nitrogen in soils. *Current Science* 25, 259-260.
 24. Tegegnetwork, G.W., Shanwad, U.K., Desai, B.K., Koppalakkar, B.G., Shankergoud, I., (2015). Response of soil test crop response (STCR) as an optimizing plant nutrient supply on yield and quality of sunflower (*Helianthus annuus* L.). *African Journal of Agricultural Research* 10(28): 2680-2686.
 25. Vidya, V., Choudhari and Channappagouda, B.B., (2015). Effect of organics on morphophysiological traits and grain yield of maize (*Zea mays* L.). *The Bioscan* 10(1): 339-341.
 26. Walkley, A. and Black, C.A., (1934). An examination to different method for determination soil organic matter and proposal for modification of the chromic acid titration method. *Soil Science* 37, 29-38.
 27. Yadav, G.S., Lal, R., Meena, R.S., Babu, S., Das, A., Bhowmik, S.N., Datta, M., Layak, J., Saha, P., (2019). Conservation tillage and nutrient management effects on productivity and soil carbon sequestration under double cropping of rice in north eastern region of India. *Ecological Indicators* 105: 303–315.



Effect of Weed Management Practices on Weed Dynamics, Quality Parameters vis-a-vis Phytotoxicity in Urdbean under Rainfed Condition

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Abstract

A field experiment was conducted at Agricultural Research Station, Kota during the *Kharif* season 2019-20 to find out suitable weed management practices in rainfed condition of south- eastern Rajasthan. The field experiment was laid out in a randomized block design with ten treatments in three replications. The highest protein yield (196.28 kg ha⁻¹) was recorded under hand weeding at 20 and 40 DAS compare to all other treatment. Among herbicide treatments application of pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS had significance effect at harvest over other herbicidal treatment on weed indices such as WMI, AMI and IWMI (2.28, 0.90 and 1.28), protein yield (186.08 kg ha⁻¹) being at par with pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ fb fomesafen 11.1% w w⁻¹ @ 220 g a.i. ha⁻¹ + fluazifop-p-butyl 11.1% w w⁻¹ @ 220 g a.i. ha⁻¹ at 20 DAS. These herbicides are producing no phytotoxicity symptoms on crop. The application of Pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS was found beneficial for obtaining high protein yield in rainfed conditions of south- eastern Rajasthan.

Key words : Urdbean, phytotoxicity, protein yield, WMI, IWMI, AMI

Introduction

Pulses provide a perfect blend of vegetarian protein with high biological value when accompanied with cereals. Pulses are an important part of India's sustainable crop production because of their unique biological nitrogen fixation, carbon sequestration, soil amelioration, low water requirement and ability to withstand harsh climates. Urdbean (*Vigna mungo* L. Hepper) is a significant *kharif* pulse crop in India, containing about three times the protein of cereals (Kanade 2006). Urdbean has a protein content of 24%, carbohydrate content of 60%, fat content of 1.3% and is high in phosphoric acid, vitamins and minerals (Islam *et al.* 2011). After chickpea, pigeon pea and green gram, urdbean is India's fourth most significant crop.

The productivity of urdbean in India is extremely poor due to a variety of factors that influence output. During the *kharif* season, the hot and humid atmosphere along with monsoon rainfall results in a thriving weed population in this crop. It is one of the major causes of decreased urdbean productivity during the *kharif* season. Weeds are major competitors of natural and man-made resources such as nutrients, water and light, all of which could have been used to increase agricultural output

(Singh and Sheoran 2008). Weeds are said to reduce urdbean yields by 87 per cent with the amount of the decline depending on the kind and severity of the weed flora (Singh *et al.*, 2002).

One of the most common weeds in urdbean is a *Echinochloa colona* affect grain yield by up to 49% (Rao and Rao, 2003). To get high urdbean yields, weeds must be removed at the appropriate time and with the appropriate approach. Because it prevents weed seed generation and soil seed bank enrichment, integrated weed management has been found to be more effective, convenient, eco-friendly and cost-efficient than solitary treatment. Furthermore, it lowers the likelihood of weed flora shift, herbicide-resistant weeds and the predominance of perennial weeds in an agro-ecosystem.

Materials and Methods

The field experiment was conducted at Research Farm of Agricultural Research Station, Ummadganj, Kota (Agriculture University, Kota), during *kharif* season of 2019-20 in order to test the efficacy of alone and per mix herbicides against mixed weed flora in urdbean. The climate of this region is humid. The total rainfall received during *kharif* season (June to October) for the year 2019-20 was 1100.8 mm. The soil of experimental site

was clay loam in texture with pH 7.2, medium in organic carbon 0.53%, available N (206.10 kg ha⁻¹), P₂O₅ (30.50 kg ha⁻¹) but high in K₂O (480.10 kg ha⁻¹). Ten treatments comprising of alone pendimethalin 30% EC 1.0 kg ha⁻¹ as pre-emergence, and per mix of propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ ME @ 50 g a.i. ha⁻¹, acifluorfen-sodium 16.5% EC @ 140 g ha⁻¹ + clodinafop-propargyl 8% EC @ 70 g ha⁻¹, fomesafen 11.1% w w⁻¹ 220 g ha⁻¹ + fluazifop-p-butyl 11.1% w w⁻¹ 220 g ha⁻¹ and fluazifop-p-butyl 13.4% w w⁻¹ @ 250 g ha⁻¹ as postemergence along and followed by pendimethalin 1.0 kg ha⁻¹, hand weeding twice (20 and 40 DAS) including weedy check were laid out in randomized block design with three replications.

Urbean variety Mukundra Urd 2 was grown on 13 July with row spacing of 30 cm and a plant spacing of nearly 10 cm during the years. The recommended dose of fertilizers for urdbean was 20 kg N and 40 kg P₂O₅. The whole quantity of N and P was applied through urea and single super phosphate at the time of sowing of urdbean. The protein content of mature grains was calculated by multiplying the nitrogen percentage of mature grains by 6.25. Protein yield was estimated by multiplying the protein content by the appropriate oven dried grain yield (kg ha⁻¹).

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Grain yield} \times \text{protein content}}{100}$$

Weed indices were computed using the standard procedure by Sarma, A. 2014 as following details :

$$\text{Weed management index} = \frac{\frac{Y_Y - Y_C}{Y_C}}{\frac{W_C - W_T}{W_C}}$$

Agronomic management index (AMI)

$$= \frac{\frac{Y_Y - Y_C}{Y_C} \times \frac{W_C - W_T}{W_C}}{\frac{W_C - W_T}{W_C}}$$

Integrated weed management index (IWMI)

$$= \frac{\text{WMI} - \text{AMI}}{2}$$

Whereas;

Y_T = yield of treated plot

Y_C = yield of control plot (weedy check)

W_C = weed dry weight in control plot (weedy check)

W_T = weed dry weight in treated plot

All of the data were subjected to statistical analysis utilising Panse and Sukhatme (1978) analysis of variance

(ANOVA) methodology. When there was a significant difference, a critical difference was calculated at a 5% probability level.

Results and Discussion

Effect on Weed indices : The values of weed indices like weed management index (WMI), agronomic management index (AMI), and integrated weed management index (IWMI) were inferior in plots receiving no any weed control throughout the growing season (Table-2). Among the herbicidal treatments application of pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ (PE) fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS resulted in higher values of WMI, AMI and IWMI which is followed by Pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ (PE) fb fomesafen 11.1% w w⁻¹ @ 220 g a.i. ha⁻¹ + fluazifop-p-butyl 11.1% w w⁻¹ @ 220 g a.i. ha⁻¹. A treatment having high values of agronomic indices such as WMI, AMI, and IWMI should be considered a good treatment with high weed control efficiency (Panda *et al.*, 2017; Shyamlal *et al.*, 2017; Suria *et al.*, 2011).

Effect on quality parameter : An assessment of data from Table-2. indicated that the weedy crop resulted in least protein yield. Maximum and significantly higher protein yield was recorded under two hand weeding at 20 and 40 DAS (196.28 kg ha⁻¹) being at par with pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ (PE) fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS. Among herbicide application of pendimethalin 30% EC @ 1 kg ha⁻¹ (PE) fb propaquizafop 2.5% w w⁻¹ @ 33.3 g ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g ha⁻¹ at 20 DAS was recorded higher protein yield (186.08 kg ha⁻¹) being at par with pendimethalin 30% EC @ 1 kg ha⁻¹ (PE) fb fomesafen 11.1% w w⁻¹ @ 220 g ha⁻¹ + fluazifop-p-butyl 11.1% w w⁻¹ @ 220 g ha⁻¹ (pre mix) at 20 DAS (173.60 kg ha⁻¹), with 57.99 and 54.97 per cent increase, respectively over weedy check. The results of study also support with findings of Singh *et al.* (2018).

Visual phytotoxicity score : Pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ (PE) fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS recorded no phytotoxic effects on urdbean in terms of epinasty, hyponasty, necrosis, vein clearing and wilting at 5 after spray found completely safe for the crop at Rajasthan. Data Table-3 indicated that after 5 days of spray of acifluorfen-sodium 16.5% EC @ 140 g ha⁻¹ + clodinafop-propargyl 8% EC @ 70 g ha⁻¹ (pre mix) at 20 DAS, pendimethalin 30% EC @ 1 kg ha⁻¹ (PE) fb acifluorfen-sodium 16.5% EC @ 140 g ha⁻¹ + clodinafop-propargyl 8% EC @ 70 g ha⁻¹ (pre mix) at 20 DAS and fluazifop-p-butyl 13.4% w w⁻¹ @ 250 g ha⁻¹ (pre

Table-1 : Effect of herbicides on nutrient content (kg ha⁻¹) in soil after harvest of crop.

Treatments	Available N	Available P ₂ O ₅	Available K ₂ O
Weedy check	207.33	33.66	489.07
Two hand weeding at 20 and 40 DAS	261.33	38.85	569.33
Pendimethalin 1 kg ha ⁻¹ (PE)	241.52	33.68	546.19
Propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	254.47	34.84	557.76
Aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	252.67	33.83	553.28
Fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	254.06	34.67	554.03
Pendi fb propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	258.95	38.03	567.70
Pendi fb aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	255.90	36.85	561.87
Pendi fb fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	256.67	37.79	567.33
Fluazi 250 g ha ⁻¹ at 20 DAS	245.70	33.75	548.05
SEm±	18.58	1.33	27.51
CD (P=0.05)	NS	NS	NS

Table-2 : Different weed indices, protein (%) and protein yield (kg ha⁻¹) as affected by different treatments in urdbean.

Treatments	WMI	AWI	IWMI	Protein (%)	Protein yjeld (kg ha ⁻¹)
Weedy check	0.0000	0.0000	0.0000	19.79	78.17
Two hand weeding at 20 and 40 DAS	1.7925	0.7925	0.5686	22.85	196.28
Pendimethalin 1 kg ha ⁻¹ (PE)	0.9815	-0.0185	0.3515	20.33	102.26
Propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	1.5960	0.5960	0.6116	21.13	133.12
Aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	1.2165	0.2165	0.4314	20.67	116.79
Fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	1.5014	0.5014	0.5694	20.85	127.19
Pendi fb propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	2.2884	1.2884	0.9053	22.50	186.08
Pendi fb aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	1.4697	0.4697	0.5058	21.88	144.63
Pendi fb fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	2.0602	1.0602	0.7966	22.40	173.60
Fluazi 250 g ha ⁻¹ at 20 DAS	0.6036	-0.3964	0.1172	20.21	97.61
SEm±	0.0542	0.0244	0.0200	0.78	5.00
CD (P=0.05)	0.16	0.07	0.0594	NS	14.85

Table-3 : Visual phytotoxicity scoring on crop at different growth stages.

Treatments	Visual rating							
	Leaf necrosis		Leaf necrosis		Leaf necrosis		Leaf necrosis	
	5 days after spray	5 days after spray	5 days after spray	5 days after spray	5 days after spray	5 days after spray	5 days after spray	5 days after spray
Weedy check	0	0	0	0	0	0	0	0
Two hand weeding at 20 and 40 DAS	0	0	0	0	0	0	0	0
Pendimethalin 1 kg ha ⁻¹ (PE)	0	0	0	0	0	0	0	0
Propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	0	0	0	0	0	0	0	0
Aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	1	0	1	0	1	0	1	0
Fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	0	0	0	0	0	0	0	0
Pendi fb propa 33.3 g ha ⁻¹ + imaz 50 g ha ⁻¹ at 20 DAS	0	0	0	0	0	0	0	0
Pendi fb aciflu-Na 140 g ha ⁻¹ + clodi prop 70 g ha ⁻¹ at 20 DAS	1	0	1	0	1	0	1	0
Pendi fb fomes 220 g ha ⁻¹ + fluazi 220 g ha ⁻¹ at 20 DAS	0	0	0	0	0	0	0	0
Fluazi 250 g ha ⁻¹ at 20 DAS	1	0	1	0	1	0	1	0

mix) at 20 DAS treatments crop plant with each influenced by leaf necrosis, yellowing of leaves, epinasty and hyponasty. Whereas, 10 days after different herbicides spray did not notice leaf necrosis in crop plants. The results of study also support with findings of Tomar, A. S. (2011); Naidu *et al.* (2012) and Soltania *et al.* (2015).

Conclusions

From this study it can be concluded that application of pendimethalin 30% EC @ 1 kg a.i. ha⁻¹ (PE) fb propaquizafop 2.5% w w⁻¹ @ 33.3 g a.i. ha⁻¹ + imazethapyr 3.75% w w⁻¹ (pre mix) ME @ 50 g a.i. ha⁻¹ at 20 DAS is recommended for weed control in urdbean as it improved the protein yield of urdbean through better weed indices like WMI, AMI and IWMI.

References

- Islam, M., Mohanty, A. K. and Kumar, S. 2011. Correlating growth, yield and adoption of urdbean technologies. *Indian Research Journal of Extension Education* 11(2): 20-24.
- Kanade, 2006. Agricultural marketing report pp. 1-6.
- Naidu, K.R.K., Ramana, A.V. and De, B. 2012. Bio-efficacy and economics of herbicides against weeds of black gram (*Vigna mungo* L.) grown in ice-fallow. *Journal of Crop and Weed* 8(1): 133-136.
- Panda, S., Kewat, M.L. and Saini, M.K. 2017. Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean. *International Journal of Current Microbiology and Applied Sciences* 6(10): 3251-3256.
- Panase, V.G. and Sukhatme, P.V. 1978. Statistical methods for agriculture workers. ICAR, New Delhi.
- Rao, A.S. and Rao, R.S.N. 2003. Bio-efficacy of clodinafop propargyl on *Echinochloa spp.* in black gram. *Indian Journal of Weed Science* 35: 251-252.
- Sarma, A. 2014. Weed control, Numerical agronomy. Kalyani publisher, New Delhi, pp. 64-65.
- Shyاملal, Kewat, M.L. and Suryavanshi, T. 2017. Weed Indices as Influenced by Propaquizafop and Imazethapyr Mixture in Soybean. *International Journal of Current Microbiology and Applied Sciences* 6(8): 3109-3115.
- Singh, J., Deal, J.S., Sardana, V. and Singh, J. 2002. Crop weed competition studies in summer black gram. *Indian Journal of Weed Science* 34(3&4): 299-300.
- Singh, M., Shekhar, K. S., Ardeep and Datta, D. 2018. Herbicide combinations for weed management in urdbean (*vigna mungo*) under tarai condition of uttarakhand. *International Journal of Chemical Studies* 6(4): 1594-1597.
- Singh, S. and Sheoran, P. 2008. Studies on integrated weed management practices in rained maize under sub-mountainous conditions. *Indian Journal of Dryland Agricultural Research and Development* 23: 6-9.
- Soltania, N., Chris, L.G., Clarence, J.S., Christy, S. and Peter, H.S. 2008. Response of white bean (*Phaseolus vulgaris*) to imazethapyr. *Crop Protection* 27: 672–677.
- Suria, A.S.M.J., Juraimi, A.S., Rahman, M.M., Man, A.B. and Selamat, A. 2011. Efficacy and economics of different herbicides in aerobic rice system. *African Journal of Biotechnology* 10: 8007–8022.
- Tomar, A.S. 2011. Evaluation of quizalofop p-ethyl 4.41% EC against grassy weeds in black gram (*Vigna mungo* L.). *Journal of Crop and Weed* 7(1): 140-141.



The Qualitative and Quantitative Survey of Insect Pests of Stored Pearlmillet, *Pennisetum glaucum* (Linn.) R.Br. Emend Stuntz. in Agro-Climatic Zone IIIa of Rajasthan

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Abstract

The study of extensive survey of insect pests on grain pearlmillet in Zone IIIa of Rajasthan revealed that the storage containers and storage structures adopted by the farmers were plastic fibre bags (25.00%) followed by bulk storage in room (22.22%), metal bin (22.22%), gunny bags (16.67%) and *Pucca Bukhari* (13.88%). The insecticides and grain protectants used by the farmers were aluminium phosphide, solarization, cow dung ash, *Neem* leaves and more than one practices. Although, large number of respondents (27.77%) did not use insecticides and grain protectants. The insect pests recorded were *Rhyzopertha dominica* (Fab.), *Tribolium castaneum* (Herbst), *Trogoderma granarium* Everts, *Sitotroga cerealella* Olivier and *Corcyra cephalonica* Staint. These insect pests inflicted quantitative loss in grain pearlmillet from 3.00-20.30 per cent.

Key words : Insect, pearlmillet, gunny bags, metal bin, neem, protectants.

Introduction

Pearlmillet, *Pennisetum glaucum* (Linn.) R. Br. emend Stuntz. (Family: Gramineae) is one of the important millet crops and comes next to sorghum in area and production. In India, it is grown in an area of 7.52 million hectares with an annual production to the tune of 10.28 million tonnes and average productivity of 1368 kg ha⁻¹ [1]. Rajasthan is one of the chief pearlmillet growing states, occupying a total area of 4.29 million hectares under cultivation with an annual production of 4.69 million tonnes and average productivity of 1093 kg ha⁻¹ [1]. In Rajasthan, Barmer, Jodhpur, Nagaur, Jaipur, Churu, Sikar, Alwar and Jhunjhunu are major pearlmillet growing districts. It is nutritionally better than many cereals as it is a good source of protein (12.6%), fat (5%), fibre (1.0%) and minerals (2.0%), chiefly Calcium, Phosphorus and Iron.

Pearlmillet is one of the most important grain crops grown in the Indian arid zone. The extent of infestation of various insect pests is variable under different storage structures and practices. The investigations on the total losses caused by insect pests were, therefore, carried out in Agro-climatic zone IIIa (Semi-arid Eastern Plain Zone) of Rajasthan. One village from each *Panchayat Samiti* was taken into consideration to draw the samples. From villages, the samples were taken from the farmers.

Research Methodology

The samples thus collected were analysed for recording different parameters for which the methodology is described hereunder :

Sampling technique : Samples of grain pearlmillet were taken during August and September, 2016. A

representative sample of 500 g each in triplicate was taken from each farmer, placed in polythene bags, sealed and brought to the laboratory for further studies.

Storage structures : The storage structures of different types adopted by the farmers were registered while taking the grain sample and their comparative usage was worked out. The efficacy of each storage structure for safe storage of grain was computed.

Insect population : In order to record the population of different insect pests in the grain, an aliquot was taken from the samples and kept in glass jars covered with muslin cloth in controlled conditions (a temperature of 29±1.5°C and relative humidity of 75±5 per cent) for a period of two months. These aliquots were critically examined every alternate day for the presence of insect pests. The total populations of insect pests were calculated. For handling insects and infested grains, a forcep and a camel hair brush was used.

Grain damage : Hundred grains from each sample were taken out, damaged grains were separated and counted. Thus, per cent damaged grains due to insect pests were recorded.

Weight loss : The weight loss due to insect pests damage in different grain samples was recorded. The frass material was excluded and the weight of grain was taken with the electronic pan balance.

Statistical analysis : The per cent data were transformed into angular values (arc sine percentage) and subjected to analysis of variance. The data on number of adult insects emerged were subjected to $\sqrt{X+0.5}$ transformation for analysis of variance.

Results and Discussion

The survey made in August to September in zone IIIa (Semi-arid Eastern Plain) of Rajasthan revealed that the farmers stored grain pearl millet in the gunny bags, bulk storage in room, *Pucca Bukhari*, metal bin and plastic fibre bags with a varying level of adoption. The maximum adoption was recorded to be of plastic fibre bag (34.35 per cent) followed by metal bin (31.48%) and gunny bag storage (16.67%), *vis-a-vis* minimum in the bulk storage in room (3.70%). The other containers and structures, *viz.* ranked in the middle order (Table-1, Figure-1). [2]. observed that bag storage was most common method adopted for storage and revealed similar type of storage structures and containers for storage of grain commodities. The moisture and temperature regime in these structures was recorded to be ranged from 10.63-13.63 per cent and 31.2- 33.3 °C, respectively. The maximum adult emergence was recorded in gunny bags and plastic fibre bags, *i.e.* 12.33 and 10.0, respectively, these differed non-significantly [2]. The minimum adult emergence was recorded in metal bin (6.00), *Pucca Bukhari* (8.33) and bulk storage in room (8.33%) which was found significantly superior over the other structures and containers. [3]. observed that the infestation of grains with lesser grain borer and flour beetle increased on seed stored in jute bags and the population of insects increased significantly after three, six and twelve months of storage [3]. The minimum seed damage was observed in metal bin (9.74%) which was significantly superior over rest of the storage structures, whereas, the maximum in gunny bags and plastic bags, *i.e.* 24.35 and 18.27 per cent, respectively, both were found at par. [4]. reported maximum infested of grain samples (61.53%) from grain stored in loose storage during June-July, whereas, infested grain samples were not found from the grain stored in metal bin during November- December, these findings partially support the present results [4].

The quantitative loss recorded in different storage containers and structures varied from 5.70-16.14 per cent, the minimum being in metal bin (5.70%) and *Pucca Bukhari* (7.53%) and maximum in gunny bags (16.14%) and plastic bags (14.94%). These results corroborate with the findings of [4,5].

The aluminium phosphide, solarization, ash, *Neem* leaves and more than one practices have been adopted by the farmers to store their produce, however, the adoption of these varied from 8.33-19.44 per cent, the minimum in ash and more than one practices and maximum in solarization. A majority of farmers (27.77%) did not adopt the use of insecticides and grain protectants. The number of adults emerged from different treated samples varied from 5.00-12.00. It was minimum

in aluminium phosphide, more than one practices and cow dung ash, *i.e.* 5.00, 7.33 and 5.33 per cent, respectively and maximum in *Neem* leaves treated grain, *i.e.* 12.00 (Table-2, Fig.-2). [4]. recorded the highest larval mortality (82.20%), pupal mortality (10.00%) and minimum adult emergence (6.00) in case of application of *Neem* leaf powder at 10g/ kg seed after 40 days of release in maize. The seed damage varied from 5.62-14.36 per cent, the minimum in aluminium phosphide treated grain and maximum in *Neem* leaves treated grain [4]. The quantitative loss in different insecticides and grain protectants ranged from 3.77-8.54 per cent. [2]. observed that a majority of farmers (66.67%) did not use insecticides and use of Aluminium phosphide stood at top among the different insecticides and grain protectants, the results partially corroborate with the present finding [2].

The insect pests observed to be attacking the grain pearl millet were *Rhyzopertha dominica* (Fab.), *Tribolium castaneum* (Herbst), *Trogoderma granarium* Everts, *Sitotroga cerealella* Olivier, *Corcyra cephalonica* Staint. and mixed population of insect pests, however, their level of infestation varied greatly (3.70-25.71%) in different grain samples. The minimum number of grain sample were infested with *T. granarium* and maximum with *C. cephalonica* and mixed population of insects. The seed damage caused by different insect pests varied from 6.14-40.35 per cent, the minimum in *S. cerealella* and maximum in *C. cephalonica* (Table-3, Fig.-3). [6]. on wheat and [5]. on maize recorded a similar insect pest spectrum or qualitative status while working at different places of India. [2]. reported losses due to insect pests in wheat to the tune of 14.56-21.21 per cent at the average moisture content of 12.35 per cent. [5]. reported 12.24 per cent losses due to insect pest vagaries during rainy season in stored maize grain. [3,4,5,7,8,9,10]. Earlier did commendable work on the survey of insect pests of stored grains.

Summary and Conclusion

The study on qualitative and quantitative survey of insect pests in Zone-IIIa (Semi-arid Eastern Plain Zone) of Rajasthan revealed that the farmers stored their produce (grain pearl millet) in the gunny bags, plastic fibre bags, bulk storage in room, *Pucca Bukhari* and metal bin. The maximum adoption was recorded in plastic bag (34.25%) and minimum in bulk storage in room (3.70%). The descending pattern of adoption by the farmers was recorded in order of: plastic fibre bags, metal bin, gunny bags, *Pucca Bukhari* and bulk storage in room. Maximum number of adult emergence was recorded in the gunny bags (12.33) and plastic fibre bags (10.00), these differed non-significantly. The minimum number of adults were

Table-1 : Losses in different types of containers and storage structures used by farmers for storage of pearl millet, *Pennisetum glaucum* R.Br. emend Stuntz.

S. No.	Types of storage structures	Number of samples	Adoption (%)	Moisture (%)	Temperature (°C)	Number of adults/sample*	Grain damage (%)**	Quantitative loss (%)**
1.	Gunny bag	18	16.67	12.88	32.0	12.33 (3.59)	24.35 (29.57)	16.14 (23.69)
2.	Bulk storage in room	4	3.70	13.63	31.2	8.33 (2.96)	12.81 (20.97)	10.29 (18.71)
3.	Plastic fibre bag	37	34.25	12.26	32.0	10.00 (3.24)	18.27 (25.30)	14.94 (22.74)
4.	Metal bin	34	31.48	10.63	33.1	6.00 (2.53)	9.74 (18.19)	5.70 (13.81)
5.	<i>Pucca Bukhari</i>	15	13.88	10.82	33.3	8.33 (2.97)	13.63 (21.66)	7.53 (15.92)
	Total	108	-	-	-			
	S.Em. +	-	-	-	-	0.13	0.68	0.44
	CD (p=0.05)	-	-	-	-	0.38	2.00	1.30

*Figures in the parentheses are (X + 0.5) values. **Figures in the parentheses are arc sine percentage values.

Table-2 : Insecticides and grain protectants used by farmers in village storage facilities and losses observed.

S. No.	Insecticides and protectants	Number of samples	Adoption (%)	Moisture (%)	Temperature (°C)	Number of adults/sample*	Grain damage (%)**	Quantitative loss (%)**
1.	Aluminum phosphide	15	13.88	12.36	32.2	5.00 (2.22)	5.62 (13.71)	3.77 (11.20)
2.	Solarization	21	19.44	10.86	33.2	6.00 (2.55)	10.13 (18.56)	5.26 (13.26)
3.	Ash	15	13.88	11.36	32.2	5.33 (2.38)	8.22 (16.66)	4.21 (11.84)
4.	Neem leaves	18	16.66	12.55	32.4	12.00 (3.56)	14.36 (22.27)	8.54 (16.99)
5.	More than one practices	9	8.33	11.73	32.1	7.33 (2.80)	8.77 (17.23)	3.83 (11.29)
6.	Without insecticides/protectants	30	27.77	13.17	31.0	14.85 (3.79)	18.27 (25.30)	11.15 (19.51)
	Total	108	-	-	-			
7.	S.Em. ±	-	-	-	-	0.07	0.09	0.05
	CD (p=0.05)	-	-	-	-	0.20	0.26	0.15

*Figures in the parentheses are (X + 0.5) values. **Figures in the parentheses are arc sine percentage values

emerged from metal bin (6.00) with non-significant difference with *Pucca Bukhari*. The minimum seed damage was recorded in metal bin (9.74%) which was significantly superior over the seed damage recorded in rest of the containers and storage structures. It was maximum in the gunny bags and plastic bags which revealed a seed damage of 24.35 and 18.27 per cent, respectively, both were found at par. The weight loss was maximum in gunny bags and plastic bags (16.14%) and (14.94%), whereas, minimum in metal bin (5.70%) and *Pucca Bukhari* (7.53%), the latter duo were found statistically at par.

The different insecticides and grain protectants adopted by the farmers for safe storage of grain pearl millet were aluminium phosphide, solarization (solar

heat treatment), ash, *Neem* leaves and more than one practices, however, the level of their adoption varied greatly (8.33-19.44%), the minimum being in more than one practices and maximum in solarization. The minimum adults were emerged from grains treated with aluminium phosphide, ash and more than one practices, i.e. 5.00, 5.33 and 7.33, respectively; these treatments were found at par in adult emergence. The grain damage observed in treated grain was ranged from 5.62-14.36 per cent, the minimum in aluminium phosphide and the maximum in *Neem* leaves. The minimum quantitative loss due to insect pests was observed to be in aluminium phosphide treated grains (3.77%) which was found significantly superior over other treatments, *vis-a-vis*, the maximum in the grains stored without insecticides and protectants (11.15%).

Table- 3 : Qualitative and quantitative insect pests status in stored pearl millet, *Pennisetum glaucum* R.Br. emend Stuntz.

S. No.	Insect pest	Number of samples	Samples (%)	Moisture (%)	Temperature (°C)	Number of adults/sample*	Grain damage (%)**	Quantitative loss (%)**
1.	<i>Rhyzopertha dominica</i> (Fab.)	16	14.81	11.23	32.6	15.67 (4.01)	24.76 (29.84)	14.44 (22.33)
2.	<i>Tribolium castaneum</i> (Herbst.)	11	10.18	11.66	32.2	8.00 (2.91)	7.47 (15.86)	4.60 (12.38)
3.	<i>Trogoderma granarium</i> Everts	4	3.70	12.20	32.3	14.67 (3.88)	23.64 (29.09)	13.68 (21.71)
4.	<i>Sitotroga cerealella</i> Olivier	9	8.57	12.05	32.2	3.67 (2.09)	6.14 (14.35)	3.00 (9.99)
5.	<i>Corcyra cephalonica</i> Staint.	27	25.71	12.78	32.7	20.00 (4.54)	40.35 (39.44)	20.30 (26.78)
6.	Mixed population (more than one insects sp.)	23	21.29	11.11	31.3	12.67 (3.63)	21.58 (27.67)	10.14 (18.57)
7.	Free from insect pests	18	17.14	12.36	32.5	0.00 (0.71)	0.00 (0.00)	0.00 (0.00)
Total		108	-	-	-	-	-	-
S.Em. +						0.05	0.06	0.03
CD (p=0.05)						0.14	0.18	0.09

*Figures in the parentheses are (X + 0.5) values. **Figures in the parentheses are arc sine percentage values.

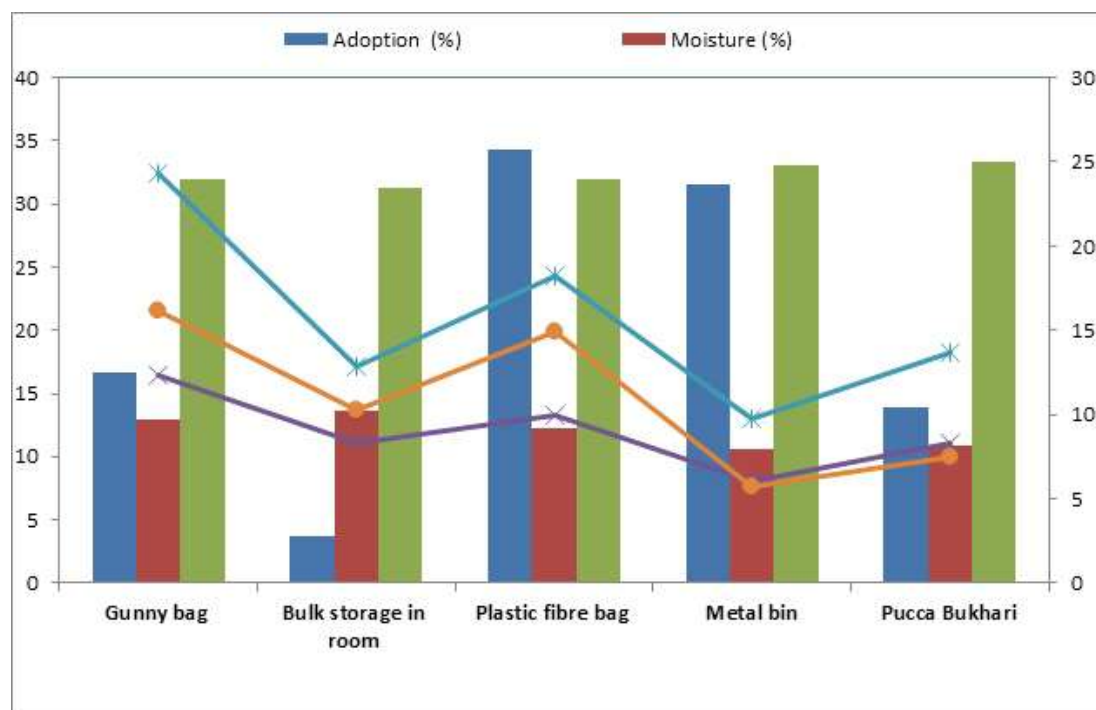


Figure-1 : Types of containers and storage structures used by the farmers for storage of pearl millet.

The insect pests recorded during survey were *Rhyzopertha dominica* (Fab.), *Tribolium castaneum* (Herbst), *Trogoderma granarium* Everts, *Sitotroga cerealella* Olivier and *Corcyra cephalonica* Staint., however, their level of infestation varied from 3.70-25.71 per cent in different grain samples. The minimum number of grain samples were infested with *T. granarium*. The minimum number of adult emergence, seed damage and quantitative loss was evident in *S. cerealella*. The other insect pests caused seed damage in the middle order.

The ascending pattern of seed damage by insect pests was found to be in order of: *S. cerealella*, *T. castaneum*, mixed population, *T. granarium*, *R. dominica* and *C. cephalonica*. The quantitative loss estimated in stored pearl millet in Zone IIIa of Rajasthan due to insect pest nuisance varied from 3.00-20.30 per cent, the minimum being due to *S. cerealella* and maximum due to *C. cephalonica*.

In stored pearl millet grain the recommendations for farmers in inert material and plant oils, neem seed

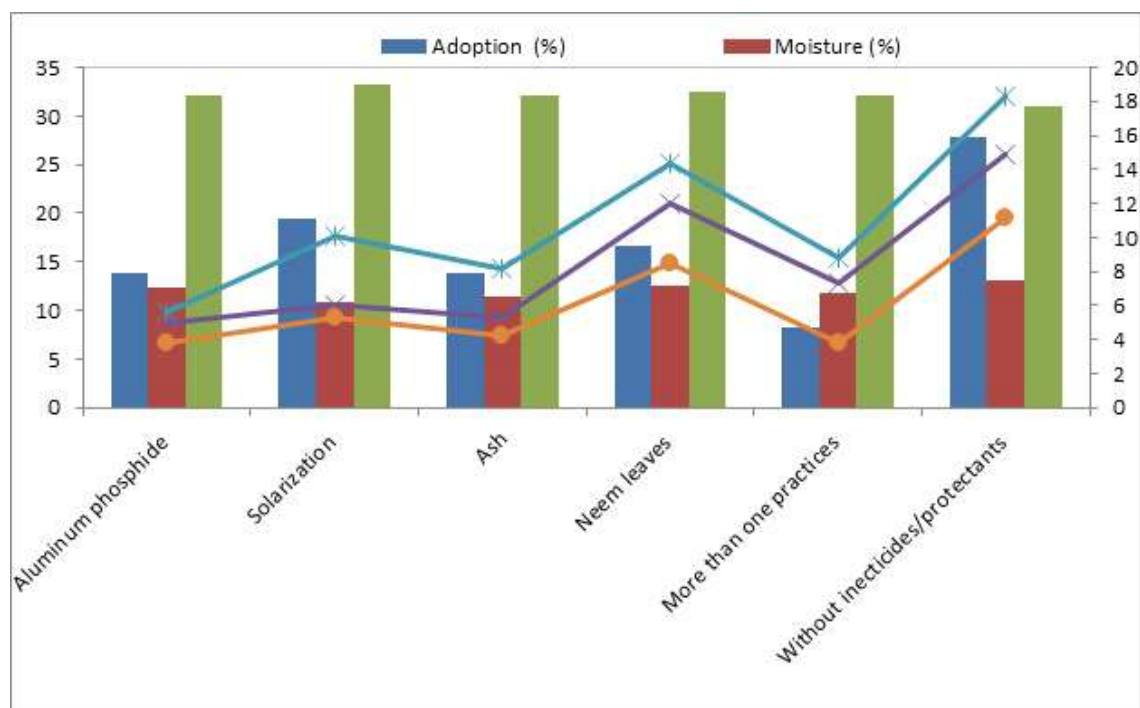


Figure-2 : Insecticides and grain protectants used by farmers in village storage facilities.

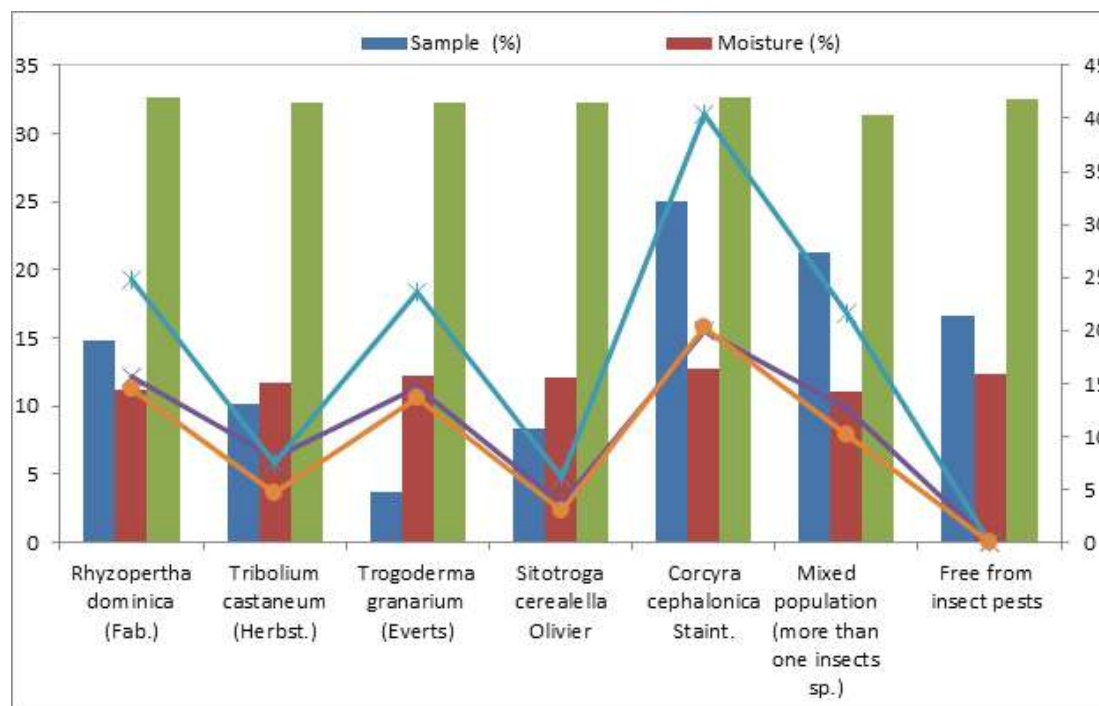


Figure-3 : Qualitative and quantitative insect pests status in stored pearl millet.

kernel extract and cow dung ash are most effective for stored pests. These organic pesticides are easily available to farmers. These pesticides are ecofriendly suitable for farmers and users, no adverse effect for consumers.

The qualitative and quantitative survey made in Zone IIIa of Rajasthan, revealed that the farmers

stored grain pearl millet in the gunny bags, plastic bags, bulk storage in room, *Pucca Bukhari* and metal bin with a varying level of adoption. Out of these the maximum adoption was recorded to be plastic bags. The metal bin was most effective structures for grain storage in which minimum adult emergence, damaged grains and weight loss of grains were observed.

Different insecticides and grain protectants were adopted by the farmers for safe storage of the grains, viz., aluminium phosphide, solarization, ash, neem leaves and more than one practices. The most effective protectants was aluminium phosphide, ash and more than one practices.

The insect pests recorded during the survey were *Rhyzopertha dominica* (Fab.), *Tribolium castaneum* (Herbst), *Trogoderma granarium* Everts, *Sitotroga cerealella* Olivier and *Corcyra cephalonica* Staint. The minimum infested grain samples were found to be with *T. granarium* and minimum number of adults, seed damage and weight loss caused by *S. cerealella*.

References

1. Anonymous. Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare. Government of India. (2020).
2. Malik Y.P., Singh S.V. and Pandey W.D. Assessment of losses under various wheat storage practices in Western Uttar Pradesh. *Indian Journal Entomology*, 56: 21-27. (1994).
3. Mali P.C., and Satyavir. Effect of storage environment and storage material on qualitative and quantitative losses in pearl millet. *Annals of Arid Zone*, 44: 177-184. (2005).
4. Meena H.R., Rana B.S., Ameta O.P., Meena B.M., Kumar A. and Meena A. Estimation of losses in stored maize caused by *Corcyra cephalonica* Stainton in Southern Rajasthan and their ecofriendly management. *Journal of Biopesticides*, 7: 186-194. (2014).
5. Lal R. and Vaidya, D.N. 2001. Weight loss in maize grains due to insect infestation in different storage structures. *Insect Environment*, 7: 37-39.(2001).
6. Choudhary S.O. and Mahla J.C., Insect infecting stored wheat in different climatic regions of Haryana. *Crop Research*, 21: 384-386.(2001).
7. Veeranki S. and Reddy K.D., Insect pests scenario in stored maize in Karimnagar and Nizamabad districts of Andhra Pradesh. *Journal of Research ANGRAU*, 27: 15-17. (1999).
8. Meena B.L. and Bhargava M.C., Effect of different storage containers on the incidence of *Corcyra cephalonica* in stored kernels of groundnut. *Indian Journal of Applied Entomology*, 17: 41-43. (2003).
9. Pareek, Suman Choudhary, Savita and Kumawat, K.C. (2010). Qualitative and quantitative survey of insect pests of stored pearl millet, *Pennisetum glaucum* (Linn.) R. Br. Emend Stuntz. National Conference on 'Plant Protection in Agriculture through Ecofriendly techniques and Traditional Farming Practices' held from 18-20 Feb. 2010 at Jaipur.
10. Bounechada M., Fenni M. and Benia F. 2011. Survey of insect pests of stored grains and biological control of *Trogoderma granarium* Everts in Setifian region. *Bulletin UASVM Agriculture*, 68:



Evaluation of Plant Products as Surface Protectant of Packaging Materials against *Corcyra cephalonica* Staint. in Stored Pearlmillet *Pennisetum glaucum* (Linn.) R. Br. Emend Stuntz

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Abstract

The plant oils and extracts viz., *Neem* oil, mustard oil, castor oil and *Neem* seed kernel extract each at three concentrations (5.0, 7.5 and 10%) and an insecticide check malathion 50 EC (0.05 and 0.1%) were evaluated by impregnating the gunny bags against *Corcyra cephalonica* Stainton (Lepidoptera: Galleriidae). The adult emergence, grain damage and weight loss were recorded after 270 days of storage pearlmillet, *Pennisetum glaucum* (Linn.). The adult emergence decrease with the increase in the concentration of test plant oils. Among the plant oils and extracts, the mean adult emergence (1.50 adults) was observed in NSKE followed by *Neem* oil (2.08 adults), mustard oil (2.84 adults) and castor oil (3.84 adults) 10.0 per cent dose. In NSKE and *Neem* oil, the adult emergence was decreased with increase in concentration. The mean per cent grain damage and weight loss also decreased with the increase in concentration of plant oils and extracts. Among the plant oils and extracts, the mean grain damage (1.58%) and (0.92%) were observed in *Neem* oil 10.0 per cent followed NSKE 10 per cent (3.17%) and (1.50%) respectively. With regards to malathion 50 EC, very low adult emergence, grain damage and weight loss were observed. All the plant oils and extracts found significantly superior over the untreated control. Among the plant oils and extracts the *Neem* oil and NSKE were the best treatments for impregnation of gunny bags having minimum adult emergence, grain damage and weight loss while mustard oil and castor oil were the least effective.

Key words : Plant oils, gunny bags, pearlmillet, *Corcyra cephalonica*, impregnation

Introduction

Pearlmillet, [*Pennisetum glaucum* (Linn.) R. Br. emend Stuntz. (Family: Gramineae) is one of the important millet crops, it comes next to sorghum in area and production. In India, it is grown in an area of 7.52 million hectares with an annual production to the tune of 10.28 million tonnes and average productivity of 1368 kg ha⁻¹ (Directorate of Economics and Statistics, DAC&FW, India, 2020) [1]. Rajasthan is one of the chief pearlmillet growing states, occupying a total area of 4.29 million hectares under cultivation with an annual production of 4.69 million tonnes and average productivity of 1093 kg ha⁻¹. Directorate of Economics and Statistics, DAC&FW, India [1]. In Rajasthan, Barmer, Jodhpur, Nagaur, Jaipur, Churu, Sikar, Alwar and Jhunjhunu are major pearlmillet growing districts. Any loss of food grain in storage means less food is available for population. Therefore, the surplus food grain of nation needs keeping facilities and care during storage.

The grains in the storage are spoiled due to the infestation of organism such as insects, mites and rodents causing heavy losses. In India an overall post harvest losses during storage and handling have been estimated to the tune of 9.33% Agarwal [2] There are many species

of insects and mites found infesting stored pearlmillet grains, but a few are major or primary pests. Among the insects, the Angoumois grain moth, *Sitotroga cerealella*, *Rhyzopertha dominica* (Fab.) and rice moth, *Corcyra cephalonica* Staint. are important. The rice moth, *Corcyra cephalonica* Staint. (Lepidoptera: Galleriidae) heavily infests the stored pearlmillet and distributed in Asia, Africa, North America and Europe. Besides pearlmillet, it feeds on rice, maize, wheat, groundnut, gram, cotton seed, sorghum etc. The larvae cause damage to the grain by feeding under silken webs. When infestation is high the entire stock of grain may be converted into webbed mass. Ultimately, a characteristic foul odour is developed and qualitative loss is caused.

The success achieved so far in making the stored grains free from insect pests has been largely on sole reliance of pesticides. The indiscriminate use of fumigants and other toxic chemicals caused serious problems, like chronic and acute toxicity, development of insect resistance, pest resurgence, residue in food and hazards to human health and last but not least, the environmental pollution. The use of plant products assumed significance as an important component of insect pest management because of their economic viability and eco-friendly nature. They hold promise as an alternative to chemical

insecticides to reduce pesticide load in the environment. Contrary to the chemical insecticides, they do not have mammalian toxicity and thus constitute no health hazards; surface persistence last for long time; have least adverse effect on seed germination, cooking quality and milling; less expensive and easily available. The increasing awareness of the hazards in use of chemical pesticides and several reported cases of food poisoning has created renewed interest in the use of plant products as grain protectants or as impregnation of packaging materials for managing the insect population in stored products. There are encouraging reports on the use of certain indigenous plant products as grain protectants (Chander *et al.* [3], Sharma and Bhargava, [4], Patel and Patel [5], Meena and Bhargava, [6] and Jacob and Qamar, [7] The insects cannot develop resistance against their own hormones, therefore, these are of great importance.

Materials and Methods

The culture of rice moth, *C. cephalonica* was procured from the pure culture already going on at the Department of Entomology, S.K.N. College of Agriculture, Jobner. The grains were cleaned, surface rinsed with water, sun dried and then subjected for fumigation to eliminate any insect infestation, hidden or otherwise. These grains were conditioned for 48 hours at $29 \pm 1.5^\circ\text{C}$ temperature and 75 ± 5 per cent relative humidity. The culture of *C. cephalonica* was developed on pearl millet (variety, Raj.-171) from few identified individuals. For maintaining subsequent insect culture, 20 pairs of newly emerged adult insects were released for oviposition in the glass jar (size 30x20 cm) containing pearl millet grain. Further, the newly emerged adults were transferred in a *Matka* bin containing conditioned grains in order to maintain a stock culture for continuous fresh supply of large number of moths and other insect stages required for the experimentation. For handling the infested grains and insects, a forcep and a camel hair brush was used. Every subsequent experiment was conducted at $29 \pm 1.5^\circ\text{C}$ temperature and 75 ± 5 per cent relative humidity.

Treatment of packaging material : The gunny bags of $12 \times 18 \text{ cm}^2$ was used for the purpose and sprayed with different concentrations of plant oils and plant extracts

(Table 1) after filling up with sterilized and conditioned pearl millet grains (350 g). The treatments were repeated at fortnightly interval. The solutions of plant oils and extracts were made in water and that of oily nature plant oils in the acetone. A standard check (Malathion 50 EC @ 0.05) and an untreated check was maintained for comparison. The experiment was conducted in CRD and each treatment was replicated thrice. The sealed bags were kept with *C. cephalonica* infested stock to have natural infestation.

Method of recording observations : Periodical inspection of the grains in bags was done to record natural infestation. The number of damaged grains and F_1 adult emergence was recorded by visual count. The adults were discarded every month after taking observations. The observations were recorded up to 270 days of storage. The grain weight loss was recorded by excluding the frass.

Statistical analysis : The per cent data on grain damage and weight loss were transformed into angular values (arc sine percentage) and number of insects into $X + 0.5$ values for analysis of variance.

Results and Discussion

Different plant oils, plant extracts and insecticide have been evaluated against *C. cephalonica* infesting stored pearl millet in the laboratory conditions. The plant oils and plant extract, viz., *Neem* oil, castor oil, mustard oil, NSKE (with 3 dose levels, i.e. 5.0, 7.5 and 10%), and malathion (2 dose levels, i.e. 0.05 and 0.10%) were evaluated. The gunny bags sprayed with different concentration of plant oils and plant extract after filling up with sterilized and conditioned pearl millet grains (350 gm) and stored. These bags kept to have a natural infestation along with infested stock. The observations were recorded after 270 days of storage.

To manage the *C. cephalonica*, the technique of impregnation of packaging material with plant oils and plant extracts was chosen with the view to keep the grains free from toxic hazards. This method has been shown to confer good protection to the seeds by earlier workers. Meena and Bhargava [6] observed the efficacy of *A. indica*, *P. glabra* (*P. pinnata*), *C. inophyllum*,

Table-1 : Treatments of plant products as surface treatment of packaging material.

S. No.	Common name	Scientific name	Dosages (%)
1.	Neem seed kernel extract	<i>Azadirachta indica</i> A. Juss	5.0, 7.5, 10.0
2.	Neem oil	<i>Azadirachta indica</i> A. Juss	5.0, 7.5, 10.0
3.	Castor oil	<i>Ricinus communis</i>	5.0, 7.5, 10.0
4.	Mustard oil	<i>Brassica juncea</i>	5.0, 7.5, 10.0
5.	Malathion (50 EC)	-	0.05, 0.1
6.	Untreated	-	-

Table-1 : Effect of plant products impregnated packaging material (gunny bags) on adult emergence of rice moth, *Corcyra cephalonica* Staint. after specified period of storage.

S. No.	Plant products	Dosage (%)	60 Days	120 Days	180 Days	270 Days	Mean
1.	NSKE	5.0	0.67	3.33	4.33	5.67	3.50
			(1.08)	(1.96)	(2.20)	(2.48)	
		7.5	0.00	2.67	3.00	4.33	2.50
			(0.71)	(1.78)	(1.87)	(2.20)	
		10.0	0.00	1.33	1.67	3.00	1.50
			(0.71)	(1.35)	(1.47)	(1.87)	
2.	Castor oil	5.0	1.00	7.67	9.33	9.67	6.92
			(1.22)	(2.86)	(3.14)	(3.19)	
		7.5	0.00	6.33	7.67	8.33	5.58
			(0.71)	(2.61)	(2.86)	(2.97)	
		10.0	0.00	4.00	5.67	5.67	3.84
			(0.71)	(2.12)	(2.48)	(2.48)	
3.	Neem oil	5.0	1.33	3.67	4.67	6.33	4.00
			(1.35)	(2.04)	(2.27)	(2.61)	
		7.5	0.00	3.00	3.33	4.67	2.75
			(0.71)	(1.87)	(1.96)	(2.27)	
		10.0	0.00	2.33	2.67	3.33	2.08
			(0.71)	(1.68)	(1.78)	(1.96)	
4.	Mustard oil	5.0	1.10	4.67	5.67	6.67	4.53
			(1.26)	(2.27)	(2.48)	(2.68)	
		7.5	0.00	3.33	4.00	5.33	3.17
			(0.71)	(1.96)	(2.12)	(2.41)	
		10.0	0.00	2.67	3.67	5.00	2.84
			(0.71)	(1.78)	(2.04)	(2.35)	
5.	Malathion 50EC	0.05	1.33	1.67	3.67	4.33	2.50
			(1.35)	(1.47)	(2.04)	(2.20)	
		0.10	0.67	1.33	2.67	3.67	2.09
			(1.08)	(1.35)	(1.78)	(2.04)	
6.	Untreated	-	6.33	30.67	32.67	38.67	27.09
			(2.61)	(5.58)	(5.76)	(6.26)	
	S.Em. +	-	0.07	0.08	0.10	0.12	-
	CD (p=0.05)	-	0.20	0.23	0.28	0.35	-

Figures in the parentheses are $\sqrt{X}$ 05 values.

Cymbopogon flexuosus, *Lawsonia inermis*, *Cocos nucifera*, Indian mustard, sesame, groundnut, soybean and sunflower extract and/or oils @ 0.1, 0.5 and 1 ml/100 g broken seeds in controlling *C. cephalonica*. The fecundity, egg viability and longevity of both male and female *C. cephalonica* decreased with increasing concentrations of the extracts and the oils. During present investigations, the neem, castor, mustard oil and neem seed kernel extract in three concentrations (5.0, 7.5 and 10.0%) and one chemical viz., malathion (0.05, 0.1%) were used in evaluating their efficacy by impregnating the gunny bags. The results obtained during the present investigations on the efficacy of impregnation

of packaging materials with different test compounds have been discussed here.

The data recorded during the present investigations revealed that after 60 days no adult emergence was recorded when gunny bags were impregnated with plant oils and extracts. However, the infestation in these treatments was observed at 90, 180 and 270 days of treatment, the most effective treatment was NSKE 10 per cent (1.33 adults), malathion 0.1 per cent (1.33 adults), malathion 0.05 (1.67 adults) and Neem oil 10 per cent (2.33 adults). It is apparent from the data that all the tested plant oils and extracts were found to be significantly superior in reducing the adult emergence

Table-2 : Effect of plant products impregnated packaging material (gunny bags) on grain damage (%) caused by rice moth, *Corcyra cephalonica* Staint. after specified period of storage.

S.No.	Plant products	Dosage (%)	60 Days	120 Days	180 Days	270 Days	Mean
1.	NSKE	5.0	1.67	6.00	8.67	10.00	6.59
			(7.43)	(14.18)	(17.12)	(18.43)	
		7.5	0.00	4.67	8.33	8.67	5.42
			(0.00)	(12.48)	(16.78)	(17.12)	
		10.0	0.00	3.33	4.00	5.33	3.17
			(0.00)	(10.51)	(11.54)	(13.35)	
2.	Castor oil	5.0	3.67	11.00	18.67	25.33	14.67
			(11.04)	(19.37)	(25.60)	(30.22)	
		7.5	0.00	10.33	17.33	16.33	11.00
			(0.00)	(18.75)	(24.60)	(23.83)	
		10.0	0.00	8.67	11.00	13.00	8.17
			(0.00)	(17.12)	(19.37)	(21.13)	
3.	Neem oil	5.0	3.00	7.67	9.67	12.33	8.17
			(9.97)	(16.08)	(18.12)	(20.56)	
		7.5	0.00	6.33	9.00	9.00	6.08
			(0.00)	(14.57)	(17.46)	(17.46)	
		10.0	0.00	1.33	2.33	2.67	1.58
			(0.00)	(6.62)	(8.78)	(9.40)	
4.	Mustard oil	5.0	3.33	8.67	10.33	14.67	9.25
			(10.51)	(17.12)	(18.75)	(22.52)	
		7.5	0.00	7.00	9.67	10.33	6.75
			(0.00)	(15.34)	(18.12)	(18.75)	
		10.0	0.00	4.33	8.33	10.00	5.67
			(0.00)	(12.01)	(16.78)	(18.43)	
5.	Malathion 50EC	0.05	0.67	3.33	4.67	5.33	3.50
			(4.70)	(10.51)	(12.48)	(13.35)	
		0.10	0.33	3.33	4.00	4.67	3.08
			(3.29)	(10.47)	(11.54)	(12.52)	
6.	Untreated	-	18.33	26.33	47.00	64.00	38.92
			(25.35)	(30.85)	(43.28)	(53.13)	
		S.Em. +	0.12	0.08	0.11	0.14	
			CD (p=0.05)	0.35	0.24	0.32	0.40

Figures in the parentheses are arc sine $\sqrt{\text{percentage}}$ values.

over untreated control (6.33 adults). The present findings are conformity with Meena and Bhargava [8] who found that no adult emergence was recorded in impregnated gunny and cloth bags. They observed the minimum number of adults emerged in the treatment of *neem* extract.

The seed damage observed after 60 days of treatment in storage was nil in NSKE, castor oil, neem oil and mustard oil 7.5 and 10.0% treated bags. The efficacy of neem oil 10 per cent and NSKE oil 10 per cent revealed low grain damage (2.67 and 5.33 %, respectively) after 270 days of treatment. These treatments were found significantly superior over rest of the treatments except the malathion 50EC (as standard check). The rest of the treatments resulted in the efficacy of lower order but significantly superior over the untreated. Yadav and Bhargava [9] observed that *Neem* extract at 1.0 ml 100 g⁻¹ seeds resulted in the longest total life cycle (57.8

days), highest reduction in adult emergence (85.7%), lowest number of eggs laid per female, highest reduction in egg viability (65.3%) and shortest longevity for males (3.3 days) and females (4.8 days). No adverse effect on the germination of sorghum seeds at any interval was noticed. Meena [10] reported that impregnation of gunny bags and cloth bags with different plant products proved effective and in reducing the grain damage and weight loss while working on *C. cephalonica*. The weight loss in Neem oil 10 per cent (0.00-1.67%) and NSKE oil 10 per cent (0.00-2.67%) were minimum which were significantly superior over the other treatments except malathion 50EC 0.1 per cent. These treatments were followed by malathion 50 EC, NSKE 7.5 %, Neem oil 7.5 % and castor oil 10 per cent (0.00-6.67%). The other treatments differed significantly over the untreated. Meena and Bhargava [8] tested the grain damage after 12 months in different treatments which ranged from 1.1 to 25.0% and

Table-3 : Effect of plant products impregnated packaging material (gunny bags) on weight loss (%) inflicted by rice moth, *Corcyra cephalonica* Staint. after specified period of storage.

S. No.	Plant products	Dosage (%)	60 Days	120 Days	180 Days	270 Days	Mean
1.	NSKE	5.0	0.67 (4.70)	2.67 (9.40)	3.33 (10.51)	5.67 (13.78)	3.09
		7.5	0.00 (0.00)	2.00 (8.13)	3.00 (9.97)	4.00 (11.54)	2.25
		10.0	0.00 (0.00)	1.33 (6.62)	2.00 (8.13)	2.67 (9.40)	1.50
2.	Castor oil	5.0	1.67 (7.43)	5.67 (13.78)	8.67 (17.12)	11.67 (19.98)	6.92
		7.5	0.00 (0.00)	4.00 (11.54)	8.00 (16.43)	7.67 (16.08)	4.92
		10.0	0.00 (0.00)	4.33 (12.01)	5.00 (12.92)	6.67 (14.97)	4.00
3.	Neem oil	5.0	1.00 (5.74)	4.00 (11.54)	4.67 (12.48)	6.33 (14.57)	4.00
		7.5	0.00 (0.00)	3.00 (9.97)	4.00 (11.54)	4.67 (12.48)	2.92
		10.0	0.00 (0.00)	0.67 (4.70)	1.33 (6.60)	1.67 (7.43)	0.92
4.	Mustard oil	5.0	1.33 (6.62)	4.00 (11.54)	5.00 (12.92)	7.67 (16.08)	4.50
		7.5	0.00 (0.00)	3.67 (11.04)	4.67 (12.48)	5.33 (13.35)	3.42
		10.0	0.00 (0.00)	2.67 (9.40)	3.33 (10.51)	4.67 (12.48)	2.67
5.	Malathion 50EC	0.05	0.00 (0.00)	1.67 (4.70)	2.33 (8.78)	3.33 (10.50)	1.83
		0.10	0.00 (0.00)	1.00 (5.74)	1.67 (7.43)	2.33 (8.78)	1.25
6.	Untreated	-	9.00 (17.46)	40.33 (39.42)	41.00 (39.82)	42.67 (40.79)	33.25
	S.Em. +	-	0.11	0.06	0.05	0.08	
	CD (p=0.05)	-	0.33	0.17	0.15	0.22	-

Figures in the parentheses are arc sine $\sqrt{\text{percentage}}$ values.

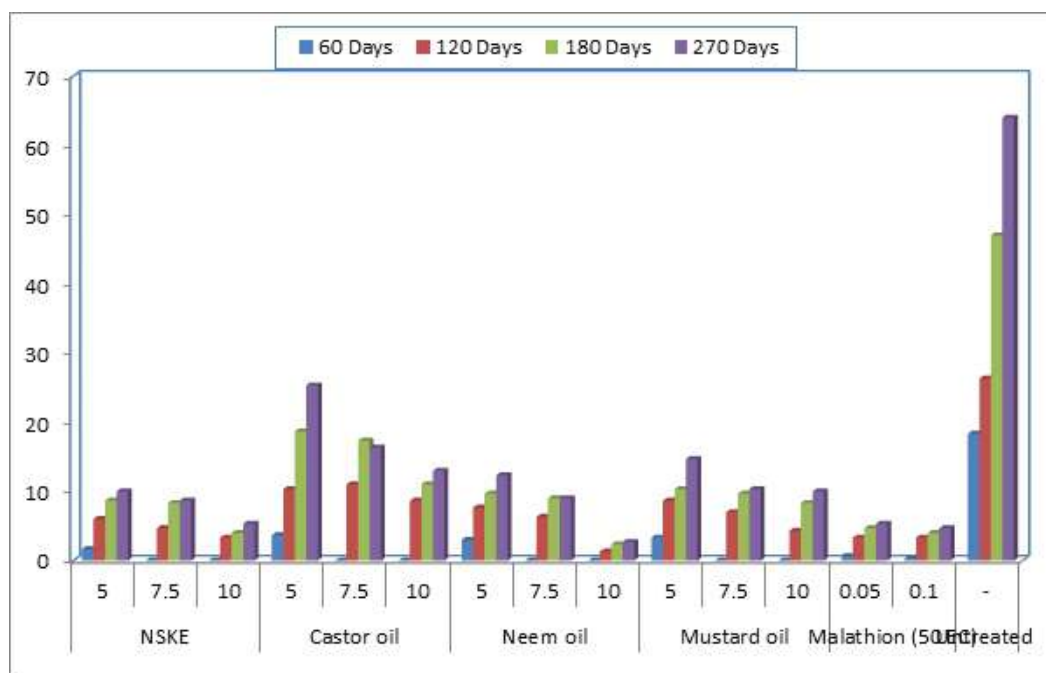


Figure-1 : Effect of plant products impregnated packaging material (gunny bags) on grain damage (%) caused by rice moth, *Corcyra cephalonica* Staint. after specified period of storage

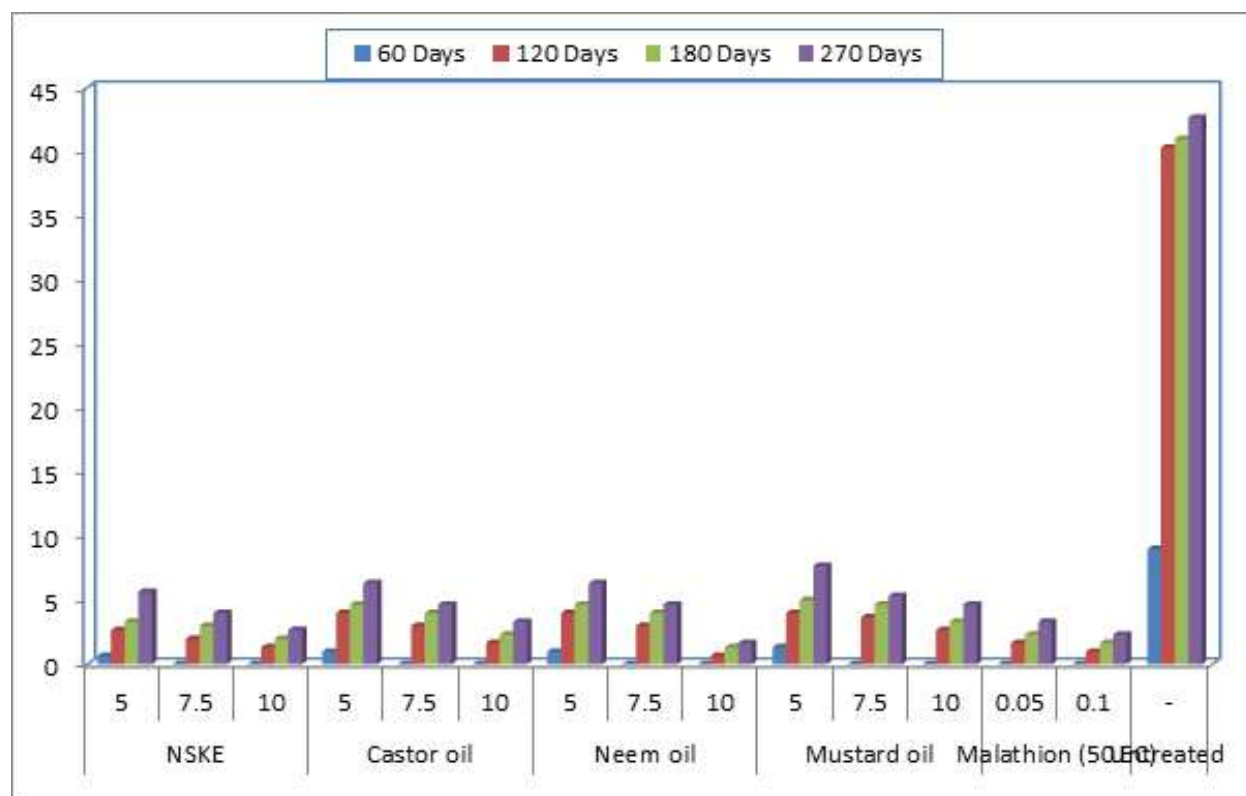


Figure-2 : Effect of plant products impregnated packaging material (gunny bags) on weight loss (%) caused by rice moth, *Corcyra cephalonica* Staint. after specified period of storage.

1.0 to 22.1% in gunny bags and cloth bags, respectively impregnated in the plant products with corroborated with the present findings. They also recorded minimum damage and weight loss in the treatment of *Neem* extract which is in full conformity with the present results. A meagre work has been conducted so far on the efficacy of plant oils and extracts as impregnation of packaging material against stored grain pests. A commendable work was done by Chander *et al.* [3] Sharma and Bhargava [4], Patel and Patel [5] Yadav and Bhargava [9] Shukla *et al.* [11] Dwivedi and Garg [12] Jadhav and Ghule [13] Meena and Bhargava [6] Jacob and Qamar [7] and Said and Pashte [14].

Conclusions

The plant oils and extracts, viz., NSKE, *neem* oil, mustard oil and castor oil were evaluated against rice moth, *C. cephalonica* as surface treatment of packaging material (gunny bags). The NSKE 10.0 per cent and *neem* oil 10.0 per cent were most effective. These treatments were followed by mustard oil and castor oil 10 per cent.

References

1. Anonymous (2020). Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare. Government of India.
2. Agarwal, N.S. (1968). Editorial, Bulletin of Grain Technology, 4 : 1.
3. Chander, Harish, Ahuja, D.K., Nagender, A. and Berry, S.K. (2000). Repellency of different plant extracts and commercial formulations used as prophylactic sprays to protect bagged grain against *Tribolium castaneum* –a field study. *Journal of Food Science and Technology*, 37: 582-585.
4. Sharma, K.C. and Bhargava, M.C. (2001). Ovicidal effect of some growth disruptions compounds on rice moth, *Corcyra cephalonica* Staint. *Indian Journal of Applied Entomology*, 15: 24-28.
5. Patel, R.A. and Patel, B.R. (2002). Evaluation of certain plant products as grain protectants against the rice moth, *Corcyra cephalonica* Staint in stored rice. *Pest Management and Economic Zoology*, 10: 121-124.
6. Meena, B.L. and Bhargava, M.C. (2003). Effect of plant products on reproductive potential of *Corcyra cephalonica* Staint. *Annals of Plant Protection Science*, 11: 196-200.
7. Jacob, P. and Qamar A. (2013). Reproductive impairment and lethal effects of selected combinations of some essential oils against the rice moth, *Corcyra cephalonica*. *European Journal of Experimental Biology*, 3: 409-415.
8. Meena, B.L. and Bhargava, M.C. (2009). Impregnation of packing materials on infestation of *Corcyra cephalonica* Stainton in groundnut. *Annals of Plant Protection Sciences*, 17: 99-102.
9. Yadav, J.P. and Bhargava, M.C. (2002). Effect of certain botanical products on biology of *Corcyra cephalonica* Stainton. *Indian Journal of Plant Protection* 30: 207-209.
10. Meena B.L. (2002). Effect of bioenvironmental factors on the biology and management of *Corcyra cephalonica*

- Stainton. *Ph.D. Thesis, submitted to Rajasthan Agricultural University, Bikaner* (2002).
11. Shukla, A.C., Shahi, S.K. and Aunpam Dikshit (2002). *Eucalyptus pauciflora* –a potential source of sustainable, ecofriendly storage pesticide, *Biotechnology of microbes and sustainable utilization* (Edited by Rajak, R.C.), *Published by Scientific Publishers, Jodhpur* (India), pp. 93-107.
 12. Dwivedi, S.C. and Seema, Garg. (2003). Toxicity evaluation of flower extract of *Lantana camara* on the life cycle of *Corcyra cephalonica*. *Indian Journal of Entomology*, 65: 330-334.
 13. Jadhav, S. and Ghule, R.N. (2003). Qualitative changes in total body proteins and haemolymph proteins due to azadirachtin in the larva of *Corcyra cephalonica* (Staint.). *Entomon*, 28: 157-159.
 14. Said, P.P. and Pashte, V.V. (2015). Botanicals: The protectants of stored grain pests. *Trends in Biosciences*, 8: 72-74.
 15. Ansari, K.K., Prakash, S. and Pandey, P.N. (2003). Effect of some indigenous plant products on the loss of weight in Jowar infested with *Corcyra cephalonica* Staint. *Flora and Fauna-Jhansi*, 9: 75-76.
 16. Choudhary, S.O. and Mahla, J.C. (2001). Insect infecting stored wheat in different climatic regions of Haryana. *Crop Research*, 21: 384-386.
 17. Meena, H.R., Rana, B.S., Ameta, O.P., Meena, B.M., Kumar, A. and Meena, A. (2014). Estimation of losses in stored maize caused by *Corcyra cephalonica* Stainton in Southern Rajasthan and their eco-friendly management. *Journal of Biopest* 7: 186-194.
 18. Veeranki, S. and Reddy, K.D. (2004). Evaluation of various products as grain protectants against rice moth (*Corcyra cephalonica*). *Journal of Research ANGRAU*, 32: 29-33.



Effect of Supplementation of Concentrate Ration on Growth Performance of Sirohi Goats in their Native Tract

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Abstract

The investigation was carried out on-farm, in the Malera village of Pindbada block in Sirohi District Rajasthan, located in the native tract of Sirohi Goats. In order to study the effect of supplementation of concentrates, 30 male kids were randomly divided into three equal groups and kept either on normal browsing (as per farmer's practices); (G1) with additional supplementation of concentrate mixture at 100 (G2) and 150 (G3) g per day per kid. During the experiment period of 120 days, BW of kids was recorded fortnightly. The average daily gain (ADG) of the kids was 31.32 ± 0.47 , 54.02 ± 0.11 and 62.84 ± 0.37 in G1, G2 and G3 respectively with significant differences ($P < 0.05$) among all the groups. It is concluded that, provision of 150g concentrate mixture along with 8h grazing significantly improved growth performance of Sirohi male kids attributable to a more efficient utilization of the native pasture.

Key words : Sirohi goat, concentrate supplementation and body weight.

Introduction

In the semi arid region of the country goats are reared mainly on community property resources (CPR) and stubble grazing on cropped arid after harvesting of field crops. Majority of the goat keepers in semi arid region don't supplement concentrate to their goats even critical physiological stages. Sirohi is one of the best suited goat breed for arid and semi arid region of the country. Non availability of the essential nutrients is the key factors for the low productivity of goats. Intensive raising of goats is not a profitable proposition as it raises cost of production. Supplemental feeding to the grazing goats may be a possible way out of this situation. Limited concentrate supplementation, in addition to free grazing on rangeland, is known to improve the growth performance of kids. The present study was conducted to assess the effect of supplementation of concentrate on the growth performance and economics of production of Sirohi kids in its native tract.

Materials and Methods

The investigation was carried out on farm, in the CPR of Bapuda village of Sirohi District of Rajasthan located in the native tract of Sirohi during December, 2020 to March, 2021. Thirty male kids owned by the farmer's were selected for this study and they were randomly divided into three equal groups in ten animals each and kept either on normal browsing (as per farmer's practice; (G-1) alone or with additional supplementation of concentrate mixture at 100 (G-2) and 150 (G-3) g per day per kid. Prior to commencement of the experiment all thirty kids were dewormed by oral albendazole suspension @ 5mg per kg

body weight. The vegetative cover of range land was dominated by *Cenchrus biflorus*, *Cynodon dactylon* grasses, *Zizyphus nummularia*, *Calotropis sp.*, shrubs and fodder trees *Acacia nilotica* and *Prosopis cineraria*. The percent ingredients composition of the concentrate mixture is presented in table-1. The feeding trial was continued for 120 days and the body weight of kids was recorded at fortnight interval. The economics of production was calculated at the end of experimental period.

Table-1 : Ingredients and chemical composition of concentrate mixture.

Ingredients composition	(%)
Maize	32
Wheat bran	33
De-oil-rice bran	15
Groundnut oil cake	17
Mineral mixture	02
Common salt	01

Chemical composition (% DM basis) of concentrate Mixture.

CP	22
EE	2.4
CF	10
NFE	55.19
NDF	40
ADF	20
Lignin	5.55

Results and Discussion

Results (Table-2) indicated that the average body weight and average daily gain varied ($p < 0.05$) parallel to the level of concentrate supplementation across the groups. Higher

Table-2 : Growth performance and cost benefit analysis of Sirohi goat.

Attributes	G 1	G 2	G 3
Initial body weight (kg)	8.17 ± 0.05	7.98 ± 0.05	8.2 ± 0.05
Final body weight (kg)	12.02 ± 0.03	14.50 ± 0.04	15.61 ± 0.04
ADG (g)	31.32 ^a ± 0.47	54.02 ^b ± 0.19	62.84 ^c ± 0.37
Total concentrate intake (kg/kid)	0.0	12.0	18.0
Cost of concentrate/kid (Rs.) 11.25/kg	—	135.0	202.5
Total live weight (kg/kid)	12.02	14.5	15.61
Cost of live weight @ Rs. 150/-per kg	1803	2175	2341.5
Additional income Rs.	—	372	538.5
Cost benefit (Rs./Rs. spent)	—	1.66	1.60

^{abc}values bearing different superscript in a column differed significantly (P<0.05).

growth rate in local goats grazing in its native pasture supplemented with concentrate mixture was reported by (Mahanta *et.al.* 2002).

Similar observation on growth performance has been reported due to supplementation of either concentrate mixture or any single ingredient or combination of feed ingredient in different breeds of goats (Hossain *et.al.* 2003, Kabir *et.al.* 2004 and Das, 2008). The growth rate observed in the present experiment in control as well as in supplemented group was higher as compared to the growth rates reported on similar diets by other workers (Parthasarathy *et.al.*1984). As regards to cost- benefit analysis of experimental male Sirohi goat, since the farmers were providing their own labour in management and grazing of goats, the cost of only concentrate mixture was considered as the additional cost. Though the cost benefit ratio was more or less similar in G-2 and G-3 but the additional income was observed to be higher in G-3 than that of G-2.

Conclusions

This study was conducted to evaluate the effect of concentrate supplementation on growth performance and economics under field condition in Sirohi district of Rajasthan. It is concluded that, provision of 150g concentrate mixture along with 8h grazing significantly improved growth performance of Sirohi male kids

attributable to a more efficient utilization of the native pasture.

References

1. Das, A. 2008. Effect of different levels of concentrate supplementation on growth performance of Sikkim local goat's kid fed jungle grass based diet. *Animal Nutrition and Feed Technology*, 8: 2013-218.
2. Hossain, M.E., Shajalal, M., Khan, M.J. and Hasant, M.S. 2003. Effect of dietary energy supplementation of feed intake, growth and reproductive performance of goats under grazing condition. *Pakistan Journal of Nutrition*, 2: 159-163.
3. Kabir, F., Sultan, M.S., Shahjalal, M. Khan, M.J. and Alam, M.Z. 2004. Effect of protein supplementation on growth performance in female goats and sheep under grazing condition. *Pakistan Journal of Nutrition*, 3: 237-239.
4. Mahanta, S.K., pailan, G.H., Pachauri, V.C. and Verma, N.C. 2002. Influence of concentrate supplementation performance of goats on rangeland. An on-Farm study. *Animal Nutrition and Feed Technology* 2; 161-167.
5. Parthasarathy, M., Singh, D., and Rawart, P.S. 1984. Performance of feed lot kid on different dietary regimen. *Indian Journal of Animal Science*.1176-1178.
6. Shah N., Mathur, M.M., Arora, N. and Mukherjee, S.K. 2003. The nutrient utilization and growth performance of Barbari kids fed tree leaves mixture with or without supplementation of concentrate mixture. *Animal Nutrition and Feed Technology* 3: 2-7.



Effect of Protein Sources on Nutrient Utilization in lactating Gir Cows

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Abstract

All sixteen cows were randomly divided into four groups of four in each group on the basis of closest in their body weight and milk yield of average per day subjected to four dietary treatments i.e. jowar cutti ad-lib+green fodder (5kg) and Pelleted Concentrate Mixture(T₁), T₁ + Groundnut Cake @ 500g* per Cow per Day (T₂), T₁ + Til Cake @ 559g* per Cow per Day (T₃) and T₁ + Cotton Seed Cake @ 1134g* per Cow per Day (T₄) the studies for their The average daily CP intakes in T₁, T₂, T₃ and T₄ groups cows were 1.237±0.064, 1.413± 0.060, 1.380±0.063 and 1.375±0.059g, respectively. The mean CPI/100kg body weight was 0.343±0.015, 0.391±0.037, 0.382±0.019 and 0.382±0.021 kg, respectively. The CP intake in the treatment T₂ was more than as compared to T₁, T₃ and T₄ (P<0.05). The average daily DCP intake (DCPI) was 0.625±0.073, 0.880±0.049, 0.835±0.069 and 0.809±0.060 g, respectively. The mean DCPI/100kg body weight was 0.173±0.015, 0.243±0.019, 0.231±0.021 and 0.224±0.022 kg, respectively. The DCP intake in the treatment T₂ was higher than T₁, T₃ and T₄ (P<0.05). Digestibility of DM, CP, and NFE were significantly (P<0.05) higher in T₂, as compared to T₁, T₃ and T₄ group.

Key words : Protein sources, Gir cows, nutrient utilization and crude protein.

Introduction

India's livestock sector is one of the largest in the world which plays an important role in the national economy and also in the socio-economic development of millions of rural households. In India, annual milk production is 198.4 million tonnes. India ranks first in the world and contributes about 16% to the world milk production. The per capita availability of milk in India is 407 g per day in 2019-20. Rajasthan stands at 2nd rank in the country with annual milk production of 23.67 million tonnes and contributes 12.60 per cent in India's milk production. Dairy animals are generally given energy and protein, concentrate supplements to increase milk production and stoking rates (Gracia *et al.*, 2000). The Gir is a famous milch cattle breed of India. The native trait of this breed is Gir hills and forest of Kathiawar Cattle of this breed are famous for their tolerance to stress conditions and resistance to various tropical diseases (Kumar and Singhal 2006). Cotton seed cakes (CSC) are being traditional used in the feed of dairy animals. CSC and Groundnut Cake (GNC) contains a large amount of protein 27.5% and 47% respectively (Ranjhan, 2004) The TDN content is variable from 75-85%.The GNC rich in nitrogen and facilitated better growth of animals cake has to be soaked in water and need to applied in animals. GNC is generally safe feed for all classes of animals. This product has been used as a protein supplement in cattle feeding Til cake contains 36.4% protein, rich in leucine arginine and methionine. It highly desirable for animal feeding. The

cost per kg milk can be reduced by 60 per cent and 40 per cent, respectively of feeding good quality leguminous or non-leguminous fodder (Upadhyay, 1994).

Feeding is one of the most important determinants of profit in the livestock farming. Variation in nutritive value of different feed stuff affects on feed intake palatability and digestibility of feed more over then feed also affect the milk yield. The objective of the feeding complete ration is to provide a blend of feed ingredients without giving any choice to the animal for the selection of any specific feed ingredient, so that each bite could supply the required amount of nutrients (Wadhwa and Bakshi 2006). Complete ration not only improves the feeding value of feed stuff but also simplifies feeding, minimizes labour and maximizes automation.

Materials and Methods

The experiment was carried at Dairy farm, Department of Livestock Production Management, S.K.N. College of Agriculture, Jobner (Jaipur). Sixteen lactating Gir cows in early stage of lactation were selected for the experiment. The details of treatments of experimental Gir cows are given in Table-1.

Table-1 :

Symbols	Treatments
T ₁	Pelleted Concentrate Mixture
T ₂	T ₁ + Groundnut Cake @ 500g* per Cow per Day
T ₃	T ₁ + Til Cake @ 559g* per Cow per Day
T ₄	T ₁ + Cotton Seed Cake @ 1134g* per Cow per Day

Table-2 : Feeding schedule of Gir cows.

S. No.	Feed and fodders	Quantity of feed and fodders
1.	Concentrate pelleted	2 kg for maintainance ration/animal and @ 1 kg/2.5 litre milk yield for production ratio
2.	Protein cakes	GNC 500g, Til cake 559g and Cotton seed cake 1134 g treatment wise.
3.	Luceren green	5 kg per cow
4.	Dry fodder (Jowar kutti)	Ad lib., (Approximately 6 kg/Cow)

Table-3 : Chemical composition (%) of feed and fodder (DM basis) offered to Gir cows.

S. No.	Feeding redients	DM	CP	EE	CF	NFE	ASH
1.	Jowar kutti	90.7	04.6	02.1	32.4	48.0	12.9
2.	Concentrate mix.	90.5	19.7	03.8	10.2	56.3	10.0
3.	Green Lucerne	16.5	17.2	02.1	32.4	37.1	11.2
4.	GNC	91.6	51.7	08.2	04.5	26.1	09.5
5.	Til cake	90.6	46.3	10.2	08.0	24.4	11.1
6.	CSC	89.5	22.8	06.8	16.4	46.9	07.1

Table-4 : Average daily intake of crude protein, DCP and TDN in (kg) in Gir cows under different treatments during experiment.

Parameters	T ₁	T ₂	T ₃	T ₄
Crude protein intake (CPI)	1.237 ^c ± 0.064	1.413 ^a ± 0.060	1.380 ^b ± 0.063	1.375 ^b ± 0.059
CPI/100kg BW	0.343 ^c ± 0.015	0.391 ^a ± 0.037	0.382 ^b ± 0.019	0.382 ^b ± 0.021
DCP intake	0.625 ^c ± 0.073	0.880 ^a ± 0.049	0.835 ^b ± 0.069	0.809 ^b ± 0.060
DCP intake/100kg BW	0.173 ^c ± 0.015	0.243 ^a ± 0.019	0.231 ^{ab} ± 0.021	0.224 ^{ab} ± 0.022
Daily TDN intake	5.658 ^{bc} ± 0.315	6.256 ^a ± 0.201	6.084 ^{ab} ± 0.267	5.807 ^{bc} ± 0.283
TDN intake/100kg BW	1.569 ^c ± 0.055	1.731 ^a ± 0.176	1.687 ^{bc} ± 0.122	1.614 ^{bc} ± 0.141

Means having different superscript differ significantly (P<0.05)

All sixteen cows were randomly divided into four groups of four in each group on the basis of nearest in their body weight and milk yield of average per day.

Parameters studied and observation taken

Collection of dung : The animal were housed in closed barn and fed twice a day. The faeces were collected quantitatively once a day before the morning. Total dung voided by each Gir cows during twenty four hours was collected and weighed. Adequate care was taken to avoid mixing of feces with urine. A 100 gm representative sample of 1/100th part of total feces of each animal was weighed in a polythene bags daily and were kept in hot air oven at 105°C temperature for over night for the determination of dry matter.

Chemical analysis of feeds, fodder, refusal and faeces : The chemical and *in-vitro* analysis was done in the Dry matter content of dry fodder (Jowar kutti), concentrate (pelleted feed) and faeces (cow dung) were determined. The samples of feed, fodder and faeces, residue left over were analyzed for proximate principles (AOAC, 2000). To formulate the ration values were taken from actual analysis of the sample at laboratory of Goat RKVY project The methodology used for analysis was as follows :-

Determination of Dry matter

$$\text{Moisture (\%)} = \frac{\text{Initial wt. of moisture cup} + \text{Sample} - \text{Final wt. after drying}}{\text{Wt. of the sample}} \times 100$$

$$\text{Dry matter} = 100 - \text{Moisture (\%)}$$

Crude protein estimation

It was estimated by micro-Kjeldahl method. Three gram samples were taken and digested in the Kjeldahl flask with 20-30 ml of concentrated H₂SO₄ in presence of 3g digestion mixture (potassium sulphate and copper sulphate in the ratio of 9 : 1).

$$\text{Crude protein} = \frac{\text{g}}{100\text{g}} \times \frac{V}{0.00014} \times \frac{D}{W} \times 100$$

Where,

V = Volume (ml) of 0.01 N H₂SO₄ used,

D = Dilution factor (Volume of digested aliquot/Volume used for distillation),

W = Weight of dried sample (g) used for digestion.

Total fat/ether extract : It was analyzed with the help of Soxhlet's apparatus. Two gram dried and ground feed sample was placed to in a weighed extraction thimble.

Petroleum ether (60-80°C) was continuously volatilized (8-10 hrs), condensed and allowed pass through the samples in a Soxhlet's apparatus. The loss in weight of the sample as the result of the ether treatment was taken as the measure of the total fat.

Crude fiber : Transfer the weighed fat free samples into oven dried crucibles. Place the crucible into the metal adopter of fiber plus hot extraction unit and Acid wash with pour 150 ml of 1.25 H₂SO₄ at 500°C for 40 min. After 40 min. boiling, drain the acid and wash the samples twice or thrice with distilled water. Thereafter Alkali wash with pour 150 ml of 1.25 NaOH at 500 °C for 40 min. After 40 min. boiling, drain the acid and wash the samples twice or thrice with distilled water. After alkali wash take out crucibles and dry them in hot air oven until the crucibles are free from moisture. Weight the crucibles and place all crucibles in ignited the muffle furnace at 550°C for four hours ashing. Weight crucibles after ashing record the reading.

$$\text{Crude fiber content (\%)} = \frac{A - C}{C} \times 100$$

Where,

A = weight of crucible with dry residue (g)

B = weight of crucible with ash (g)

C = weight of sample (g)

Total ash : Five gram dried sample was placed in the pre-weighed silica crucible, smoked and then ignited in the muffle furnace at 550°C for four hours (AOAC, 2000). The previously recorded empty crucible weight was subtracted from the weight of crucible and its contents after ignition to determine weight of ash and expressed as percent of the dried sample, expressed as percent of the dried sample.

$$\text{Ash (g/100 g)} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times 100$$

Calculation of Nitrogen-Free Extract (NFE)

$$\text{NFE (\%)} = 100 - (\text{CP\%} + \text{CF\%} + \text{EE\%} + \text{Total ash})$$

Where,

CP = Crude protein

CF = Crude fibre

EE = Ether extract

Total Digestible Nutrients (TDN) : A term used in animal feeding that designates the sum of all the digestible organic nutrients. (Digestible fat is multiplied by 2.25 because of its higher energy content) TDN is a feed is the sum of the digestible crude protein, digestible crude fibre, digestible nitrogen free extract and 2.25 times digestible

ether extract. TDN requirements are given as Kilograms (Kg.). TDN is a way of expressing the energy content of feed. The TDN is calculated by the following formula:-

$$\text{TDN} = \text{DCP} + \text{DCF} + \text{DNFE} + \text{DEE} \times 2.25$$

Where,

TDN = Total digestible nutrients(kg.)

DCP = Digestible crude protein

DCF = Digestible crude fibre

DNFE = Digestible nitrogen free extra

DEE = Digestible ether extract

Statistical analysis of data : The experiment data were statistically analyzed using standard statistical methods (Snedecor and Cochran, 1994). The experiment planned with subjected to analysis of variance (ANOVA) for a completely randomized design (CRD) with one way classification of analysis of variance Different statistical tools such as mean, standard deviation (SD), standard error (SE) were worked out to compare the group means. The difference among treatment means were tested for significance performing Duncan's multiple range tests. (DMRT).

Results and Discussion

Proximate composition of feed and fodders : The Chemical composition of different feed and fodders ingredients on laboratory is given in Table-3.

Nutrients Intake

Crude protein and digestible crude protein : The average crude protein intake (CPI) have been given in Table 4. The daily CP intakes in T₁, T₂, T₃ and T₄ groups cows were 1.237±0.064, 1.413±0.060, 1.380±0.063 and 1.375±0.059 g, respectively. The mean CPI/100kg body weight was 0.343±0.015, 0.391±0.037, 0.382±0.019 and 0.382±0.021 kg, respectively. The CP intake in the treatment T₂ was more than as compared to T₁, T₃ and T₄ (P<0.05). The average daily DCP intake (DCPI) was 0.625±0.073, 0.880±0.049, 0.835±0.069 and 0.809±0.060 g, respectively. The mean DCPI/100kg body weight was 0.173±0.015, 0.243±0.019, 0.231±0.021 and 0.224±0.022 kg, respectively. The DCP intake in the treatment T₂ was higher than T₁, T₃ and T₄ (P<0.05).

The higher crude protein and digestible crude protein intake in treatment T₂ group might be attributed to higher dry matter intake, which was due to better utility of nutrients through feed additive as GNC conditions. Crude protein intake by the animals was sufficient to meet the body requirements. The results are in agreement with the findings of Meisoguiru, *et al.*, (2006) and singal (2001), Reddy *et al.*, (2003), Thirumalesh, *et al.*, (2003),

Madhavi, *et al.*, (2006), Rekhathe, *et al.*, (2008), and Nagalaxmi *et al.*, (2012).

Total digestible nutrients intake : The average total digestible nutrients intake (TDNI) The daily consumption of TDN by Gir cows was 5.658 ± 0.315 , 6.256 ± 0.201 , 6.084 ± 0.267 and 5.807 ± 0.283 kg in treatments T₁, T₂, T₃ and T₄ respectively. The feed supplements had significant ($P < 0.05$) influence on TDN intake by Gir cows. The average daily TDN intake was more ($P < 0.05$) in T₂ as compared to T₁, T₃ and T₄ groups. When TDN intake was calculated on 100 kg body weight basis was 1.569 ± 0.055 , 1.731 ± 0.176 , 1.687 ± 0.122 and 1.614 ± 0.141 kg in T₁, T₂, T₃ and T₄ group's cows, respectively. It was higher in T₂ group than other three groups (T₁, T₃ and T₄). Improved nutrient utilization with higher feed intake resulted higher TDN intake in GNC supplemented group. The higher DCP and TDNI in T₂ as compared to T₁, T₃ and T₄ group cows might be attributed to higher DMI. The results are in agreement with the findings of Reddy, *et al.*, (2003), Thirumalesh, *et al.*, (2003) Rekhathe, *et al.*, (2008).

Digestibility co-efficient of feed nutrients : Apparent Digestibility: Apparent digestibility for sake of brevity will here after be called digestibility. The average digestibility co-efficient of various nutrients in different experimental groups are

Dry Matter : The average digestibility of DM in T₁, T₂, T₃ and T₄ was 69.59 ± 1.00 , 73.16 ± 0.20 , 69.26 ± 0.99 and 70.16 ± 0.84 percent, respectively. The digestibility co-efficient of DM was higher ($P < 0.05$) in T₂ than T₄, T₁ and T₃ groups.

Crude Protein : The digestibility of CP in T₁, T₂, T₃ and T₄ was 50.52 ± 1.85 , 62.05 ± 2.02 , 60.57 ± 2.29 and 58.74 ± 1.26 per cent, respectively. Which was higher ($P < 0.05$) in T₂ than T₃, T₄ and T₁ groups. But no significant difference between T₁, T₃ and T₄ was observed.

Ether Extract : The digestibility of EE in T₁, T₂, T₃ and T₄ was 57.22 ± 2.11 , 63.64 ± 1.50 , 58.41 ± 1.53 and 59.12 ± 1.35 per cent, respectively. The digestibility co-efficient of EE was not significant differ between the treatments.

Crude Fibre : The digestibility of CF in T₁, T₂, T₃ and T₄ was 61.82 ± 1.11 , 63.12 ± 1.21 , 60.29 ± 0.23 and 61.19 ± 0.22 per cent, respectively. The digestibility co-efficient of CF was not also significant differ between the treatments.

Nitrogen Free extract : The digestibility of NFE in T₁, T₂, T₃ and T₄ was 72.69 ± 1.31 , 74.16 ± 0.59 , 72.64 ± 1.11 and 72.93 ± 1.22 percent, respectively. The digestibility of nitrogen free extract was higher ($P < 0.05$) in T₂ than T₁, T₃ and T₄ group animals. There was significant difference between T₁, T₄, T₂ and T₃ treatments.

Apparent digestibility of DM, CP, and NFE were

significantly ($P < 0.05$) higher in T₂, as compared to T₁, T₃ and T₄ group due to higher DMI and VWI which was more palatable with the protein sources. These results are in close agreement to the findings of Chaturvedi and Walli (2000), Mahanta *et al.*, (2004), Sharma *et al.*, (2007), Shankhpal *et al.*, (2016) and Sharma *et al.*, (2016).

This was expected since apparent digestibility of feed protein is directly related to percentage of protein in the diet Toppo *et al.*, (1997). Improved nutrient utilization with higher feed intake resulted higher DCP and TDN intake in GNC supplemented group indicating better nutritive value of diet (Bose *et al.*, (2001). Similar results have been observed earlier Sudhakar *et al.*, (2002) and Sahoo *et al.*, (2009).

Conclusions

Therefore, It can be concluded that feeding of GNC (T₂) increased the digestibility as compared to cotton seed cake and til cake feeding in Gir cows as well as increased palatability and utility of poor quality roughage (Jowar Cutti).

Acknowledgements

The authors thanks to Dean S.K.N College of Agriculture, Jobner, for providing necessary facilities

References

1. AOAC, 2000. Official Methods of Analysis of the AOAC international. 17th Edition, Vol. 1 and 2, AOAC International, Gaithersburg, MD, USA.
2. Chaturvedi, O.H. and Walli, T.K. 2000. Effect of feeding graded levels of bypass protein on nutrient utilizations, nutrient partitioning and on performance of lactating crossbred cows. *Indian Journal of Dairy Science*, 53: 1-10.
3. Gracia, S.C., Santini, F.J. and Elizalde, J.C. 2000. Sites of digestion and bacterial protein synthesis in dairy heifers fed oats with or without corn or barley grain. *Journal of dairy Science*, 83: 746-755.
4. Kumar M. and Singhal R.S. 2006. Performance of high producing Cows in early Lactation ,Fed Protein varying amounts and degradability. *Pallavpuram Phase II*, Modipuram, Meerut-250 110, Uttar Pradesh, India.
5. Madhavi, K., Reddy, T.J., Reddy, Y., Ramana and Reddy, G.V.N. 2006. Growth rate and carcass characteristics of Nellore ram lambs fed on differently processed and detoxified neem (*azadiracta indica*) seed cake incorporated complete diets. *Animal Nutrition and Feed Technology*, 10(2): 201-206.
6. Mahanta, S.K., Khan, S.A. and Bedi, S.P.S. 2004. Effect of supplementation of phosphate on nutrition utilization on buffaloes. *Indian journal of Animal nutrition*, 21: 164-168.
7. Miesoguiru, Prasad, S. and Kamboj, M.L. 2006. Effect of energy and bypass protein supplementation on production performance of Lactating Crossbred Goats. *Indian Journal of dairy science*, 59: 90-94.
8. Nagalaximi, D. Reddy D. and Narasimha. 2012. Effect of

- feeding processed paddy straw based completed diet on nutrients utilization and Ruman fermentation pattern in sheep *Indian journal of animal nutrition*. 29(2): 132-137
9. Ranjhan, S.K. 2004. Animal nutrition and feeding practices page no.384-385.
 10. Reddy, G.V.N., Wilhelmina, P. Dipti and Reddy M.S. 2003. Effect of Different processed complete diet on performance of Murrah Buffaloes. *Indian journal of Animal Science* 20(2): 131-135.
 11. Rekhat, D.H., Patil, J.M. Dhok, A.P. 2008. Nutrients utilization and growth performance of goat. *Indian journal of animal nutrition* 23(4): 235-236.
 12. Sahoo, B., Bhushan, V.C., Kwatra, J. and Agarwal, A. 2009. Effect of urea molasses mineral block supplementation on milk production of cows (*Bos indicus*) in mid hills of Uttarakhand. *Animal Nutrition and Feed Technology*, 9: 171-178.
 13. Shankhpal, S., Gupta, R.S., Pamerkar, S. and Dharni, A.J. 2016. Effect Of Feeding Bypass Fat And Unprotected Oil On Feed Intake, Digestibility And Production Performance In Lactating Crossbred Cows. *Indian journal of Animal nutrition*, 33(3): 266-272.
 14. Sharma, P., Gupta, R.S., Baghel, R.P.S. and Nayak, S. 2007. Effect of diammonium phosphate on the performance of lactating buffaloes. *Indian journal of Animal nutrition*, 24: 248-250.
 15. Sharma, R., Tiwari, D.P., Mondal, B.C. and Kumar, A. 2016. Replacement of Dicalcium Phosphate with Diammonium Phosphate in the Diet its Effect on Nutrient Utilization and Milk Production in lactating Crossbred Cattle. *Indian journal of Animal nutrition*, 33(3): 273-278.
 16. Singal, J.S. 2001. Effect of Feeding Bypass Protein and Improved Managemental Practices on Growth Performance of Murrah Buffalo Heifers. *Ph.D. Thesis, Haryana Agricultural University, Hisar, India*.
 17. Snedecor, G.W. and Cochran, W.G. 1994. Statistical methods, 7th Edition Oxford and IBH Publishing Co., Calcutta, India.
 18. Sudhakar, K., Reddy, G.V.K. and Krishna, N. 2002. Effect of Supplementation of Urea-Molasses Mineral Blocks (ummb) on Quantity and Quality of Milk Production in Murrah Buffaloes. *Indian Journal of Animal Nutrition*, 19(4): 301-305.
 19. Thirumalesh, T., Surekha, K. and Reddy, V.N. 2003. Effect of Bajra based complete diet on nutrient digestibility and rumen metabolism in sheep. *Indian Journal of Animal Nutrition*. 20(4): 389-394.
 20. Toppo, S., Verma, A.K., Dass, R.S. and Mehra, U.R. 1997. Nutrients utilization and rumen fermentation pattern in crossbred cattle fed different planes of nutrition supplemented with urea molasses mineral block. *Animal Feed Science and Technology*, 64: 101-112.
 21. Upadhyay, V.S. 1994. Forage resource development for increased Animal Productivity National Symp. *Indian Society of Livestock Production and management*, 11: 177-185.
 22. Wadhwa, A. and M.P.S. Bakshi, 2006. Effect off feeding total mixed rations on the performance of buffalo calves. *Indian Journal of Animal nutrition*, 23: 159-164.



Economics of Different Protein Sources and other Feeds for Milk Production in Gir Cows

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Abstract

All sixteen cows were randomly divided into four groups of four in each group on the basis of closest in their body weight and milk yield of average per day subjected to four dietary treatments i.e. juar cutti ad-lib+green fodder(5kg) and Pelleted Concentrate Mixture(T₁), T₁ + Groundnut Cake @ 500g* per Cow per Day (T₂), T₁ + Til Cake @ 559g* per Cow per Day(T₃) and T₁ + Cotton Seed Cake @ 1134g* per Cow per Day(T₄) the studies for their economic of milk production. The average milk production in morning was 3.238±0.599, 3.616±0.384, 3.476±0.598 and 3.371±0.889 litre for T₁, T₂, T₃ and T₄, respectively. The average milk production in evening for T₁, T₂, T₃ and T₄ was 3.313±0.387, 3.779±0.847, 3.365±0.698 and 3.355±0.874 litre/day, respectively. The total milk production in T₁, T₂, T₃ and T₄ was 6.374±0.654, 7.245±0.487, 6.842±0.658 and 6.726±0.689 litre/day, respectively. The milk production in T₂ was higher (P<0.05) than T₁, T₃ and T₄. The feed cost per liter of milk production was Rs 21.92, 22.46, 23.58, and 25.35 in T₁, T₂, T₃, and T₄ groups, respectively. The higher return over feed cost treatment T₂ in spite of higher total feed cost as compared to T₁ but lower feed cost as compared to T₃ and T₄ groups due to more milk production which is more economical milk production of Gir cows.

Key words : Protein sources, Gir cows, milk production and economics.

Introduction

India's livestock sector is one of the largest in the world which plays an important role in the national economy and also in the socio-economic development of millions of rural households. In India, annual milk production is 198.4 million tonnes. India ranks first in the world and contributes about 16% to the world milk production. The per capita availability of milk in India is 407 g per day in 2019-20. Rajasthan stands at 2nd rank in the country with annual milk production of 23.67 million tonnes and contributes 12.60 per cent in India's milk production. Dairy animals are generally given energy and protein, concentrate supplements to increase milk production and stocking rates (Gracia *et al.*, 2000). The Gir is a famous milch cattle breed of India. The native trait of this breed is Gir hills and forest of Kathiawar including Junagadh, Bhavnagar, Rajkot and Amreli districts of Gujarat and also in parts of Maharashtra and Rajasthan. Cattle of this breed are famous for their tolerance to stress conditions and resistance to various tropical diseases (Kumar and Singhal 2006). Nutrition plays pivotal role in exploiting the genetic potential of dairy animals. Most farm animals will develop with feeding systems consisting of a small range of components, or even a single component, but production levels may be low and the nutrient levels in the feed are not balanced. Optimum yields of milk are obtained by feeding farm animals appropriate quantities of various raw material components. Feeding is one of the most important determinants of profit in the livestock farming. Variation in nutritive value of different feed stuff

affects on feed intake palatability and digestibility of feed more over then feed also affect the milk yield. The objective of the feeding complete ration is to provide a blend of feed ingredients without giving any choice to the animal for the selection of any specific feed ingredient, so that each bite could supply the required amount of nutrients (Wadhwa and Bakshi 2006). Complete ration not only improves the feeding value of feed stuff but also simplifies feeding, minimizes labour and maximizes automation.

Materials and Methods

The experiment was carried out between 18 february 2018 to 18 may 2018 (90 days) under RKVY project at Dairy farm, Department of Livestock Production Management, S.K.N. College of Agriculture, Jobner (Jaipur). Sixteen lactating Gir cows in early stage of lactation were selected for the experiment. The details of treatments of experimental Gir cows are given in Table-1.

Table-1 :

Symbols	Treatments
T ₁	Pelleted Concentrate Mixture
T ₂	T ₁ + Groundnut Cake @ 500g* per Cow per Day
T ₃	T ₁ + Til Cake @ 559g* per Cow per Day
T ₄	T ₁ + Cotton Seed Cake @ 1134g* per Cow per Day

All sixteen cows were randomly divided into four groups of four in each group on the basis of nearest in their body weight and milk yield of average per day (Table-2).

Table-2 :

Treatments	Animal No.	Body weight (kg)	Milk production (litres/day)
T ₁	004	346	4.3
	007	365	5.1
	012	374	9.4
	015	357	7.5
Average	-	360.5	6.5
T ₂	011	370	3.9
	018	351	10.3
	023	359	7.3
	024	365	5.1
Average	-	361	6.6
T ₃	008	422	4.6
	013	362	10.3
	014	336	5.3
	020	322	6.2
Average	-	360.5	6.6
T ₄	16	385	4
	17	312	6.1
	21	374	6.3
	26	368	10.1
Average	-	359.75	6.6

The experiment data were statistically analyzed using standard statistical methods (Snedecor and Cochran, 1994). The experiment planned with subjected to analysis of variance (ANOVA) for a completely randomized design (CRD) with one way classification of analysis of variance. Different statistical tools such as mean, standard deviation (SD), standard error (SE) were worked out to compare the group means. The difference among treatment means were tested for significance performing Duncan's multiple range tests (DMRT).

Cost of feed : The feed cost of milk production was calculated based on actual cost of feed and fodders at Department of Livestock Production Management. The cost of Lucerne and Jowar Kutti was 600/Qtl. and 675/Qtl. respectively, which cost of concentrate palleted 1650/Qtl, Groundnut cake Rs. 3600/qtl Till cake Rs. 3700 Cotton Seed Cake Rs. 2500/qtl. The milk was sold to milk window @ 34/lit. during experiment period. Feeding one of the most important principles for economics. Feeding of dairy cattle in that they should be fed with sufficient quantity of nutrition and palatable fodder. Adult cows are

Table-2 : Feeding schedule of Gir cows.

S. No.	Feed and fodders	Quantity of feed and fodders
1.	Concentrate pelleted	2 kg for maintainance ration/animal and @ 1 kg/2.5 litre milk yield for production ratio
2.	Protein cakes	GNC 500g, Til cake 559g and Cotton seed cake 1134 g treatment wise.
3.	Luceren green	5 kg per cow
4.	Dry fodder (Jowar kutti)	<i>Ad lib.</i> , (Approximately 6 kg/Cow)

Table-4 : Feed cost of milk production under different treatment.

Particulars	Treatments			
	T ₁	T ₂	T ₃	T ₄
Total quantity of Jowar kutti (q)	19.80	20.52	19.44	19.44
Total quantity of concentrate	15.84	16.56	16.20	15.84
Total quantity of lucerne green	18.00	18.00	18.00	18.00
Total quantity of cakes (GNC, Til, (CSC))	-	01.80	02.01	04.53
Feed cost				
Jowarkutti	13365 (26.57)	13851 (23.69)	13122 (22.58)	13122 (21.37)
Concertrate	26136 (52.28)	27324 (46.74)	26730 (46.01)	26136 (42.05)
Lucern green	10800 (21.47)	10800 (18.47)	10800 (18.59)	10800 (17.59)
Cake	-	6480 (11.08)	7437 (12.80)	11325 (18.44)
Total feed cost	50301	58455	58089	61383
Average daily feed cost per animal	139.72	162.37	161.35	170.50
Total milk in 90 days	2294.4	2602.1	2462.9	2421.32
Lactation Yield (300 day/cow)	1911.9	2168.4	2051.7	2017.7
Milk yield /cow	6.37	7.23	6.84	6.73
Total income sale of milk	78009.6	88471.4	83738.6	82324.88
Feed cost /liter of milk	21.92	22.46	23.58	25.35

Figure in perenthesis indicates in percentage

Cost of items

Concentrate –

Rs. 1650/ qtl

Til - Rs. 3700/qtl

Green –

Rs. 600/qtl

Jowarkutti – Rs. 675/qtl.

GNC –

Rs. 3600/qtlCSC –

Rs. 2500 /qtl

Milk – Rs. 34/lit

provided with 5 kg good quality Lucerne green along with 6 kg dry fodder as jowar kutti to make up dry matter requirement they are given concentrate @ 2 kg/cow for maintenance and 1 kg/2.5 kg milk production.

Results and Discussion

The feed cost and cost per liter milk was worked and have been presented in Table-4. The total feed cost per Quintal is T₁, T₂, T₃, and T₄ group was Rs. 50301, 58455, 58089 and 61383, respectively. The daily percent of feed cost through concentrate is T₁, T₂, T₃, and T₄ was Rs. 52.28, 46.74, 46.01 and 42.08, respectively. The corresponding percent for dry fodder was 26.57, 23.69, 22.58, and 21.37, respectively. While percent of green fodder cost was Rs 21.47, 18.47, 18.59, and 17.08, respectively. Income for sale of milk is Rs. 78009.6, 88471.4, 83738.6 and 82324.8 in T₁, T₂, T₃ and T₄ groups respectively. The feed cost per liter of milk production was Rs 21.92, 22.46, 23.58, and 25.35 in T₁, T₂, T₃, and T₄ groups respectively. Lactation yield (300 days) were calculate is 1911.9, 2168.4, 2051.7 and 2021.7 liter in T₁, T₂, T₃ and T₄ groups, respectively. The higher return over feed cost treatment T₂ inspite of higher total feed cost as compared to T₁ but lower feed cost as compared to T₃ and T₄ groups due to more milk production which is more economical milk production of Gir cows. Similar results were obtained by Chaudhary *et al.*, (2002), Gulati *et al.*, (2002), Garg *et al.* (2004) and Yadav and Chaudhary (2004) in lactating cows fed various levels of protected protein (GNC) in the diets. Similar results were also reported by Chatterjee and Walli (2003b) in growing buffalo calves fed protected protein in the diets.

References

1. Chatterjee, A. and Walli, T.K. 2003b. Economics of feeding formaldehyde treated mustard cake as bypass protein to growing buffalo calves. *Indian Journal of Dairy Science*, 56: 241-244.
2. Chaudhary, J.L., Gupta, L.R. and Mandai, A.B. 2002. Effect of feeding different levels of berseem on milk yield and composition and feed conversion efficiency in buffaloes. *Buffalo Journal*, 1 : 13-23.
3. Garg, M. R., Bhandari, B.M., Sherasia, P.L., Gulati, S.K. and Scott, T.W. 2004. Significance of feeding protected protein meals for improving efficiency of milk production in developing countries. *Animal Nutrition and Feed Technology* 36: 123-126.
4. Gracia, S.C., Santini, F.J. and Elizalde, J.C. 2000. Sites of digestion and bacterial protein synthesis in dairy heifers fed oats with or without corn or barley grain. *Journal of dairy Science*, 83: 746-755.
5. Gulati, S.K., Scott, T.W., Garg, M.R. and Singh, D.K. 2002. An overview of rumen protected or bypass protein and their potential to increase milk production in India. *Indian Dairy management*, 54 : 31-35.
6. Kumar M. and Singhal R.S. 2006. Performance of high producing Cows in early Lactation, Fed Protein varying amounts and degradability. *Pallavpuram Phase II*, Modipuram, Meerut-250 110, Uttar Pradesh, India.
7. Snedecor, G.W. and Cochran, W.G. 1994. Statistical methods, 7th Edition Oxford and IBH Publishing Co., Calcutta, India.
9. Wadhwa, A. and M.P.S. Bakshi. 2006. Effect off feeding total mixed rations on the performance of buffalo calves. *Indian Journal of Animal nutrition*, 23: 159-164.
10. Yadav, C.M. and Chaudhary, J.L. 2004. Effect of feeding protected protein on nutrient utilization, milk yield and milk composition of lactating crossbred cows. *Indian Journal of Dairy Science*, 57: 394-399.



Heterosis studies for Grain Yield and Quality Parameters in Rice (*Oryza sativa* L.)

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Abstract

An experiment was conducted with 45 hybrids generated by crossing 10 diverse rice genotypes. The hybrids were developed in diallel fashion excluding reciprocals. Relative heterosis, heterobeltiosis and standard heterosis were estimated for yield and quality characters. Significant heterosis recorded for grain yield, yield and quality component characters. Hybrids Pratap-1 × P-2511, P-1592 × P-2511, P-1121 × P-2511, P-1612 × P-2511, Pratap-1 × P-1612, P-1592 × Mahi Sugandha and P-1592 × Pratap-1 performed well for grain yield combined with several grain quality characters. These crosses can be further used in heterosis breeding programme.

Key words : Heterosis, diallel mating, heterosis breeding, rice

Introduction

Rice (*Oryza sativa* L.) being the important staple food for more than 50 per cent of the world and 70 percent of the population in India. It is cultivated under range of agro-climatic zone in an area of 43.78 million hectares with the production of 118.43 million tonnes and average productivity of 2705 kg/ha in India (Anonymous 2020). In Rajasthan, it is cultivated in an area of 2.19 lakh hectares with the production of 4.80 lakh tonnes and the productivity of 2180 kg/ha (Anonymous 2019-20). Approximately 90 per cent of the world's rice is grown in the Asian continent and it ranks second in the grain production in India. Rice is separated into aromatic and non-aromatic rice based on the presence of fragrance (aroma). The various quality traits of basmati rice viz., kernel breadth, kernel length, aroma, high volume expansion during cooking, fluffy texture of cooked rice, maximum linear kernel elongation with minimum breadth-wise swelling, palatability, easy digestibility and longer shelf-life make it unique and class apart from other rice. Rice contains 8% protein, small amount of fat, fibre, antioxidants, calcium, iron and vitamin like thiamine, riboflavin, niacin etc.

To study the extent of heterosis for grain yield and quality character, the knowledge of nature and the magnitude of heterosis controlling yield and quality components are very useful for development of the new hybrids varieties. Hybrid rice technology had also shown increased yield, farmer profitability and better adaptability to stress. Exploitation of heterosis in rice has been

recognized as practical tool in providing the breeders a means of improving yield and other important traits for developing promising varieties through hybridization. Existence of a significant amount of dominance variance is essential for undertaking heterosis breeding programme. In this study several cross combinations exhibited conspicuous relative heterosis, heterobeltiosis and standard heterosis for different traits.

Materials and Methods

The experimental material for present experiment consisted of fifty-five entries including ten genotypes (P-1592, P-1121, Pratap-1, Surabhi, P-1612, Basmati-370, Pakistan Basmati, Mahi Sugandha, P-2511 and P-1509). These parents were crossed in diallel mating design (without reciprocal) of Griffing (1956) to produce 45 hybrids during Kharif 2019. The experiment was laid out in a Randomized Block Design with three replications at Agricultural Research Station, Ummadganj, Kota (Rajasthan) during Kharif-2020. Each entry was planted in a two row with a spacing 20 × 10 cm. The standard agronomical practices were followed to raise the good experimental crop. Ten genotypes (parents) were selected for study of combining ability with the following observation like; days to 50% flowering, days to 75% maturity, plant height (cm), no. of effective tillers/ plant, no. of panicles/ plant, panicle length (cm), no. of spikelets/ panicle, 1000-grain weight (g), grain yield/ plant (g), hulling (%), milling (%), hrr (%), kernel length (mm), kernel

breadth (mm), l/b ratio, kernel length after cooking (mm), elongation ratio and amylose (%). Observations were recorded on ten randomly selected plants of each genotype in each replication for all traits except for days to 50% flowering and days to 75% maturity. These two observations were recorded on whole plot basis, subjected to statistical analysis.

Results and Discussion

The results of analysis of variance revealed that the mean squares due to genotypes were highly significant for most of the traits, which indicated the considerable amount of variability were presented among genotypes for most of the traits. The mean squares due to genotypes were further partitioned into parents, hybrids and parent vs. hybrid. The differences between parents were significant for all the traits except days to 75 % maturity and hulling per cent. The mean squares due to hybrids and parents vs. hybrids were found significant for most of the traits indicating substantial amount of heterosis among hybrids. Similar results were reported by Singh *et al.* (2020), and Dharwal *et al.* (2017) in rice.

The relative heterosis varied from -12.72 per cent (Pratap-1 × Pakistan Basmati) to 13.30 per cent (P-1592 × P-1121), heterobeltiosis ranged from -14.40 per cent (IET-12016 × P-2511) to 27.67 per cent (P-1592 × Pakistan Basmati) and standard heterosis ranged from -11.15 per cent (P-1592 × P-1509) to 9.12 per cent (P-1592 × Pakistan Basmati) for days to days to 50 per cent flowering (Table-1). Eight, six and six hybrids showed significant negative relative heterosis, heterobeltiosis and standard heterosis, respectively for earliness. The hybrid Pratap-1 × Pakistan Basmati showed highest significant negative relative heterosis. The hybrid, Surabhi × P-2511 were found highest negative significant heterosis over better parent and the hybrids, the hybrids P-1592 × P-1509, P-1121 × Surabhi, P-1592 × Mahi Sugandha, Surabhix P-1509, Pakistan Basmati × P-2511 and Mahi Sugandha × P-1509 were recorded highest negative heterosis over standard check. Similar results were reported by Vedivel *et al.* (2018) and Devi *et al.* (2017) for earliness in desired direction.

For days to 75 per cent maturity, the relative heterosis varied from -12.61 per cent (P-1121 × Surabhi) to 6.25 per cent (Pratap-1 × P-1509), heterobeltiosis ranged from -12.04 per cent (P-1121 × Surabhi) to 7.09 per cent (Pratap-1 × P-1509) and standard heterosis ranged from -12.04 per cent (P-1121 × Surabhi) to 7.85 per cent (P-1592 × P-1612). Fourteen, Eight and six hybrids showed significant negative relative heterosis, heterobeltiosis and standard heterosis, respectively for this trait. The hybrid P-1121 × Surabhi showed highest significant negative relative heterosis. The hybrids P-1121

× Surabhi, Pratap-1 × Pakistan Basmati, Surabhix P-1509, P-1121 × P-1612, P-1612 × Basmati-370, P-2511 × P-1509, Pakistan Basmati × Mahi Sugandha and P-1121 × P-1509 were found highest negative significant heterosis over better parent and the hybrids, the hybrids P-1121 × Surabhi, P-1121 × P-1612, Pratap-1 × Pakistan Basmati, Surabhix P-1509, Pakistan Basmati × P-2511 and P-2511 × P-1509 were recorded highest negative heterosis over standard check.

With regard to plant height, the relative heterosis varied from -12.61 per cent (Pratap-1 × Pakistan Basmati) to 17.48 per cent (Mahi Sugandha × P-2511), heterobeltiosis ranged from -17.67 per cent (Pakistan Basmati × Mahi Sugandha) to 34.06 per cent (Pakistan Basmati × P-1509) and standard heterosis ranged from -18.31 per cent (P-1592 × Surabhi) to 23.06 per cent (Pakistan Basmati × P-2511). Thirteen, six and seven hybrids showed significant negative relative heterosis, heterobeltiosis and standard heterosis, respectively for plant height. The hybrid Pratap-1 × Pakistan Basmati showed highest significant negative relative heterosis. The hybrid Pakistan Basmati × Mahi Sugandha was found highest negative significant heterosis over better parent and the hybrids, P-1592 × Surabhi, P-1592 × P-1121, P-1592 × P-1612, P-1592 × Mahi Sugandha, P-1592 × P-2511, P-1592 × P-1509 and P-1121 × Surabhi were recorded highest negative heterosis over standard check. The results are in akin with the findings of Sharma and Jaiswal (2020), Dillon *et al.*, (2021) and Saidaiyah *et al.* (2012).

For number of effective tillers per plant, the relative heterosis varied from -40.40 per cent (Basmati-370 × P-2511) to 18.55 per cent (P-1121 × P-2511), heterobeltiosis ranged from -59.10 per cent (Basmati-370 × P-2511) to 20.64 per cent (P-1612 × P-2511) and standard heterosis ranged from -62.60 per cent (Pakistan Basmati × Mahi Sugandha) to 19.07 per cent (P-1592 × P-2511). four, three and three crosses expressed positive significant relative heterosis, heterobeltiosis and standard heterosis, respectively. Hybrid P-1121 × P-2511 recorded highest positive heterosis over mid parent. Hybrid P-1612 × P-2511 recorded highest positive heterosis over batter parent. The hybrids P-1592 × P-2511, P-1592 × P-1612 and P-1121 × P-2511 recorded significant positive standard heterosis. Similar results were also reported by Ambikabathy *et al.* (2019) and Devi *et al.* (2017) in rice.

With regard to number of panicles per plant, the relative heterosis varied from -40.63 % (P-1592 × P-1509) to 41.48 % (Basmati-370 × Pakistan Basmati), heterobeltiosis ranged from -58.24 % (Basmati-370 × P-2511) to 28.60 % (Basmati-370 × Pakistan Basmati) and standard heterosis ranged from -61.73 %

Table-1a : Estimation of relative heterosis, heterobeltiosis and standard heterosis for days to 50% flowering, days to 75% maturity and plant height.

S. No.	Hybrids	Heterosis											
		Days to 50% flowering				Days to 75% maturity				Plant height (cm)			
		RH	Hb	SH	RH	RH	Hb	SH	RH	RH	Hb	SH	SH
1.	P 1592 x P 1121	13.30**	22.92**	5.07	1.43	2.09	2.09	2.09	-10.42**	-10.42**	-5.26	-15.05**	-15.05**
2.	P 1592 x Pratap 1	7.72*	21.34**	3.72	2.58	2.58	2.58	2.58	-2.57	-2.57	6.47	-4.53	-4.53
3.	P 1592 x Surabhi	7.84	8.70	-7.09	-3.88*	-3.88*	-3.88	-2.62	-9.57**	-9.57**	-8.89*	-18.31**	-18.31**
4.	P 1592 x P 1612	13.00**	23.72**	5.74	5.78**	6.46**	6.46**	7.85**	-4.49	-4.49	1.29	-9.18*	-9.18*
5.	P 1592 x Basmati 370	1.60	12.65*	-3.72	-3.85*	-3.10	-3.10	-1.83	1.07	1.07	14.46**	2.64	2.64
6.	P 1592 x Pakistan Basmati	12.74**	27.67**	9.12*	3.30	5.17*	5.17*	6.54**	-4.03	-4.03	19.80**	7.43*	7.43*
7.	P 1592 x Mahi Sugandha	2.29	5.93	-9.46*	-2.22	-1.32	-1.32	-1.83	-7.58*	-7.58*	-6.48	-16.14**	-16.14**
8.	P 1592 x P 2511	3.50	11.07*	-5.07	0.78	1.85	1.85	1.05	-3.58	-3.58	1.15	-9.30*	-9.30*
9.	P 1592 x P 1509	2.33	3.95	-11.15**	-3.39	-2.62	-2.62	-2.88	-2.70	-2.70	-2.01	-13.36**	-13.36**
10.	P 1121 x Pratap 1	-6.36	-3.04	-3.04	-2.99	-2.36	-2.36	-2.36	2.75	2.75	5.99	5.99	5.99
11.	P 1121 x Surabhi	-3.80	3.50	-10.14*	-12.61**	-12.04**	-12.04**	-12.04**	-12.11**	-12.11**	-7.76	-16.06**	-16.06**
12.	P 1121 x P 1612	-7.54*	-6.76	-6.76	-6.98**	-5.76**	-5.76**	-5.76**	-0.63	-0.63	-0.37	-0.37	-0.37
13.	P 1121 x Basmati 370	-0.99	-8.95*	1.01	-3.13*	1.57	1.57	1.57	-6.94*	-6.94*	-14.12**	14.12**	14.12**
14.	P 1121 x Pakistan Basmati	-1.62	2.36	2.36	1.15	3.66	3.66	3.66	-10.02**	-10.02**	5.37	5.37	5.37
15.	P 1121 x Mahi Sugandha	10.05**	15.13**	5.41	4.99**	5.26*	5.26*	4.71*	0.38	0.38	4.87	-3.74	-3.74
16.	P 1121 x P 2511	2.73	3.79	1.69	5.12**	5.54*	5.54*	4.71*	-1.86	-1.86	-1.09	-2.61	-2.61
17.	P 1121 x P 1509	-7.52*	13.03**	-0.34	-4.44*	-4.31*	-4.31*	-1.57	4.91	4.91	11.78**	-1.16	-1.16
18.	Pratap 1 x Surabhi	2.44	14.40**	-0.68	-1.29	-1.29	-1.29	0.00	0.64	0.64	9.11*	-0.71	-0.71
19.	Pratap 1 x P 1612	-8.41*	-9.98*	-4.39	-3.72*	-3.10	-3.10	-1.83	-6.66*	-6.66*	-8.19*	5.13	5.13
20.	Pratap 1 x Basmati 370	-6.24	-4.87	-1.01	-2.31	-1.55	-1.55	-0.26	-6.70*	-6.70*	-3.58	2.51	2.51
21.	Pratap 1 x Pakistan Basmati	-12.72**	-12.30**	-6.08	-8.12**	-6.46**	-6.46**	-5.24*	-12.61**	-12.61**	-1.15	5.09	5.09
22.	Pratap 1 x Mahi Sugandha	1.36	9.96*	0.68	0.91	-2.90	-2.90	-3.66	-7.87*	-7.87*	-4.20	-5.68	-5.68
23.	Pratap 1 x P 2511	-7.74*	20.31**	-5.41	-3.92*	7.09**	7.09**	6.81**	10.50**	10.50**	21.68**	7.59*	7.59*
24.	Pratap 1 x P 1509	8.65*	17.90**	2.36	1.41	2.07	2.07	3.40	2.48	2.48	7.84	-1.87	-1.87
25.	Surabhi x P 1612	8.60*	20.62**	4.73	2.31	3.10	3.10	4.45*	1.01	1.01	13.45**	3.24	3.24
26.	Surabhi x Basmati 370	9.73*	14.40**	-0.68	-3.55	-1.81	-1.81	-0.52	-7.92**	-7.92**	13.94**	3.68	3.68
27.	Surabhi x Pakistan Basmati	1.91	8.17	-6.08	-2.48	-1.58	-1.58	-2.09	1.57	1.57	2.02	-7.17	-7.17
28.	Surabhi x Mahi Sugandha	5.30	14.40**	-0.68	-2.35	-1.32	-1.32	-2.09	7.44*	7.44*	11.84**	1.78	1.78
29.	Surabhi x P 2511	7.50	5.06	-8.78*	-7.03**	-6.30**	-6.30**	-6.54**	9.12*	9.12*	10.71*	-2.11	-2.11
30.	Surabhi x P 1509	4.25	-4.65	-3.04	-5.73**	-5.61**	-5.61**	-3.14	0.37	0.37	6.81	7.36*	7.36*
31.	P 1612 x Basmati 370	-5.75	-1.00	0.68	-2.65	-1.53	-1.53	1.05	-8.78**	-8.78**	6.51	7.06	7.06
32.	P 1612 x Pakistan Basmati	-4.03	6.27	-2.70	-2.07	-0.53	-0.53	-1.05	-3.17	-3.17	1.43	-6.89	-6.89
33.	P 1612 x Mahi Sugandha	0.70	4.83	2.70	0.13	1.85	1.85	1.05	-1.05	-1.05	-8.01*	-1.56	-1.56
34.	P 1612 x P 2511	2.88	13.79**	0.34	-3.49	-2.10	-2.10	-2.36	1.31	1.31	-8.24*	-4.29	-4.29
35.	P 1612 x P 1509	5.69	-4.22	-0.34	-1.26	-0.25	-0.25	2.62	-8.67**	-8.67**	-0.30	13.08**	13.08**
36.	Basmati 370 x Pakistan Basmati	-6.05	15.13**	5.41	-0.65	1.05	1.05	0.52	3.91	3.91	16.15**	6.62	6.62
37.	Basmati 370 x Mahi Sugandha	7.77*	4.48	2.36	-0.26	1.58	1.58	0.79	-2.51	-2.51	4.89	3.28	3.28
38.	Basmati 370 x P 2511	1.34	5.75	-6.76	-4.39*	-2.89	-2.89	-3.14	7.57*	7.57*	22.78**	8.57*	8.57*
39.	Basmati 370 x P 1509	-2.99	17.71**	7.77	-4.92*	-4.74*	-4.74*	4.19	-4.41	-4.41	-17.67**	8.02*	8.02*
40.	Pakistan Basmati x Mahi Sugandha	-7.95*	-11.48**	-8.78*	-6.92**	-4.22	-4.22	-4.97	5.79*	5.79*	24.99**	23.06**	23.06**
41.	Pakistan Basmati x P 2511	6.02	18.01**	4.05	1.02	3.67	3.67	3.40	6.49*	6.49*	34.06**	18.54**	18.54**
42.	Pakistan Basmati x P 1509	4.46	8.12	-1.01	0.40	0.53	0.53	-0.26	17.48**	17.48**	21.74**	11.75**	11.75**
43.	Mahi Sugandha x P 2511	1.88	3.83	-8.45*	-3.55	-3.42	-3.42	-3.93	8.50*	8.50*	10.57*	-2.23	-2.23
44.	Mahi Sugandha x P 1509	-0.18	5.36	-7.09	-5.79**	-5.54*	-5.54*	-6.28**	11.24**	11.24**	17.55**	3.94	3.94

S. No.	Hybrids		Heterosis	
	No. of effective tillers/plant	No. of panicles/plant	No. of effective tillers/plant	Panicle length (cm)
1	10	10	10	10
2	10	10	10	10
3	10	10	10	10
4	10	10	10	10
5	10	10	10	10
6	10	10	10	10
7	10	10	10	10
8	10	10	10	10
9	10	10	10	10
10	10	10	10	10
11	10	10	10	10
12	10	10	10	10
13	10	10	10	10
14	10	10	10	10
15	10	10	10	10
16	10	10	10	10
17	10	10	10	10
18	10	10	10	10
19	10	10	10	10
20	10	10	10	10
21	10	10	10	10
22	10	10	10	10
23	10	10	10	10
24	10	10	10	10
25	10	10	10	10
26	10	10	10	10
27	10	10	10	10
28	10	10	10	10
29	10	10	10	10
30	10	10	10	10
31	10	10	10	10
32	10	10	10	10
33	10	10	10	10
34	10	10	10	10
35	10	10	10	10
36	10	10	10	10
37	10	10	10	10
38	10	10	10	10
39	10	10	10	10
40	10	10	10	10
41	10	10	10	10
42	10	10	10	10
43	10	10	10	10
44	10	10	10	10
45	10	10	10	10
46	10	10	10	10
47	10	10	10	10
48	10	10	10	10
49	10	10	10	10
50	10	10	10	10
51	10	10	10	10
52	10	10	10	10
53	10	10	10	10
54	10	10	10	10
55	10	10	10	10
56	10	10	10	10
57	10	10	10	10
58	10	10	10	10
59	10	10	10	10
60	10	10	10	10
61	10	10	10	10
62	10	10	10	10
63	10	10	10	10
64	10	10	10	10
65	10	10	10	10
66	10	10	10	10
67	10	10	10	10
68	10	10	10	10
69	10	10	10	10
70	10	10	10	10
71	10	10	10	10
72	10	10	10	10
73	10	10	10	10
74	10	10	10	10
75	10	10	10	10
76	10	10	10	10
77	10	10	10	10
78	10	10	10	10
79	10	10	10	10
80	10	10	10	10
81	10	10	10	10
82	10	10	10	10
83	10	10	10	10
84	10	10	10	10
85	10	10	10	10

S. No.	Hybrids	Heterosis									
		No. of effective tillers/plant			No. of panicles/plant			Panicle length (cm)			
		RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	
1.	P 1592 x P 1121	16.97*	16.16*	-16.16*	-6.41	-17.58**	-17.58**	-0.39	-1.51	-1.51	
2.	P 1592 x Pratap 1	-17.91*	-20.67*	-37.87**	16.16*	19.36*	-38.60**	3.02	-0.92	-3.14	
3.	P 1592 x Surabhi	-25.88**	-41.38**	-54.09**	-28.53**	-45.46**	-58.47**	0.27	-2.59	-4.78	
4.	P 1592 x P 1612	-8.53	18.39**	18.52**	-9.51	20.24**	-20.39**	2.75	1.85	-0.44	
5.	P 1592 x Basmati 370	-20.35	-42.68**	-55.10**	-21.27	-46.25**	-59.08**	-2.01	-6.00*	-8.11**	
6.	P 1592 x Pakistan Basmati	9.58	-17.20	-35.15**	11.32	-19.48*	-38.69**	7.36**	0.87	-1.40	
7.	P 1592 x Mahi Sugandha	9.75	2.52	19.07**	11.14	2.86	-21.69**	-2.82	-3.49	-5.66*	
8.	P 1592 x P 2511	17.19*	-12.41	19.07**	-5.81	-13.78	-20.99**	5.99*	5.15	2.78	
9.	P 1592 x P 1509	-38.10**	-41.56**	-54.23**	-40.63**	-44.39**	-57.66**	-1.71	-2.91	-5.09	
10.	P 1121 x Pratap 1	-22.55*	-32.99**	-32.99**	-22.23**	-33.77**	-33.77**	-0.49	-5.32	-5.32	
11.	P 1121 x Surabhi	-0.90	-27.88**	-27.88**	1.47	-28.93**	-28.93**	8.71**	4.46	4.46	
12.	P 1121 x P 1612	-20.05**	-20.12**	-20.12**	-19.04**	-19.12**	-19.12**	4.35	2.28	2.28	
13.	P 1121 x Basmati 370	-30.34**	-53.18**	-53.18**	-27.13**	-53.43**	-53.43**	1.53	-3.65	-3.65	
14.	P 1121 x Pakistan Basmati	-13.58	-39.49**	-39.49**	-31.76**	-54.27**	-54.27**	3.23	-4.03	-4.03	
15.	P 1121 x Mahi Sugandha	-6.60	-21.54**	-21.54**	-7.40	-23.71**	-23.71**	-3.55	-5.29	-5.29	
16.	P 1121 x P 2511	18.55*	-8.18	18.18**	-1.34	-5.47	-5.47	5.92*	3.90	3.90	
17.	P 1121 x P 1509	6.36	-9.82	-9.82	6.19	-11.60	-11.60	-3.07	-5.31	-5.31	
18.	Pratap 1 x Surabhi	-18.74	-34.03**	-51.81**	-13.68	-32.25**	-52.34**	12.04**	10.90**	2.23	
19.	Pratap 1 x P 1612	-16.63*	-27.82**	-27.82**	18.60**	20.62**	-30.75**	8.10**	4.87	0.72	
20.	Pratap 1 x Basmati 370	1.33	-25.47**	-45.55**	1.60	-29.11**	-50.14**	3.09	2.81	-7.17*	
21.	Pratap 1 x Pakistan Basmati	-1.97	-24.12*	-44.57**	9.87	-18.51*	-42.68**	9.16**	6.53*	-3.81	
22.	Pratap 1 x Mahi Sugandha	11.56	7.70	-21.32**	13.28	8.80	-23.47**	-4.86	-7.88**	-11.20**	
23.	Pratap 1 x P 2511	-7.35	-17.05*	-23.35**	-8.26	-18.92**	-25.70**	0.49	-2.59	-6.30*	
24.	Pratap 1 x P 1509	-5.75	-8.00	-32.79**	-6.60	-9.15	-36.09**	0.84	-1.85	-6.39*	
25.	Surabhi x P 1612	-3.02	-29.38**	-29.50**	18.45*	-32.34**	-32.47**	8.09**	6.03*	-3.93	
26.	Surabhi x Basmati 370	5.70	-7.23	-57.74**	24.91	5.80	-57.60**	5.28	-4.21	-14.88**	
27.	Surabhi x Pakistan Basmati	16.90	9.82	-49.97**	27.27	17.63	-18.46	-4.42	-7.66*	-6.04*	
28.	Surabhi x Mahi Sugandha	-5.51	-21.11*	-46.35**	0.75	-18.46	-47.18**	-0.35	-2.53	-1.91	
29.	Surabhi x P 2511	4.95	-21.65**	-27.61**	18.78*	14.63*	-21.78**	7.14**	6.46*	-5.80*	
30.	Surabhi x P 1509	-17.38	-31.64**	-52.44**	-20.66	-36.42**	-57.72**	0.44	-1.24	-5.55	
31.	P 1612 x Basmati 370	-26.57**	-50.63**	-50.71**	-30.76**	-55.73**	-55.81**	1.65	-1.65	-4.68	
32.	P 1612 x Pakistan Basmati	-11.60	-38.07**	-38.17**	-13.34	-41.91**	-42.01**	4.76	-0.75	-8.23**	
33.	P 1612 x Mahi Sugandha	-33.52**	-44.12**	-44.21**	-30.64**	-42.81**	-42.92**	-4.63	-4.80	2.49	
34.	P 1612 x P 2511	17.57**	20.64**	-20.77**	-14.02*	-17.55**	-17.70**	6.63*	6.55*	6.06*	
35.	P 1612 x P 1509	-16.18*	-28.89**	-29.01**	-18.14**	-31.80**	-31.92**	7.10*	6.06*	-5.57	
36.	Basmati 370 x Pakistan Basmati	15.44	7.33	-57.03*	41.48*	28.60	-56.27**	7.47**	5.16	-4.26	
37.	Basmati 370 x Mahi Sugandha	-18.86	-38.90**	-58.45**	-11.87	-37.02**	-59.20**	2.84	-0.68	-3.33	
38.	Basmati 370 x P 2511	-40.40**	-59.10**	-62.21**	-35.93**	-58.24**	-61.73**	3.94	0.49	-2.91	
39.	Basmati 370 x P 1509	12.33	-16.06	-41.60*	14.95	-18.48	-45.79**	4.86	1.79	-7.84**	
40.	Pakistan Basmati x Mahi Sugandha	-30.76**	-45.00**	-62.60**	-17.95	-37.44**	-59.47**	1.09	-4.40	-4.34	
41.	Pakistan Basmati x P 2511	-12.02	-36.95**	-41.74**	-13.94	-41.00**	-45.94**	5.04	-0.56	0.21	
42.	Pakistan Basmati x P 1509	-10.62	-29.59**	-51.02*	-12.74	-34.06**	-56.15**	10.54**	5.07	-0.85	
43.	Mahi Sugandha x P 2511	-34.54**	-43.18**	-47.50**	-38.98**	-47.92**	-52.28**	2.96	2.85	-7.39*	
44.	Mahi Sugandha x P 1509	-22.12*	-23.00*	-46.43**	-25.51**	-26.48**	-51.10**	-3.42	-3.93	-5.78*	
45.	P 2511 x P 1509	-24.67**	-33.98**	-39.00**	-20.17**	-31.11**	-36.88**	-1.64	-2.06	-5.78*	

Table-1c : Estimation of relative heterosis, heterobeltiosis and standard heterosis for number of spikelets per panicle, 1000-Grain weight (g) and grain yield/ plant (g).

S. No.	Hybrids	Heterosis									
		No. of spikelets/ panicle					1000-Grain weight (g)				
		RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	SH
1.	P 1592 x P 1121	8.22	6.07	6.07	11.58**	4.13**	4.13**	4.75	2.49	2.49	2.49
2.	P 1592 x Pratap 1	6.62	6.26	2.72	0.51	-4.81**	-7.74**	9.92*	4.68	0.16	0.16
3.	P 1592 x Surabhi	5.39	3.85	-0.28	0.12	-0.83	-14.07**	13.52*	-3.06	-7.25	-7.25
4.	P 1592 x P 1612	-8.61	-13.61**	-6.85	7.28**	1.47	-1.41	7.85	7.32	2.69	2.69
5.	P 1592 x Basmati 370	10.70*	2.17	-1.90	4.19**	2.22	-7.95**	-6.43	-18.58**	-22.10**	-22.10**
6.	P 1592 x Pakistan Basmati	16.80**	-4.94	-8.72	0.35	-3.12	-9.82**	-3.26	-20.17**	-23.61**	-23.61**
7.	P 1592 x Mahi Sugandha	-3.95	-9.69	-13.28*	2.65	-2.28	-6.32**	13.12**	4.95	0.42	0.42
8.	P 1592 x P 2511	11.11*	14.02**	-10.53	9.12**	4.59**	-1.16	13.08**	12.68*	7.81	7.81
9.	P 1592 x P 1509	-15.84**	-22.92**	-25.99**	5.35**	3.84**	-4.43**	17.37**	14.41*	-2.97	-2.97
10.	P 1121 x Pratap 1	-9.90*	-11.40*	-11.40*	-0.41	-1.94	-1.94	-2.05	-8.64	-8.64	-8.64
11.	P 1121 x Surabhi	-7.39	-10.53	-10.53	-5.68**	-12.76**	-12.76**	4.18	-12.63*	-12.63*	-12.63*
12.	P 1121 x P 1612	18.95**	14.63**	23.60**	-1.62	-3.01	-3.01	2.23	-0.45	-0.45	-0.45
13.	P 1121 x Basmati 370	17.17**	6.16	6.16	-0.47	-5.42**	-5.42**	8.52	-7.30	-7.30	-7.30
14.	P 1121 x Pakistan Basmati	-23.81**	-38.94**	-38.94**	-1.21	-4.62**	-4.62**	-10.08	-27.06**	-27.06**	-27.06**
15.	P 1121 x Mahi Sugandha	-16.86**	-23.29**	-23.29**	-1.69	-3.72*	-3.72*	-3.16	-11.95*	-11.95*	-11.95*
16.	P 1121 x P 2511	4.48	1.86	7.24	4.37**	1.50	1.50	10.40*	7.64	7.64	7.64
17.	P 1121 x P 1509	21.86**	9.59	9.59	4.47*	3.15*	-2.15	16.86**	-0.87	-0.87	-0.87
18.	Pratap 1 x Surabhi	8.38	6.44	2.90	2.38	-3.92*	-6.88**	-1.23	-11.97*	-23.80**	-23.80**
19.	Pratap 1 x Basmati 370	7.15	-1.42	-4.70	5.22**	5.09**	2.11	11.00*	6.20	0.63	0.63
20.	Pratap 1 x Pakistan Basmati	9.63	-11.01*	-13.97*	0.25	-1.73	-4.75**	1.82	-12.48*	-15.89**	-15.89**
21.	Pratap 1 x Mahi Sugandha	-18.65**	-23.76**	-26.29**	0.67	0.12	-2.95	8.03	5.09	-9.03	-9.03
22.	Pratap 1 x P 2511	10.02*	13.70**	-9.14	-0.55	-1.79	-4.81**	18.88**	13.60**	7.92	7.92
23.	Pratap 1 x P 1509	-8.81	-16.74**	-19.51**	2.92*	1.78	-1.35	-4.88	-14.17*	-25.70**	-25.70**
24.	Surabhi x P 1612	-9.47*	-15.61**	-9.00	6.37**	-0.29	-3.12*	16.63**	12.00*	-5.24	-5.24
25.	Surabhi x Basmati 370	6.13	-0.70	-7.44	9.06**	6.00**	-4.55**	0.68	-1.53	-30.25**	-30.25**
26.	Surabhi x Pakistan Basmati	9.14	-10.15	-16.24**	0.64	-3.73*	-10.38**	2.66	-1.50	-33.29**	-33.29**
27.	Surabhi x Mahi Sugandha	3.49	-1.33	-8.02	-0.38	-6.03**	-9.91**	3.88	-5.08	-22.30**	-22.30**
28.	Surabhi x P 2511	-0.54	-6.24	-1.29	1.73	-3.39*	-8.69**	18.19**	1.23	-3.83	-3.83
29.	Surabhi x P 1509	6.62	-1.01	-7.73	3.69*	-1.66	-6.79**	11.54	10.00	-23.39**	-23.39**
30.	P 1612 x Basmati 370	-9.19	-20.40**	-14.16**	0.64	-3.04	-5.79**	-10.54*	-21.83**	-25.93**	-25.93**
31.	P 1612 x Pakistan Basmati	22.70**	-4.35	3.13	-1.11	-3.19	-5.93**	16.25**	-3.70	-8.75	-8.75
32.	P 1612 x Mahi Sugandha	-2.20	-12.76*	-5.94	-0.60	-1.26	-4.06*	-2.87	-9.48	-14.23**	-14.23**
33.	P 1612 x P 2511	2.28	1.07	8.98	4.63**	3.20	0.27	12.21**	12.06*	6.47	6.47
34.	P 1612 x P 1509	3.88	-9.59	-2.51	-0.44	-1.67	-4.45**	16.81**	1.34	-3.98	-3.98
35.	Basmati 370 x Pakistan Basmati	12.59	-1.93	-20.35**	0.11	-1.52	-8.33**	11.00	4.26	-26.14**	-26.14**
36.	Basmati 370 x Mahi Sugandha	-2.09	-4.01	-18.85**	0.48	-2.56	-6.59**	-5.77	-12.11*	-28.05**	-28.05**
37.	Basmati 370 x P 2511	-4.72	-15.61**	-11.15*	-0.13	-2.49	-7.84**	12.66*	-1.67	-6.58	-6.58
38.	Basmati 370 x P 1509	15.66**	14.70*	-6.85	-0.36	-2.84	-7.91**	-1.70	-2.52	-30.95**	-30.95**
39.	Pakistan Basmati x Mahi Sugandha	-15.49*	-27.62**	-38.81**	-3.28*	-4.68**	-8.62**	-0.45	-12.39*	-28.28**	-28.28**
40.	Pakistan Basmati x P 2511	-23.26**	-39.67**	-36.48**	0.71	-0.05	-5.54**	6.69	-11.71*	-16.12**	-16.12**
41.	Pakistan Basmati x P 1509	-17.53**	-27.64**	-42.21**	2.51	1.60	-3.71*	6.02	0.37	-30.09**	-30.09**
42.	Mahi Sugandha x P 2511	-29.29**	-36.26**	-32.89**	-0.08	-0.79	-4.89**	1.86	-5.19	-9.92*	-9.92*
43.	Mahi Sugandha x P 1509	-2.16	-4.86	-19.57**	1.21	0.64	-3.52*	-3.28	-10.49	-26.73**	-26.73**
44.	P 2511 x P 1509	-1.49	-13.38**	-8.81	2.09	1.94	-3.38*	13.49**	-1.65	-6.57	-6.57

S. No.	Hybrids	Heterosis								
		Hulling (%)			Milling (%)			HRR (%)		
		RH	Hb	SH	RH	Hb	SH	RH	Hb	SH
1.	P 1592 x P 1121	2.36	0.36	4.43*	1.37	0.70	2.06	6.90**	6.84**	6.84**
2.	P 1592 x Pratap 1	-1.50	-2.28	1.68	-0.34	-1.30	0.03	6.08**	3.65*	8.50**
3.	P 1592 x Surabhi	4.48**	3.57*	7.77**	-0.24	-0.79	1.67	5.67**	2.76	8.61**
4.	P 1592 x P 1612	1.34	0.76	4.84**	3.27	2.24	3.62	8.96**	7.98**	9.83**
5.	P 1592 x Basmati 370	3.41*	2.32	6.47**	3.64	3.13	4.52	5.45**	4.00*	6.81**
6.	P 1592 x Pakistan Basmati	3.14*	2.88	7.05**	6.19**	5.02*	6.44**	6.16**	4.58**	7.65**
7.	P 1592 x Mahi Sugandha	0.09	-0.49	3.55*	2.65	0.54	1.89	5.84**	5.52**	5.39**
8.	P 1592 x P 2511	0.46	0.34	4.66**	2.98	1.82	3.19	6.50**	3.82*	9.19**
9.	P 1592 x P 1509	1.37	-0.19	3.85*	4.67*	0.68	2.04	6.61**	5.57**	7.54**
10.	P 1121 x Pratap 1	0.73	-0.45	1.95	0.79	0.48	0.48	5.50**	3.14	7.98**
11.	P 1121 x Surabhi	3.97**	2.83	5.13**	2.12	0.88	3.39	5.03**	2.20	8.02**
12.	P 1121 x P 1612	2.61*	3.52*	0.81	-0.04	-0.37	-0.37	5.09**	4.21*	5.99**
13.	P 1121 x Basmati 370	2.32	1.39	3.27	4.83*	4.65*	2.00	6.71**	5.31**	8.15**
14.	P 1121 x Pakistan Basmati	2.47*	-0.26	4.25*	2.51	2.06	2.06	6.74**	5.22**	8.31**
15.	P 1121 x Mahi Sugandha	-0.28	-1.66	1.13	0.41	-1.01	-1.01	0.16	-0.21	-0.21
16.	P 1121 x P 2511	1.44	-0.66	3.62*	1.36	0.88	0.88	0.57	-1.90	3.17
17.	P 1121 x P 1509	-1.18	-1.60	-0.75	-0.40	-3.57	-3.57	0.47	-0.45	1.40
18.	Pratap 1 x Surabhi	3.20*	3.11	5.60**	3.80	2.24	4.78*	0.19	-0.28	5.39**
19.	Pratap 1 x P 1612	1.25	1.03	3.92*	3.75	3.72	3.09	0.85	-0.58	4.07*
20.	Pratap 1 x Basmati 370	2.85*	2.57	5.04**	4.31*	3.81	4.17	0.17	-0.78	3.87*
21.	Pratap 1 x Pakistan Basmati	2.46	1.92	5.50**	4.83*	4.69	4.05	0.69	-0.15	4.53**
22.	Pratap 1 x Mahi Sugandha	1.66	1.44	4.33*	5.22*	4.05	3.42	-0.28	-2.86	1.69
23.	Pratap 1 x P 2511	1.41	0.49	4.82**	4.70*	4.53	3.89	-0.33	-0.56	4.58**
24.	Pratap 1 x P 1509	1.51	0.74	3.17	6.11**	3.03	2.40	1.29	-0.08	4.61**
25.	Surabhi x P 1612	2.96*	2.64	5.58**	4.67*	3.06	5.63*	3.32*	1.38	7.15*
26.	Surabhi x Basmati 370	5.07**	4.87**	7.22**	5.01*	3.91	6.49**	6.08**	4.58**	10.53**
27.	Surabhi x Pakistan Basmati	4.02**	3.38*	7.01**	5.53**	3.79	6.37**	4.26**	2.90	8.76**
28.	Surabhi x Mahi Sugandha	2.99*	2.69	5.61**	4.52*	1.81	4.34	10.02**	6.68**	12.75**
29.	Surabhi x P 2511	1.35	0.34	4.66**	3.00	1.27	3.79	5.69**	5.43**	11.43**
30.	Surabhi x P 1509	2.52	1.83	4.11*	7.27**	2.63	5.18*	7.18**	5.23**	11.22**
31.	P 1612 x Basmati 370	5.11**	4.60**	7.59**	6.66**	6.13*	6.49**	9.47**	8.95**	11.88**
32.	P 1612 x Pakistan Basmati	2.50	1.78	5.35**	5.04*	4.92*	4.22	6.57**	5.94**	9.05**
33.	P 1612 x Mahi Sugandha	2.53	2.52	5.45**	6.76**	5.60*	4.90*	11.39**	10.05**	11.94**
34.	P 1612 x P 2511	2.43	1.72	6.11**	5.81**	5.67*	4.97*	8.24**	6.46**	11.96**
35.	P 1612 x P 1509	1.75	0.76	3.65*	7.88**	4.77*	4.08	9.43**	9.35**	11.38**
36.	Basmati 370 x Pakistan Basmati	3.16*	2.34	5.93**	4.56*	3.92	4.28	7.73**	7	

Table-1e : Estimation of relative heterosis, heterobeltiosis and standard heterosis for kernel length (mm), kernel breadth (mm) and kernel length-breadth ratio.

S. No.	Hybrids	Heterosis									
		Kernel length (mm)					Kernel breadth (mm)				
		RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	L/B ratio
1.	P 1592 x P 1121	4.91	1.48	1.48	-2.74	-1.43	-1.43	7.78**	2.90	2.90	
2.	P 1592 x Pratap 1	7.72**	2.71	-4.01	4.65*	5.49*	6.62**	2.94	-1.12	-10.07**	
3.	P 1592 x Surabhi	4.41	-0.38	-6.90*	0.09	0.70	3.40	4.25	-1.20	-10.14**	
4.	P 1592 x P 1612	17.31**	15.19**	11.69**	5.42*	5.79*	7.87**	11.18**	8.77*	3.41	
5.	P 1592 x Basmati 370	6.53*	-1.75	-8.18**	6.58**	7.43**	8.59**	-0.04	-7.17*	-15.58**	
6.	P 1592 x Pakistan Basmati	7.76**	5.63	-1.29	0.52	1.92	4.65	7.09*	3.51	-5.87	
7.	P 1592 x Mahi Sugandha	12.45**	10.30**	3.08	-3.60	0.17	2.86	16.39**	10.04**	0.07	
8.	P 1592 x P 2511	8.21**	6.64*	2.65	-2.67	-0.55	-2.15	10.73**	6.64*	4.71	
9.	P 1592 x P 1509	19.29**	18.33**	12.39**	12.89**	15.25**	13.60**	5.77	2.86	-1.01	
10.	P 1121 x Pratap 1	13.22**	4.60	4.60	9.96**	10.55**	10.55**	2.84	-5.51	-5.51	
11.	P 1121 x Surabhi	11.59**	3.16	3.16	-0.88	1.07	1.07	12.54**	2.10	2.10	
12.	P 1121 x P 1612	12.46**	10.75**	10.75**	0.97	1.97	1.97	11.22**	8.48*	8.48*	
13.	P 1121 x Basmati 370	19.53**	6.93*	6.93*	-3.91	-3.40	-3.40	24.19**	10.51**	10.51**	
14.	P 1121 x Pakistan Basmati	10.90**	5.22	5.22	-2.87	-0.18	-0.18	13.99**	5.36	5.36	
15.	P 1121 x Mahi Sugandha	7.55**	2.10	2.10	-7.47**	-2.50	-2.50	15.45**	4.49	4.49	
16.	P 1121 x P 2511	10.48**	8.41**	8.41**	-0.09	0.73	-0.89	10.20**	9.20**	9.20**	
17.	P 1121 x P 1509	13.13**	10.28**	10.28**	1.08	1.81	0.36	11.82**	9.71**	9.71**	
18.	Pratap 1 x Surabhi	11.64**	11.56**	-5.30	3.66	5.13*	6.26*	7.63*	6.14	-11.09**	
19.	Pratap 1 x P 1612	18.80**	11.33**	7.95**	8.37**	8.85**	10.02**	9.64**	3.12	-1.96	
20.	Pratap 1 x Basmati 370	24.56**	20.27**	1.95	9.03**	9.03**	10.20**	14.25**	10.29**	-7.61*	
21.	Pratap 1 x Pakistan Basmati	12.99**	9.85**	-1.40	4.07*	6.37**	7.51**	8.55*	7.86*	-8.48*	
22.	Pratap 1 x Mahi Sugandha	17.29**	13.96**	2.42	1.35	6.19*	7.33**	15.66**	13.75**	-4.71	
23.	Pratap 1 x P 2511	10.26**	3.68	-0.19	9.42**	10.91**	9.12**	0.36	-7.01*	-8.70**	
24.	Pratap 1 x P 1509	17.47**	11.16**	5.57	15.95**	17.42**	15.74**	1.21	-5.35	-8.91**	
25.	Surabhi x P 1612	6.34*	-0.28	-3.31	5.82**	6.84**	8.94**	0.41	-6.78	-11.38**	
26.	Surabhi x Basmati 370	28.56**	24.05**	5.30	6.11**	7.61**	8.77**	21.27**	18.68**	-3.33	
27.	Surabhi x Pakistan Basmati	11.84**	8.81**	-2.34	-1.11	-0.34	3.58	13.20**	10.93**	-5.87	
28.	Surabhi x Mahi Sugandha	12.97**	9.84**	-1.29	-5.33**	-2.24	1.61	19.36**	19.04**	-3.04	
29.	Surabhi x P 2511	9.38**	2.91	-0.93	5.22*	8.18**	6.44**	3.51	-5.31	-7.03*	
30.	Surabhi x P 1509	12.71**	6.73*	1.36	17.49**	20.69**	18.96**	-4.32	-11.67**	-15.00**	
31.	P 1612 x Basmati 370	26.87**	15.07**	11.57**	9.43**	9.91**	11.09**	15.91**	5.49	0.29	
32.	P 1612 x Pakistan Basmati	14.58**	10.33**	6.97*	4.66*	6.49**	8.59**	9.38**	3.51	-1.59	
33.	P 1612 x Mahi Sugandha	7.09*	3.17	0.04	1.93	6.32**	8.41**	4.77	-2.97	-7.75*	
34.	P 1612 x P 2511	12.30**	11.89**	8.49**	10.18**	12.18**	10.38**	1.54	-0.07	-1.88	
35.	P 1612 x P 1509	-0.47	-1.49	-4.48	20.61**	22.69**	20.93**	-17.65**	-18.15**	-21.23**	
36.	Basmati 370 x Pakistan Basmati	3.56	-2.69	-12.66**	4.07*	6.37**	7.51**	-0.31	4.36	-18.84**	
37.	Basmati 370 x Mahi Sugandha	5.89	-0.56	-10.63**	1.69	6.55**	7.69**	4.19	2.24	-17.17**	
38.	Basmati 370 x P 2511	4.87	-4.57	-8.14**	10.31**	11.82**	10.02**	-5.39	-15.13**	-16.67**	
39.	Basmati 370 x P 1509	2.87	-5.82	-10.56**	17.56**	19.06**	17.35**	-12.40**	-20.71**	-23.70**	
40.	Pakistan Basmati x Mahi Sugandha	14.08**	14.00**	2.45	-5.38**	-3.05	2.33	20.49**	17.76**	-0.07	
41.	Pakistan Basmati x P 2511	8.02**	4.37	0.47	4.91*	8.73**	6.98**	2.45	-4.50	-6.23	
42.	Pakistan Basmati x P 1509	17.88**	14.64**	8.88**	11.13**	15.06**	13.42**	5.88	-0.38	-4.13	
43.	Mahi Sugandha x P 2511	11.72**	8.01**	3.97	0.43	6.73**	5.01*	10.39**	0.74	-1.09	
44.	Mahi Sugandha x P 1509	1.54	-1.19	-6.16*	10.43**	17.24**	15.56**	-8.42**	-15.66**	-18.84**	
45.	P 2511 x P 1509	14.77**	14.00**	9.74**	21.71**	21.82**	19.86**	-5.93*	-6.86*	-8.55*	

Table-2 : Estimation of relative heterosis, heterobeltiosis and standard heterosis for kernel length after cooking (mm), elongation ratio and amylose content (%).

S. No.	Hybrids	Heterosis														
		Kernel length after cooking (mm)					Elongation ratio			Amylosecontent (%)						
		RH	Hb	SH	RH	Hb	SH	RH	Hb	SH	RH	Hb	SH			
1.	P 1592 x P 1121	18.02**	19.69*	-9.69	-6.71	-11.37	-11.37	-6.71	-11.37	-11.37	1.72	-0.80	4.37**			
2.	P 1592 x Pratap 1	-18.43**	-21.98**	-34.19**	-24.19**	-24.32**	-31.64**	-24.19**	-24.32**	-31.64**	0.21	-2.99*	9.05**			
3.	P 1592 x Surabhi	-13.44*	-15.85*	-29.02**	-17.32**	-18.88**	-24.12**	-17.32**	-18.88**	-24.12**	2.07	-1.37	11.27**			
4.	P 1592 x P 1612	2.33	-0.70	-10.97	-12.65*	-13.67*	-20.43**	-12.65*	-13.67*	-20.43**	4.06**	2.62	11.05**			
5.	P 1592 x Basmati 370	-4.64	-17.41*	-30.34**	-9.69	-15.70*	-24.12**	-9.69	-15.70*	-24.12**	0.40	-0.24	4.97**			
6.	P 1592 x Pakistan Basmati	-5.30	-19.14*	-31.80**	-11.90	-23.55**	-31.18**	-11.90	-23.55**	-31.18**	-0.76	-1.83	3.29			
7.	P 1592 x Mahi Sugandha	-9.64	-12.62	-26.30**	-19.58**	-20.82**	-28.73**	-19.58**	-20.82**	-28.73**	2.38	1.38	8.79**			
8.	P 1592 x P 2511	-5.36	-12.32	-26.05**	-12.79*	-20.31**	-28.26**	-12.79*	-20.31**	-28.26**	0.77	-0.51	7.40**			
9.	P 1592 x P 1509	20.03**	12.00	-5.53	0.55	-7.00	-16.28**	0.55	-7.00	-16.28**	2.66*	-0.57	11.64**			
10.	P 1121 x Pratap 1	-16.10**	-25.74**	-25.74**	-25.75**	-29.34**	-29.34**	-25.75**	-29.34**	-29.34**	5.24**	-0.57	11.77**			
11.	P 1121 x Surabhi	-4.39	-14.12*	-14.12*	14.29**	14.05**	-17.05**	14.29**	14.05**	-17.05**	14.56**	2.87*	-0.58			
12.	P 1121 x P 1612	-1.10	-6.22	-6.22	12.07*	15.51**	-15.51**	12.07*	15.51**	-15.51**	0.78	-3.04	4.92**			
13.	P 1121 x Basmati 370	15.34*	-6.72	-6.72	-2.16	-12.90*	-12.90*	-2.16	-12.90*	-12.90*	-1.53	-3.37*	0.39			
14.	P 1121 x Pakistan Basmati	18.18**	-18.41**	-18.41**	13.21*	-22.89**	-22.89**	13.21*	-22.89**	-22.89**	-6.27**	-7.61**	14.89**			
15.	P 1121 x Mahi Sugandha	-12.23*	-21.55**	-21.55**	-18.62**	-23.81**	-23.81**	-18.62**	-23.81**	-23.81**	5.36**	1.48	9.55**			
16.	P 1121 x P 2511	7.33	-7.73	-7.73	-2.82	-15.21*	-15.21*	-2.82	-15.21*	-15.21*	1.05	-2.39	4.74**			
17.	P 1121 x P 1509	15.44*	-0.11	-0.11	2.35	-9.68	-9.68	2.35	-9.68	-9.68	2.08	-3.50*	8.35**			
18.	Pratap 1 x Surabhi	-5.45	-7.01	-25.94**	-15.12**	-16.58**	-21.97**	-15.12**	-16.58**	-21.97**	3.22*	3.04*	16.24**			
19.	Pratap 1 x P 1612	2.05	-5.14	-14.95*	-13.80*	-14.67*	-21.35**	-13.80*	-14.67*	-21.35**	2.26	0.36	12.81**			
20.	Pratap 1 x Basmati 370	19.49*	7.65	-17.10**	-3.47	-10.03	-18.74**	-3.47	-10.03	-18.74**	2.21	-1.66	10.54**			
21.	Pratap 1 x Pakistan Basmati	-6.81	-17.29*	-36.30**	-17.76**	-28.74**	-35.64**	-17.76**	-28.74**	-35.64**	5.06**	0.63	13.12**			
22.	Pratap 1 x Mahi Sugandha	-9.20	-10.22	-29.27**	-22.49**	-23.81**	-31.18**	-22.49**	-23.81**	-31.18**	-2.56	-4.50**	7.35**			
23.	Pratap 1 x P 2511	-4.18	-7.35	-28.64**	-13.51*	-21.09**	-28.73**	-13.51*	-21.09**	-28.73**	5.88**	3.48*	16.33**			
24.	Pratap 1 x P 1509	18.71**	15.67	-10.92	0.92	-6.80	-15.82**	0.92	-6.80	-15.82**	5.06**	5.00**	18.03**			
25.	Surabhi x P 1612	-0.02	-5.61	-15.37*	-6.04	-6.73	-12.75*	-6.04	-6.73	-12.75*	2.12	0.04	12.86**			
26.	Surabhi x Basmati 370	36.45**	21.13**	-3.53	6.36	-2.46	-8.76	6.36	-2.46	-8.76	3.75**	-0.35	12.41**			
27.	Surabhi x Pakistan Basmati	8.60	-5.00	-24.34**	-3.27	-17.41**	-22.73**	-3.27	-17.41**	-22.73**	3.53**	-1.00	11.68**			
28.	Surabhi x Mahi Sugandha	-0.16	-0.70	-20.92**	-11.81*	-14.78*	-20.28**	-11.81*	-14.78*	-20.28**	1.14	-1.04	11.64**			
29.	Surabhi x P 2511	2.19	-2.76	-22.55**	-7.31	-16.75**	-22.12**	-7.31	-16.75**	-22.12**	1.60	-0.88	11.82**			
30.	Surabhi x P 1509	20.30**	15.34	-8.14	6.23	-3.45	-9.68	6.23	-3.45	-9.68	-1.30	-1.54	11.08**			
31.	P 1612 x Basmati 370	34.09**	13.22	1.51	6.50	-1.67	-9.37	6.50	-1.67	-9.37	1.10	-0.92	7.22**			
32.	P 1612 x Pakistan Basmati	17.83*	-6.85	-16.48**	-1.84	-15.67*	-22.27**	-1.84	-15.67*	-22.27**	0.48	-1.97	6.08**			
33.	P 1612 x Mahi Sugandha	-7.85	-13.44	-22.39**	-13.53*	-15.83*	-22.43**	-13.53*	-15.83*	-22.43**	0.96	0.84	9.12**			
34.	P 1612 x P 2511	8.94	-1.83	-11.98	-3.04	-12.33	-19.20**	-3.04	-12.33	-19.20**	2.66*	2.23	10.63**			
35.	P 1612 x P 1509	4.13	-5.51	-15.28*	4.92	-4.00	-11.52	4.92	-4.00	-11.52	2.61*	0.75	13.12**			
36.	Basmati 370 x Pakistan Basmati	12.01	10.15	-31.98**	7.35	-0.79	-22.58**	7.35	-0.79	-22.58**	2.58	2.11	6.08**			
37.	Basmati 370 x Mahi Sugandha	0.96	-9.95	-29.06**	-4.28	-9.33	-20.89**	-4.28	-9.33	-20.89**	5.11**	3.13*	11.33**			
38.	Basmati 370 x P 2511	15.27	7.11	-22.95**	11.96*	16.01*	-16.90**	11.96*	16.01*	-16.90**	-0.93	-2.51	4.61**			
39.	Basmati 370 x P 1509	21.14**	11.76	-18.34**	17.50**	16.34*	-9.22	17.50**	16.34*	-9.22	4.79**	0.87	13.26**			
40.	Pakistan Basmati x Mahi Sugandha	5.22	-7.52	-27.15**	-7.71	-18.84**	-29.19**	-7.71	-18.84**	-29.19**	-5.25**	-7.45**	-0.09			
41.	Pakistan Basmati x P 2511	0.29	-8.24	-33.99**	-6.77	-11.96	-34.41**	-6.77	-11.96	-34.41**	2.08	0.00	7.31**			
42.	Pakistan Basmati x P 1509	35.14**	22.78**	-10.29	14.96*	7.23	-17.97**	14.96*	7.23	-17.97**	-0.44	-4.58**	7.13**			
43.	Mahi Sugandha x P 2511	1.00	-3.38	-23.89**	-9.78	-16.37*	-27.04**	-9.78	-16.37*	-27.04**	0.75	0.45	8.44**			
44.	Mahi Sugandha x P 1509	-3.22	-6.72	-26.52**	-3.94	-9.86	-21.35**	-3.94	-9.86	-21.35**	0.47	-1.47	10.63**			
45.	P 2511 x P 1509	28.79**	27.79**	-6.63	12.51	11.04	-15.05*	12.51	11.04	-15.05*	-0.47	-2.67	9.28**			

(Basmati-370 × P-2511) to -5.47 % (P-1121 × P-2511). Five hybrids each for relative heterosis and heterobeltiosis, showed significantly positive value for this trait. The hybrid Basmati-370 × Pakistan Basmati showed highest significant positive relative heterosis. The hybrid, Pratap-1 × P-1612 were found highest positive significant heterosis over better parent. Similar results were also reported by Sharma and Jaiswal (2020) and Joshi (2011) in rice.

For panicle length, the relative heterosis varied from -4.86 % (Pratap-1 × Mahi Sugandha) to 12.04 % (Pratap-1 × Surabhi), heterobeltiosis ranged from -7.88 % (Pratap-1 × Mahi Sugandha) to 10.90 % (Pratap-1 × Surabhi) and standard heterosis ranged from -14.88 % (Surabhix Pakistan Basmati) to 4.46 % (P-1121 × Surabhi). Thirteen, three and seven hybrids showed significant positive relative heterosis, heterobeltiosis and standard heterosis, respectively for this trait. The hybrid Pratap-1 × Surabhi showed highest significant positive relative heterosis. The hybrids Pratap-1 × P-1612 were found highest positive significant heterobeltiosis. Similar results were also reported by Devi et al. (2017) and Sharma et al. (2013).

With regards to number of spikelets per panicle, the relative heterosis varied from -29.29 % (Mahi Sugandha × P-2511) to 22.70 % (P-1612 × Pakistan Basmati), heterobeltiosis ranged from -39.67 % (Pakistan Basmati × P-2511) to 14.70 % (Basmati-370 × P-1509) and standard heterosis ranged from -42.21 % (Pakistan Basmati × P-1509) to 23.60 % (P-1121 × P-1612). Nine, Four and one crosses expressed positive significant relative heterosis, heterobeltiosis and standard heterosis, respectively. Hybrid P-1612 × Pakistan Basmati recorded highest positive heterosis over mid parent. Hybrid Basmati-370 × P-1509 recorded highest positive heterosis over better parent. The hybrid P-1121 × P-1612 recorded significant positive standard heterosis. Similar results were also reported by Ambikabathy et al. (2019) and Thakor et al. (2018) in rice.

With regards to 1000-grain weight, the relative heterosis varied from -5.68 % (P-1121 × Surabhi) to 11.58 % (P-1592 × P-1121), heterobeltiosis ranged from -12.76 % (P-1121 × Surabhi) to 6.00 % (Surabhix Basmati-370) and standard heterosis ranged from -14.07 % (P-1592 × Surabhi) to 4.13 % (P-1592 × P-1121). Fourteen, seven and one hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. The hybrid P-1592 × P-1121 exhibited significantly highest positive relative heterosis as well as standard heterosis. The hybrids Surabhix Basmati-370, P-1592 × P-1121 and P-1592 × P-2511 exhibited highly significant positive heterobeltiosis. Similar results were recorded by Devi et al. (2017) and Sharma et al. (2013).

For grain yield per plant, the relative heterosis varied from -10.54 per cent (P-1612 × Basmati-370) to 18.88 per cent (Pratap-1 × P-2511), heterobeltiosis ranged from -27.06 per cent (P-1121 × Pakistan Basmati) to 14.41 per cent (P-1592 × P-1509) and standard heterosis ranged from -33.29 per cent (Surabhix Pakistan Basmati) to 7.92 per cent (Pratap-1 × P-2511). Hybrid Pratap-1 × P-2511 recorded highest positive heterosis over mid parent. Hybrids P-1592 × P-1509, Pratap-1 × P-2511, P-1592 × P-2511, P-1612 × P-2511 and Surabhix P-1612 recorded highest positive heterosis over better parent. The hybrid Pratap-1 × P-2511 recorded significant positive standard heterosis. Similar results were also reported by Ambikabathy et al. (2019) and Thakor et al. (2018) in rice.

For hulling percent, the relative heterosis varied from -1.50 per cent (P-1592 × Pratap-1) to 5.11 per cent (P-1612 × Basmati-370), heterobeltiosis ranged from -2.28 per cent (P-1592 × Pratap-1) to 4.87 per cent (Surabhix Basmati-370) and standard heterosis ranged from -0.75 per cent (P-1121 × P-1509) to 7.77 per cent (P-1592 × Surabhi). Fourteen, five and thirty-seven hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. The hybrid P-1612 × Basmati-370 exhibited significantly highest positive relative heterosis as well as standard heterosis. The hybrids Surabhix Basmati-370, P-1612 × Basmati-370, P-1592 × Surabhi, P-1121 × P-1612 and Surabhix Pakistan Basmati exhibited highly significant positive heterobeltiosis. Similar results were recorded by Sreelakshmi et al. (2019) and Devi et al. (2017).

For milling percentage, the relative heterosis varied from -0.40 % (P-1121 × P-1612) to 7.88 % (P-1612 × P-1509), heterobeltiosis ranged from -3.57 % (P-1121 × P-1509) to 6.13 % (P-1612 × Basmati-370) and standard heterosis ranged from -3.57 % (P-1121 × P-1509) to 6.49 % (Surabhix Basmati-370 and P-1612 × Basmati-370). Twenty-six, eight and ten hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. Hybrid P-1612 × P-1509 recorded highest positive heterosis over mid parent. Hybrids P-1612 × Basmati-370, P-1592 × Pakistan Basmati, P-1612 × Pakistan Basmati, P-1612 × Mahi Sugandha, P-1612 × P-2511, P-1612 × P-1509, P-1121 × Basmati-370 and Pakistan Basmati × P-2511 recorded highest positive heterosis over better parent. The hybrids Surabhix Basmati-370, P-1612 × Basmati-370, P-1592 × Pakistan Basmati, Pratap-1 × Surabhi, Surabhix P-1612, Surabhix Pakistan Basmati, Surabhi × P-1509, P-1612 × Basmati-370, P-1612 × Mahi Sugandha, P-1612 × P-2511 and Pakistan Basmati × P-2511 recorded significant positive standard heterosis. The results are in

akin with the findings of Sreelakshmi *et al.* (2019) and Devi *et al.* (2017).

For head rice recovery, the relative heterosis varied from -0.33 % (Pratap-1 × P-2511) to 11.39 % (P-1612 × Mahi Sugandha), heterobeltiosis ranged from -2.86 % (Pratap-1 × Mahi Sugandha) to 10.05 % (P-1612 × Mahi Sugandha) and standard heterosis ranged from -0.21 % (P-1121 × Mahi Sugandha) to 12.56 % (Basmati-370 × P-1509). Thirty-five hybrids showed significant positive heterosis over mid parent. Thirty hybrids showed significant positive heterosis over better parent. Forty-one hybrids showed significant positive heterosis over standard check. The present findings are in accordance with results reported by Sreelakshmi *et al.* (2019), Devi *et al.* (2017) and Sharma *et al.* (2013).

With regards to kernel length, the relative heterosis varied from -0.47 % (P-1612 × P-1509) to 28.56 % (Surabhix Basmati-370), heterobeltiosis ranged from -5.82 % (Basmati-370 × P-1509) to 24.05 % (Surabhix Basmati-370) and standard heterosis ranged from -12.66 % (Basmati-370 × Pakistan Basmati) to 12.39 % (P-1592 × P-1509). Thirty-seven hybrids showed significant positive heterosis over mid parent. Twenty-five hybrids showed significant positive heterosis over better parent. Twelve hybrids showed significant positive heterosis over standard check. The present findings are in accordance with results reported by Sharma and Jaiswal (2020), Gnanamalar and Vivekanandan (2013).

With regards to kernel breadth, the relative heterosis varied from -7.47 per cent (P-1121 × Mahi Sugandha) to 21.71 per cent (P-2511 × P-1509), heterobeltiosis ranged from -3.40 per cent (P-1121 × Basmati-370) to 22.69 per cent (P-1612 × P-1509) and standard heterosis ranged from -3.40 per cent (P-1121 × Basmati-370) to 20.93 per cent (P-1612 × P-1509). Three, eight and six hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. Hybrid P-1121 × Mahi Sugandha exhibited significantly highest negative relative heterosis and hybrid P-1121 × Basmati-370 exhibited highest negative heterobeltiosis and standard heterosis. The present findings are in accordance with results reported by Sreelakshmi *et al.* (2019), Parmar *et al.*, (2021) and Devi *et al.* (2017).

In respect to kernel length-breadth ratio, the relative heterosis varied from -17.65 per cent (P-1612 × P-1509) to 24.19 per cent (P-1121 × Basmati-370), heterobeltiosis ranged from -20.71 per cent (Basmati-370 × P-1509) to 19.04 per cent (Surabhix Mahi Sugandha) and standard heterosis ranged from -23.70 per cent (Basmati-370 × P-1509) to 10.51 per cent (P-1121 × Basmati-370). Twenty-four, fourteen and four hybrids showed significant and positive heterosis over mid parent, better parent and

standard check, respectively. The hybrids P-1121 × P-1612, P-1121 × Basmati-370, P-1121 × P-2511 and P-1121 × P-1509 showed highly significant positive standard heterosis. The present findings are in accordance with results reported by Sharma and Jaiswal (2020) and Devi *et al.* (2017).

With regards to kernel length after cooking, the relative heterosis varied from -18.43% (P-1592 × Pratap-1) to 36.45% (Surabhix Basmati-370), heterobeltiosis ranged from -25.74% (P-1121 × Pratap-1) to 27.79 % (P-2511 × P-1509) and standard heterosis ranged from -36.30 % (Pratap-1 × Pakistan Basmati) to 1.51 % (P-1612 × Basmati-370). Eleven, three and one hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. The Hybrid Surabhix Basmati-370 exhibited significantly highest positive relative heterosis, hybrids P-2511 × P-1509, Pakistan Basmati × P-1509 and Surabhix Basmati-370 exhibited significantly positive heterobeltiosis and hybrid P-1612 × Basmati-370 exhibited positive standard heterosis for this trait. The results are in akin with the findings of Sharma and Jaiswal (2020) and Devi *et al.* (2017).

With regards to elongation ratio, the relative heterosis varied from -25.75 % (P-1121 × Pratap-1) to 17.50 % (Basmati-370 × P-1509), heterobeltiosis ranged from -29.34 % (P-1121 × Pratap-1) to 16.34 % (Basmati-370 × P-1509) and standard heterosis ranged from -35.64 % (Pratap-1 × Pakistan Basmati) to -8.76 % (Surabhix Basmati-370). The hybrid Basmati-370 × P-1509 exhibited significantly highest positive relative heterosis as well as heterobeltiosis. Similar results were also reported by Sharma and Jaiswal (2020), Sreelakshmi *et al.* (2019) in rice.

For Amylose content, the relative heterosis varied from -6.56 per cent (P-1121 × Surabhito 5.88 per cent (Pratap-1 × P-2511), heterobeltiosis ranged from -11.87 per cent (P-1121 × Surabhi) to 5.00 per cent (Pratap-1 × P-1509) and standard heterosis ranged from -4.89 per cent (P-1121 × Pakistan Basmati) to 18.03 per cent (Pratap-1 × P-1509). Fifteen, five and forty-two hybrids showed significant and positive heterosis over mid parent, better parent and standard check, respectively. The hybrids Pratap-1 × P-1509, Pratap-1 × Surabhi, Pratap-1 × P-2511, P-1121 × Surabhi and Basmati-370 × Mahi Sugandha showed highly significant positive heterobeltiosis.

The present investigation concluded that sufficiently high magnitude of heterosis, heterobeltiosis and standard heterosis was observed in desired direction for most of the traits studied. The significant and desirable estimate of relative heterosis for grain yield per plant was registers

by the crosses P-1592 × Pratap-1, P-1592 × Surabhi, P-1592 × Mahi Sugandha, P-1592 × P-2511, P-1592 × P-1509, P-1121 × P-2511, P-1121 × P-1509, Pratap-1 × P-1612, Pratap-1 × P-2511, Surabhix P-1612, Surabhix P-2511, P-1612 × Pakistan Basmati, P-1612 × P-2511, P-1612 × P-1509, Basmati-370 × P-2511 and P-2511 × P-1509. The significant and positive heterobeltiosis for grain yield per plant was registered by the crosses P-1592 × P-2511, P-1592 × P-1509, Pratap-1 × P-2511, Surabhix P-1612, P-1612 × P-2511. According to *per se* performance and heterosis, the crosses Pratap-1 × P-2511, P-1592 × P-2511, P-1121 × P-2511, P-1612 × P-2511, Pratap-1 × P-1612, P-1592 × Mahi Sugandha and P-1592 × Pratap-1 were found best for heterosis breeding.

Acknowledgement

The authors are grateful to the Zonal Director Research, Dean, COA, Kota for providing all the facility in conducting the experiment at Agricultural Research Station, Ummedganj, Kota.

References

1. Ambikabathy A., Banumathy S., Gnanamalar R.P., Arunachalam P., Jeyaprakash P., Amutha R. and Venkatraman N.S. (2019). Heterosis and combining ability for yield and yield attributing traits in rice. *Electronic Journal of Plant Breeding*, 10(3): 1060-1066.
2. Anonymous (2019-20). Rajasthan Agricultural Statistics at Glance. *Commissionerate of Agriculture Rajasthan-Jaipur*, pp.1.
3. Anonymous (2020). Pocket Book of Agricultural Statistics at Glance 2020. *Department of Agriculture, co-operation and farmer welfare, Directorate of economics and statistics. Government of India*. pp.24-31.
4. Devi A., Kumari P., Dwivedi R., Dwivedi S., Verma O.P., Singh P.K. and Dwivedi D.K. (2017). Studies on heterosis and combining ability in rice (*Oryza sativa* L.) for morpho-physiological traits under normal and saline conditions. *Int. J. Curr. Microbiol. App. Sci.*, 6(8): 1558-1571.
5. Dharwal G., Verma O.P. and Verma G.P. (2017). Combining ability analysis for grain yield and other associated traits in rice. *Indian Journal of Pure & Applied Biosciences*, 5(2): 96-100.
6. Dhillon S.K., Tiwana U.S. and Jagandeep Singh (2021). Comparison of nitrogen application with leaf color chart and conventional method in basmati rice (*Oryza sativa* L.). *Progressive Research : An International Journal*, 16(1): 27-29.
7. Griffing B. (1956). A general treatment of the use of diallel cross in quantitative inheritance. *Heredity*, 10: 31-50.
8. Joshi B.K. (2011). Heterosis for yield and yield components in rice. *Nepal Agric. Res. J.*, 4 (5): 2000-2001.
9. Parmar J.G., Javia R.M., Sharma L.K., Vala J.P., Nayee S.J. and Singh S.P. (2021). Character association and path coefficient analysis in blackgram [*Vigna mungo* (L.) hepper] during summer season. *Progressive Research : An International Journal*, 16(2): 115-119.
10. Saidaiah P., Ramesha M.S. and Kumar S. (2012). Evaluation of CMS system based rice hybrids for heterosis over locations. *Oryza*, 49(3): 153-162.
11. Sharma A. and Jaiswal H.K. (2020). Heterosis for yield and grain quality parameters in basmati rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 11(4): 1106-1115.
12. Sharma S.K., Singh S.K., Nandan R., Sharma A., Kumar R., Kumar V. and Singh M.K. (2013). Estimation of heterosis and inbreeding depression for yield and yield related traits in rice (*Oryza sativa* L.). *Mol. Plant Breeding*, 4(29): 238-246.
13. Singh V., Dwivedi D.K., Khan N.A., Verma R.L., Kumar M., Jena D., Rout D., Arsode P. and Samantaray S. (2020). Combining ability analysis for yield and contributing traits in short duration rice (*Oryza sativa* L.). *Oryza*, 57(4): 271-276.
14. Thakor R.P., Balat J.R., Delvadiya I.R. and Rathva S.R. (2018). Heterosis and heterobeltiosis studies for grain yield and yield attributing traits in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 9(4): 1286-1294.
15. Vadivel K., Anitha V.Y. and Saravanan K.R. (2018). Studies on combining ability and heterosis in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, 9(3): 1115-1121.



Legume Intercrops in Fruit Based Agroforestry System of Coastal Odisha

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Abstract

A field experiment was conducted during 2020 and 2021 at the Agroforestry Research Station under the All India Co-ordinated Research Project on Agroforestry, O.U.A.T., Bhubaneswar. The experiment was consisted in RBD with 16 treatment combinations including 12 fruit based intercropping systems are comprised of three fruit species i.e. mango (*Mangifera indica* L.), jackfruit (*Artocarpous heterophyllus* L.) and cashewnut (*Anacardium occidentale* L.) which were 5 year old and four legume crops i.e. arhar, cluster bean, blackgram and cowpea and its four sole crops. Soil moisture content is not significantly differ with each other, however among the intercrops higher soil moisture content was observed with cluster bean followed by blackgram, arhar and cowpea irrespective of fruit tree associated and among the fruit trees higher soil moisture was recorded with mango followed by jackfruit and cashew nut irrespective of the associated intercrops throughout the cropping season. The maximum available nitrogen was observed in mango + blackgram (250.2 kg ha⁻¹) followed by mango + cowpea (243 kg ha⁻¹). However the maximum available phosphorous content was observed in under mango + clusterbean system (64.3 kg ha⁻¹) followed by jackfruit + clusterbean system (57.6 kg ha⁻¹) and the maximum available potassium content was observed in under mango + cowpea system (167.1 kg ha⁻¹) followed by jackfruit + cowpea system (164.1 kg ha⁻¹). Out of jackfruit based intercrops the maximum tree height was recorded in jackfruit + cowpea (8.09 m), out of mango based intercrops mango+ cowpea (3.92 m) and out of Cashewnut based intercrops cashewnut + cowpea (4.27 m) at 66 months. The maximum collar girth was recorded with cashewnut (73 cm) in cashewnut + blackgram followed by jackfruit + cowpea (69.35 cm). However maximum crown spread observed with cashewnut (7.69 m) in Cashewnut + blackgram system followed by cashewnut + cowpea (6.49 m). Sole crops were performing better in all legume but when we considered economics of combination cashewnut + arhar contributed significantly maximum gross return (Rs.73060 ha⁻¹) over others, as well as the maximum net return was obtained from cashewnut + arhar (Rs. 51060 ha⁻¹). Similarly the cashewnut + arhar system the B: C ratio was found to be highest (3.32) as compared to its controlled condition.

Key words : Legume intercrops, fruit crops, soil moisture, available NPK, growth performance of legume and fruit trees, yield and economics.

Introduction

Agricultural production in red acidic uplands soil of Odisha under rainfed condition is unstable and unproductive. The different intensities of cyclones, droughts and floods occur almost every year in most of the coastal districts. The irregularities of monsoon behaviour and cyclone greatly affect the overall production potential. Some alternate land-use systems for these uplands for the enrichment of soil fertility and enhance productivity are suggested. Fruit trees inter-cropped with legume being an alternative land-use system that integrates the cultivation of arable crops, fruit trees and silvi component. Legume crops are playing important role in the initial growth years of trees and fruit plants that provide nitrogen to the fruit tree. Because there is less competition for natural resources such as sunlight, moisture, air, and nutrients, so different cropping sequences have been verified for yielding a higher level of production by growing different crops that can be grown successfully underneath fruit plants and trees in their early stages of growth. (7)

Keeping these all facts in view, an experiment was

conducted to analyze the performance of legume intercrops, their nutrient enrichment status under a fruit-based agroforestry system for rainfed uplands agro-ecological situations of coastal Odisha.

Materials and Methods

The research site is situation in the Agroforestry Research Station of O.U.A.T., Bhubaneswar that is located at 20 ° 15 ' North longitude and 85 ° 52 ' East latitude with an altitude of 25.9 meter MSL. The area comes under tropical hot and humid climate, with rainfall of 1472 mm, average maximum temperature of 32.7° C and minimum temperature of 25.2° C. Tillage operation was done by a power tiller drawn Cultivator to prepare the field, followed by two cross-harrowing to pulverise the soil. After harrowing, well-rotten FYM was applied, well-mixed with the soil by planking, and levelled the soil. The texture of the soil is sandy loam. Before starting the experiment, soil samples were taken from a depth of 0-15 cm, on using all of the recommended soil sampling protocols. This experiment was started in 2015 *kharif* season under AICRP project and this is the sixth year of

Agri-horticultural system. Also in previous years legume intercrop was grown in this site. In this study the intercrops were sown in respective plots where it was grown during 2019 with the existing fruit crops. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The experiment was consisted of 16 treatment combinations involving three fruit crops along with four legume intercrops. Three fruit tree species such as *Magnifera indica* L. (Mango), *Anacardium occidentale* L. (Cashewnut), *Artocarpous heterophyllus* L. (Jackfruit) and four intercrops are *Cajanus cajan* L. (Arhar), *Cyamopsis tetragonoloba* (Cluster bean), *Vigna mungo* L. (Blackgram), *Vigna unguiculata* L. (Cowpea) were grown in *kharif* season of 2020 and 2021. Four intercrops i.e. Arhar (Variety- *Asha*), Cowpea (Variety- *Utkal manik*), Cluster bean (Variety- HG-563), Black gram (Variety- OBGG-17), raise during the *kharif* season with a recommended spacing and package of practices. The fruit trees such as jack fruit (Variety- *Daspalla local*), mango (Variety- *Arka Neelachal Keshari*), and cashewnut (Variety- *Jagannath*), were raised in 2015 by transplanting of fruit seedlings at spacing of 8 m × 7.5 m with recommended package of practices. The proper plant protection technique was followed for managing the ill effects of weeds, pests, and diseases on the growth of fruit trees and legume intercrops. The mango, jackfruit, and Cashewnut plant heights were measured by the Nickon hypsometer from convenient distance vertically from ground level to the tip of the leading crown. By using a measuring tape and calliper, the collar girth of individual trees was measured. The collar girth was measured at 15 cm above the soil surface. The crown spread was recorded at 12 pm noon by using shadow of crown. Crown width taken in east - west direction as well as north – south direction for taking mean of both direction. The soil samples from each treatment were collected from 0 to 15 cm depth before sowing and after harvest of each season crop. The collected samples were shade dried followed by grinding and sieving (2 mm mesh sieve) of the samples, which were kept in polythene bags for analysis of soil fertility status. The soil available N, P and K were estimated by following standard methods. On gravimetric technique, soil samples were taken in moisture boxes, one at 0-15 cm and the other at 15-30 cm for estimating the soil moisture content. The percentage of soil moisture content was calculated by using the formula :

Soil moisture content (%)

$$= \frac{\text{Fresh weight} - \text{dry weight}}{\text{Dry weight}} \times 100$$

The yield of fruit tree and legumes intercrop were recorded time to time from each plot, and at the end of each season, the total yield was calculated and converted

to yield per hectare. An economic analysis was conducted in order to compare the profitability of various treatments. The benefit cost ratio was computed by dividing the gross return by the cost of cultivation. The experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as outlined by (6).

Results and Discussion

Soil moisture content : Out of all intercrops, it observed maximum soil moisture content with cluster bean subsequently in blackgram, arhar, and cowpea without considering the fruit tree associated. As because the cluster bean is a drought resistance, deep rooted legume crop and it required less water for its growth and development as compared to other legume crops that contribute on its higher water use efficiency by which there was more moisture content in the soil. (5) found that cluster bean is a drought resistant crop and it required less water for its growth and development.

The soil moisture content subsequently increases from July to August and reduce slowly after September, and the lowest soil moisture content was observed in December in all treatments. (Table-1) It might be because of crop water requirement was increase with crop growth and also, we, observed less rainfall in December and subsequent months. We also observe higher soil moisture contain in lower depth as compared to upper surface of soil in all the treatment during entire duration. The high soil moisture content was found with sole intercrops grown in open control from September to October but after that, the higher available soil moisture content was found in all fruit based agroforestry system as compared to the open field conditions. If we not considered the fruit trees associated, when the soil moisture was low towards the end of the *kharif* season, there was lower evaporation loss under the tree canopy. (2) observed that mango intercrop plantation had highest soil moisture content as compared to sole mango plantation.

Available nitrogen, phosphorous and potassium : The available nitrogen, phosphorous and potassium was observed higher in all fruit based agroforestry system as compared to its initial values. (Table-2) The value of available nitrogen ranged from 214.7 kg ha⁻¹ to 201.2 kg ha⁻¹. The maximum available nitrogen was observed in Mango + Blackgram (T4) (250.2 kg ha⁻¹) then after Mango + Cowpea (T3) (243 kg per hectare) and the lowest available nitrogen content was found in Cashewnut + Arhar system (T9) (214.7 kg per hectare). The increase in available nitrogen owing to the addition of manures and fertiliser to leguminous as well as nitrogen fixation by legume intercrops such as blackgram, cowpea, and arhar over the years. (8) observed that blackgram have higher nitrogen content (0.85 %) as compared to other legumes

Table-1 : Soil moisture content (%) of sole legume crop, different fruit crop and intercrop in fruit-based agroforestry system (Pool data of 2020 and 2021).

Tretatment	September		October		November		December		Mean	Mean	Mean
	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	Overall (cm)
Mango + Arhar : T ₁	12.4	13.5	11.4	12.7	11.51	13.43	7.14	9.7	10.61	12.33	11.47
Mango + cluster bean : T ₂	11.44	13.82	10.87	13.98	11.67	13.42	10.31	12.84	11.07	13.51	12.29
Mango + Cowpea : T ₃	13.07	14.2	12.15	13.28	9.68	11.19	7.28	9.56	10.54	12.05	11.30
Mango + Blackgram : T ₄	11.57	13.65	11.35	13.46	10.88	12.66	8.17	8.64	10.49	12.10	11.29
Mean	12.12	13.79	11.44	13.35	10.93	12.67	8.22	10.18			
Jackfruit + Arhar : T ₅	11.24	14.49	10.41	11.47	9.37	11.34	9.11	10.63	10.03	11.98	11.00
Jackfruit + cluster bean : T ₆	12.4	13.61	11.45	12.33	10.96	11.46	8.19	10.77	10.75	12.04	11.39
Jackfruit + Cowpea : T ₇	12.45	13.63	11.26	12.26	10.62	11.89	8.56	10.44	10.72	12.055	11.38
Jackfruit + Blackgram : T ₈	12.68	13.53	11.42	13.43	10.45	12.62	9.82	10.84	11.09	12.60	11.84
Mean	12.19	13.81	11.13	12.37	10.35	11.82	8.92	10.67			
Cashewnut + Arhar : T ₉	12.78	13.42	11.78	12.62	10.62	12.57	8.87	10.61	11.0125	12.305	11.65
Cashewnut + cluster bean : T ₁₀	12.37	13.78	11.69	12.56	11.27	12.22	8.53	10.44	10.965	12.25	11.60
Cashewnut + Cowpea : T ₁₁	11.84	13.85	10.71	12.81	9.36	11.46	7.28	7.82	9.79	11.48	10.64
Cashewnut + Blackgram : T ₁₂	11.58	12.78	11.74	12.15	10.84	12.03	7.73	10.07	10.47	11.75	11.11
Mean	12.14	13.45	11.48	12.53	10.52	12.07	8.10	9.73			
Sole Arhar : T ₁₃	12.49	13.27	11.22	12.31	10.69	12.93	8.65	10.42	10.76	12.23	11.49
Sole cluster bean : T ₁₄	12.71	13.75	11.67	12.79	10.81	12.37	8.41	10.87	10.9	12.44	11.67
Sole Cowpea : T ₁₅	12.83	11.46	11.71	12.56	10.58	12.32	7.43	9.53	10.63	11.46	11.05
Sole Blackgram : T ₁₆	12.94	13.92	11.49	12.75	10.53	12.64	8.32	10.59	10.82	12.47	11.64
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-2 : Available N, P, K in soil under fruit based Agroforestry system (Pool data of 2020 and 2021).

Treatment	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
Mango + Arhar : T ₁	231.8	55.6	149.4
Mango + clusterbean : T ₂	238.9	64.3	155.6
Mango + cowpea : T ₃	243.0	54.4	167.1
Mango + blackgram : T ₄	250.2	50.7	158.5
Jackfruit + Arhar : T ₅	216.6	53	147.2
Jackfruit + clusterbean : T ₆	218.3	57.6	153.5
Jackfruit + cowpea : T ₇	216.8	50.1	164.1
Jackfruit + blackgram : T ₈	234	48	157
Cashewnut + Arhar : T ₉	214.7	49.1	146
Cashewnut + clusterbean : T ₁₀	216	53.2	150.2
Cashewnut + cowpea : T ₁₁	220.2	48.4	157.4
Cashewnut + blackgram : T ₁₂	229.1	47.4	153.1
Initial soil status (2015)	213.8	44.8	144.1

which contribute in increasing the nitrogen content in soil. Maximum nitrogen concentration in intercropping treatment of cowpea was observed by. (3)

The available phosphorus the value ranged from 47.4 kg ha⁻¹ to 64.3 kg ha⁻¹. The highest content of available phosphorous was observed in mango + Clusterbean intercropping (T₂) (64.3 kg ha⁻¹) subsequently in jackfruit + Clusterbean intercropping (T₆) (57.6 kg ha⁻¹) and the minimum content of available phosphorous was observed in Cashewnut + Blackgram intercropping (T₁₂) (47.4 kg ha⁻¹). The improvement in available phosphorous content was because of legume intercrop root exudates solubilised the exchangeable

phosphorus as well as increase the total microorganisms in rhizosphere particularly PSB (phosphorous solubilising bacteria).

The content of available potassium values under fruit based agroforestry systems ranged from 146 kg ha⁻¹ to 165.2 kg ha⁻¹. (Table- 2) The highest content of available potassium was found in mango + cowpea intercropping (T₃) (167.1 kg ha⁻¹) subsequently in jackfruit + cowpea system (T₇) (164.1 kg ha⁻¹) and the minimum content of available potassium was observed in under cashewnut + Arhar intercropping (T₉) (146 kg ha⁻¹). This might be because of more uptake of potassium by arhar and less uptake by cowpea.

Table-3 : Growth performance of legume intercrops and fruit trees under fruit based Agroforestry system (Pool data of 2020 and 2021).

Fruit Tree Species	Intercrops	Number of branches per legume plants	Legume plant height (cm)	Number of pods per legume plants	Tree height (m)	Collar girth (cm)	Crown spread (m)
Mango	Arhar (T ₁)	21.23	142.92	420.34	3.37	44.09	3.6
	Clusterbean (T ₂)	23.76	60.02	64.85	3.63	46.59	3.76
	Cowpea (T ₃)	5.67	62.72	13.42	3.92	54.23	4.45
	Blackgram (T ₄)	5.85	60.02	17.67	3.71	49.37	4.2
Jackfruit	Arhar (T ₅)	17.35	141.22	336.76	6.35	56.67	4.27
	Clusterbean (T ₆)	21.61	57.51	58.89	6.92	57.06	5.73
	Cowpea (T ₇)	3.67	54.31	11.53	8.09	69.35	6.41
	Blackgram (T ₈)	5.01	57.51	16.11	7.32	61.47	6.07
Cashewnut	Arhar (T ₉)	17.42	141.13	330.34	3.71	58.5	6.11
	Clusterbean (T ₁₀)	21.83	58.52	59.65	3.64	60.71	6.41
	Cowpea (T ₁₁)	4.27	55.34	11.37	4.27	61.81	6.49
	Blackgram (T ₁₂)	5.21	58.52	16.25	3.58	73.00	7.69
Control (Sole Intercrops)	Arhar (T ₁₃)	20.31	142.42	422.84	0	0	0
	Clusterbean (T ₁₄)	24.72	60.39	66.81	0	0	0
	Cowpea (T ₁₅)	5.97	63.53	13.13	0	0	0
	Blackgram (T ₁₆)	5.91	60.39	17.72	0	0	0
C.D. (0.05)		0.47	5.33	1.21	1.24	14.14	1.96

Table-4 : Yield and Economics of fruit trees and legume intercrops under fruit based Agroforestry system (Pool data of 2020 and 2021).

Fruit Tree Species	Intercrops	Intercrop Grain/Green Yield (Kg/ha.)	Fruit Yield (Kg/ha)	Gross Return (Rs./ha)	Net Return (Rs./ha)	B : C Ratio
Mango	Arhar (T ₁)	740	430	59520	37520	2.70
	Clusterbean (T ₂)	8350	290	42100	20100	1.91
	Cowpea (T ₃)	1763	368	46300	24300	2.10
	Blackgram (T ₄)	392	315	40810	18810	1.85
Jackfruit	Arhar (T ₅)	595	0	37485	15485	1.70
	Clusterbean (T ₆)	7800	0	31200	9200	1.41
	Cowpea (T ₇)	1274	0	25480	3480	1.15
	Blackgram (T ₈)	312	0	24960	2960	1.13
Cashewnut	Arhar (T ₉)	620	340	73060	51060	3.32
	Clusterbean (T ₁₀)	8200	270	32800	10800	1.49
	Cowpea (T ₁₁)	1445	333	62200	40200	2.82
	Blackgram (T ₁₂)	326	300	26080	4080	1.18
Control (Sole Intercrops)	Arhar (T ₁₃)	734	0	46242	24242	2.10
	Clusterbean (T ₁₄)	8500	0	34000	12000	1.54
	Cowpea (T ₁₅)	1775	0	35500	13500	1.61
	Blackgram (T ₁₆)	390	0	31200	9200	1.41
C.D. (0.05)		117	0	4989	1463	

Crops	Sale rate (Rs/kg)	Crops	Sale rate (Rs/kg)
Arhar (grain)	63	Blackgram (grain)	80
Clusterbean (green)	4	Mango (ripe)	30
Cowpea (green)	20	Cashewnut (kernal)	100

Growth performance of legume crops : It was observed that number of branches per plant significantly higher in cowpea sole crop as compare the other combination. In order to number of branches per plant; cowpea sole > T3> T11 > T7 was observe in different stage of crop development. It might be due to shading effect of fruits trees. (Table-3)

It was observed that plant height significantly higher in cowpea sole crop as compare the other combination. In order to plant height cowpea sole > T3> T11 > T7 was observe in different stage of crop development. It was observed that number of pod per plant significantly higher in cowpea sole crop as compare the other combination. In order to number of pod per plant cowpea sole T3> T11 > T7 was observe in different stage of crop development, which might be due to shading effect of fruits trees.

It was observed that plant height significantly higher in Mango + Arhar (T1) as compare the other combination. In order to plant height T1> T13 > T5> T9 was observe in different stage of crop development. It was observed that number of branch per plant significantly higher in arhar sole crop as compare the other combination. In order to number of branch per plant T1> T13 > T9> T5 was observe in different stage of crop development. It was observed that number of pod per plant significantly higher in Arhar sole crop as compare the other combination. In order to number of branch per plant T1> T13 > T5> T9 was observe in different stage of crop development. (4) Observed intercrop yield was less than sole and intercrop yields increased with increase in tree row spacing.

Growth performance of fruit trees : Irrespective of the intercrops, jackfruit has highest tree height subsequently in cashew nut and mango. This is might be because jackfruit has more growth in sapling stage as comprised to mango and cashew nut. Irrespective of woody species, the total height in trees in association with cowpea and blackgram was observed higher over cashew nut and arhar. It was shows that less competition gives by cowpea and blackgram for moisture, nutrient etc. to fruit trees. The height of fruit trees with arhar was observed less, (Table-3) that might be because arhar gives more competition to fruit trees for different resources as we know arhar is a exhaustive crop with regards to water utilization, nutrient uptake, etc. and it's also have long growing duration as compared to other intercrops grown and also it might be due to jackfruit have hereditary high growth rate as compare to cashew nut and mango as well as positive effect of cowpea and blackgram as intercrop ,similar finding also reported by (9).

The fruit trees collar girth was significantly differ from other trees in fruit based agroforestry system. It was observed that high collar girth found in cashew nut +

blackgram and lowest collar girth found in mango + arhar agroforestry systems. (Table-3) That was might be because less competition of these intercrops with trees as well as we know that blackgram and cashew nut have different soil moisture and nutrient extraction pattern/depth. The positive effect of blackgram and cowpea as intercrop has also been reported by (10).

Similarly, out of all fruit trees, cashew nut gives out the maximum crown spread (7.69 m) subsequently in jackfruit and mango. In respect of interaction of fruit trees with intercrops no significant variation was observed. The values of crown spread gives out a clear cut difference at the end of fifth year's age. That is might be because of difference in genetic makeup among fruit trees with respect to crown spread. Cashewnut plants have more crown spread ability as compared to mango and jackfruit (11) also reported similar effect of the fruit trees.

Yield and economics of fruit based intercropping system : Out of all intercrops the maximum legume yield was observed in mango + cluster bean system (8350 kg ha⁻¹) and the sole cluster bean was observed 8500 kg ha⁻¹. The performance of cluster bean was relatively better compared to other legume intercrops.

Economics of all the fruit based agroforestry systems and open field grown crops were differed due to their difference in production. The gross return from intercrops significantly differs in fifth year of the fruit based agroforestry system. Arhar + cashew nut (T₉) gives out significantly highest gross return (Rs. 73,060 ha⁻¹) as compare than others. Blackgram + Jackfruit (T₇) gives out significantly less gross return (Rs. 24,960 ha⁻¹). The difference in gross return in intercrops is because of difference in yield and sale price.

Out of the all intercrops the highest net return was observed in cashew nut + arhar (T₉) (Rs 51060 ha⁻¹) and the net return from its control was observed Rs 24242 ha⁻¹. The minimum net return was found in blackgram under jackfruit + blackgram system (T₇) (Rs 2960 ha⁻¹), the net return of control was observed Rs 9200 ha⁻¹. The difference due to different yield cost of cultivation and sale price. (Table-4).

The B: C ratio of the fruit based agroforestry system was observed low as compared to its controlled condition. In the fruit based agroforestry system, the range of B: C ratio differ from 1.13 to 3.32 and in control condition it differs from 1.41 to 2.21. The B: C ratio was observed highest (3.32) in the cashew nut + arhar system (T₉) as compared to its controlled condition (2.10). The lowest B: C ratio (1.13) found in jackfruit + blackgram (T₇). Intercrops not only give some seasonal return throughout the development phase of fruit tree, but they

also aid in the enhancement of soil physic-chemical characteristics. (Table-4) Because the tree canopy was so low throughout the period, shade had no influence on the growth and economic production of these intercrops. (1) found that multi cropping outperformed sole cropping in terms of yield and economics.

References

1. Arya R, Awasthi OP and Singh J. 2010. Comparison of fruit based multi-species cropping system versus sole cropping system under arid region of Rajasthan, *Indian Journal Agriculture Science*, 80 (5): 423–426.
2. Avinash CR, Saroj PL, Sharma H, Jayaprakash NK and Chaturvedi N. 2013. Performance of mango based agrihorticultural models under rainfed situations of Western Himalaya, India, *Agroforestry System*, 87: 1389–1404.
3. Bedse RD, Patel AM, Raval CH, Rathore BS and Vyas KG. 2015. Forage equivalent yield, quality, soil status and economics of maize (*Zea mays* L.) as influenced by intercropping of cowpea (*Vigna unguiculata* L.) and fertility levels during kharif season, *Research on Crops*, 16: 236-242.
4. Dhara PK and Sharma Babloo 2015. Evaluation of Mango Based Agroforestry is an Ideal Model for Sustainable Agriculture in Red and Laterite Soil, *Journal of pure and applied microbiology*, 9 (2): 265-272.
5. Garg B.K., Burman U., and Kathju S. 2005. Physiological aspect of drought tolerance in clusterbean and strategies for yield important under drought condition, *Journal of Arid Legume*, 2(1): 61-66
6. Gomez KA and Gomez AA. 1976. Statistical procedures for agricultural research with emphasis on rice, 38 (1): 76-82.
7. Pathal P.S. and Paterioa HM 2001. Agroforestry : a tool for sustainable management of forest resource in India, *International book distributor*: 336-412.
8. Prasad Rajendra, Kumar Dinesh, Rana D.S, Shivay YS, Tewatia Rk 2014. Textbook of plant nutrient management, Indian society of agronomy, New Delhi
9. Rathore AC, Saroj PL, Lal H, Sharma NK, Jayaprakash J, Chaturvedi OP, Raizada A, Tomar JMS and Dogra P. 2013. Performance of mango based agri-horticultural models under rainfed situation of Western Himalaya, India, *Agroforestry Systems*, 87 (6): 1389-1404.
10. Raut RL and Jain PK. 2013. Intercropping systems in mango orchard for rainfed area of Central India, *International Journal of Horticulture*, 3(15): 87-90.
11. Swain SC. 2014. Performance and profitability study of different mango based intercropping systems in Eastern ghat high land zone of Odisha, *Journal of Crop and Weed*, 10 (2): 170-178.



Characterization of Different Genotypes of Aonla (*Emblca officinalis* Gaertn) Developed in JNKVV Jabalpur, M.P.

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Abstract

The present experiment entitled "Characterization of different varieties of Aonla (*Emblca officinalis* Gaertn) developed in JNKVV Jabalpur (M.P.)" was conducted during 2019–20 at Fruit Research Station, Imliya, Department of Horticulture, JNKVV, Jabalpur (M.P.). The Maximum fruit yield per plant (133.38kg), pulp percentage (97.13%), acidity (1.66%), ascorbic acid (566.87 mg/100g) and total sugar (5.08%) were recorded JA 116. The maximum fruit volume (34.40ml) with Francis while minimum (17.20ml) were recorded with JA110. The maximum fruit weight (53g), fruit diameter (4.63), fruit length (4.14cm), specific gravity (1.70g), and TSS (9.11 Obrix) were recorded with JA 114 while highest stone weight (2.26g) and reducing sugar (3.51%) with chakaiya. The highest moisture percentage (86.49%) with JA 113 while lowest (81.98%), fruit length (2.49cm), and fruit weight (16.93g) were recorded with JA107. The minimum specific gravity (0.87g) and reducing sugar (2.05%) were recorded with treatment JA105 while the minimum non reducing sugar (0.27%) and total sugar (3.38%) were recorded under treatment JA 118. The minimum pulp percentage (93.43%) in JA 109, TSS (5.42 Obrix) in JA 118, acidity (0.86%) in JA 112, ascorbic acid (453.12 mg/100g) in JA 103 and stone weight (0.96g) was recorded with JA 116.

Key words : Aonla, genotypes and jawahar aonla.

Introduction

The Aonla (*Emblca officinalis* Gaertn.) Syn. *Phyllanthus emblica* (commonly known as Indian gooseberry) Linnaeus is known for its medicinal and therapeutic properties from the ancient time in India and considered as a wonder fruit for health conscious population it belongs to family Euphorbiaceae. It is one of the important indigenous fruit of India subcontinent. In different parts of India it is known by different vernacular name such as Amla or Aonla in hindi, Dhatri, Dhatriphala or Amlaki in sanskrit, Amla or Amalaki in Bengali and Oriya, Nelli in Malayalam and Tamil, Amlakamu, Usirikai Usrika in Telugu, Amolphal in Punjabi, and Aonla, Myrobalan, Inaian Goosberry in English.

Aonla is said to be indigenous to tropical South – Eastern Asia, particularly in central and southern India. It is also reported to be the native of India, Pakistan, Bangladesh, Srilanka, Malaysia, and China and to Islands. It is more popular in India and is commercially cultivated in Uttar Pradesh including the ravenous area in Agra, Mathura, Kanpur, Pratapgarh, Raibareli, Etawah, Fatehpur and semi – arid tracks of Bundelkhand. The major concentration of Aonla cultivation is in Pratapgarh district. The natural distribution of wild Aonla is found on the Himalayas, Chhota Nagpur, Bihar, Orissa, West

Bengal, North Circars, Deccan, Karnatka, and in Western Ghats.

Aonla is basically sub-tropical plant and prefers dry sub-tropical climate. Tree growth is not influenced either by hot wind or frost. A mature Aonla tree can tolerant freezing as well as high temperature up to 44°C. It is a hardy fruit crop and is now being cultivated in variable soil conditions. Its deep root system and deciduous nature is helpful in providing vertical drainage and incorporation of around 10 t/ha of biomass for continuous improvement in physical, chemical and biological soil properties.

Aonla is highly nutritive and is one of the richest natural source of vitamin-C (600mg/100g of pulp). It is the second highest source of vitamin-C among fruits next only to Barbados cherry. The fruits contain tannins which is useful in protecting the ascorbic acid from oxidation. It is valued as an antiscorbutic diuretic laxative alternative and antibiotic. The fruit of Aonla are very extensively utilized by processing industry. It is an essential ingredient of chyawanprash and Triphala are popular ayurvedic medicine and in other products i.e. preserves, pickles, candy, jelly, jam, and squash. Fruits can also be dried and powdered to be used subsequently in the preparation of hair oils.

The stone, number on fruit size and weight of Tangerine cv. Khieo Waan and found that number of

stone per fruit was significantly correlated with fruit size (diameter) and fruit weight (Ketsa, 1988).

Banarasi cultivar showed its highest TSS, ascorbic acid and lesser amount of acidity than other cultivar. The total sugar content was maximum in Chakaiya followed by Banarasi and the minimum total sugar found in Desi cultivar. Under rainfed condition of south west Haryana, Banarasi performed well superior to Chakaiya and Desi. In Chakaiya and Banarasi cultivar the TSS increased. The acidity and ascorbic acid content of the fruits were recorded in high range then it decreased significantly at later stage of maturity.

Aonla fruits as 3.4% fiber, 81.2% moisture, 600mg/100g ascorbic acid. Fruit of Krishna has TSS of 11.5° brix, 40g fruit weight, 475 mg/100g ascorbic acid. Desi cultivar reported to have 14.8° brix TSS, 458.9 mg/100g and fruit weight 12.90g.

The average fruit length as 3.94 cm, fruit weight as 32.9g, fruit diameter as 3.74 cm, pulp as 97.5%, stone 2.50%, moisture content as 87.4%, crude fiber as 6.6%, TSS 10%, 416mg/100g of ascorbic acid. NA-7 also observed with fruit weight 40.9g, fruit length 4.19 cm, fruit diameter 3.99cm, 6.6% crude fiber, 252.72 mg/100g ascorbic acid. It was further noticed that delay in harvest leads to increase in TSS and ascorbic acid of the fruit.

Materials and Methods

The present experiment entitled Characterization of different varieties of Aonla (*Emblica officinalis* Gaertn) developed in JNKVV Jabalpur (M.P.) was conducted during 2019–20 at Fruit Research Station, Imliya, Department of Horticulture, JNKVV, Jabalpur (M.P.) During the study, 20 genotypes were selected from the existing plant population for detailed study on the basis of fruiting behavior and size of fruits. Selected genotypes were tagged to study their physico-chemical characteristic of fruits. The experiment was laid out in Randomized block design with three replications. Treatment details are given below :

Treatments	Genotypes/Varieties	
T ₁	Jawahar Aonla (JA)	101
T ₂	Jawahar Aonla (JA)	102
T ₃	Jawahar Aonla (JA)	103
T ₄	Jawahar Aonla (JA)	104
T ₅	Jawahar Aonla (JA)	105
T ₆	Jawahar Aonla (JA)	106
T ₇	Jawahar Aonla (JA)	107
T ₈	Jawahar Aonla (JA)	108
T ₉	Jawahar Aonla (JA)	109
T ₁₀	Jawahar Aonla (JA)	110
T ₁₁	Jawahar Aonla (JA)	111
T ₁₂	Jawahar Aonla (JA)	112
T ₁₃	Jawahar Aonla (JA)	113
T ₁₄	Jawahar Aonla (JA)	114
T ₁₅	Jawahar Aonla (JA)	115

T ₁₆	Jawahar Aonla (JA)	116
T ₁₇	Jawahar Aonla (JA)	117
T ₁₈	Jawahar Aonla (JA)	118
T ₁₉	Chakaiya	
T ₂₀	Francis	

The Following observations were recorded of Aonla genotypes :

Fruit yield per tree (kg), Fruit weight (g), Stone weight (g) Pulp (%), Fruit diameter (cm), Fruit length (cm), Fruit volume, Specific gravity, Moisture, TSS (°Brix), Acidity (%) and Ascorbic acid content (mg/100g), Sugar, Reducing sugar, Non reducing sugar and Total sugar.

Results and Discussion

Physical parameters : The maximum yield (133.38 kg) was noted in JA 116 followed by JA 117 (120.20 kg). The minimum moisture content (67.55 kg) was observed in JA 115.

The maximum fruit weight (53 g) was recorded under JA 114 followed by Francis (51.93 g) which was statistically at par with each other. The minimum fruit weight (16.93 g) were recorded under the JA 107.

The maximum stone weight (2.26 g) was noted in Chakaiya followed by Francis (2.02 g) which was statistically at par with each other. The minimum weight (0.96 g) was recorded under JA 106 and JA 116.

The maximum pulp % (97.13%) was observed in JA 116 followed by JA 114 (95.37%) which was statistically at par with each other, whereas minimum pulp% were recorded under JA 109 (93.43%).

The maximum fruit diameter (4.63 cm) was recorded under JA 114 followed by Francis (4.34 cm) which was statistically at par with each other. The minimum fruit diameter (3.22 cm) was observed in JA 104.

The maximum fruit length (4.14 cm) was recorded in JA 114 followed by Francis (4.03 cm) which was statistically at par with each other. The minimum fruit length (2.49 cm) was recorded under JA 107.

The maximum fruit volume (34.40 ml) observed in Francis followed by Chakaiya (31.40 ml) while minimum fruit volume (17.20 ml) was noted in JA 110.

The maximum specific gravity (1.70g/ml) was observed in JA 114 followed by Francis (1.50 g/ml) which was statistically at par with each other. The minimum specific gravity (0.87 g/ml) was recorded under JA 105.

The maximum moisture (86.49%) was noted in JA 113 followed by JA 111 (85.26%). The minimum moisture content (81.98%) was observed in JA 107.

The maximum TSS (9.11 °brix) were recorded in JA 114 followed by JA 109 (8.18 °brix) was statistically at par

Table-1: Characterization of different varieties of Aonla (*Emblca officinalis* Gaertn).

Treatment	Yield (kg/plant)	Fruit Weight (g)	Stone Weight (g)	Pulp%	Fruit Diameter (cm)	Fruit Length (cm)	Fruit Volume (ml)	Specific Gravity (g/ml)
T ₁	79.65	22.50	1.50	93.33	3.67	2.86	21.40	1.05
T ₂	82.82	20.20	1.50	92.25	3.26	2.85	18.60	1.08
T ₃	103.08	30.23	1.00	93.75	3.79	3.34	24.80	1.21
T ₄	68.40	17.10	1.00	91.50	3.22	2.96	19.0	1.11
T ₅	100.94	24.33	1.13	93.58	3.59	2.77	21.20	0.87
T ₆	111.74	26.60	0.96	94.16	3.86	3.21	19.60	1.35
T ₇	81.26	16.93	1.53	94.54	3.31	2.49	17.26	0.98
T ₈	102.08	25.53	1.23	94.28	3.57	2.68	21.0	1.21
T ₉	95.06	27.96	1.26	93.43	3.87	3.11	25.0	1.10
T ₁₀	70.20	19.50	1.03	94.67	3.48	2.70	17.20	1.13
T ₁₁	117.35	33.53	1.06	95.63	4.11	3.34	25.20	1.33
T ₁₂	103.08	34.36	1.26	94.86	4.24	3.43	25.0	1.37
T ₁₃	107.52	25.60	1.00	95.11	3.24	2.57	26.0	0.98
T ₁₄	79.50	53.00	1.33	95.13	4.63	4.14	31.30	1.80
T ₁₅	67.55	19.30	1.10	94.78	3.46	2.66	20.40	0.94
T ₁₆	133.38	35.10	0.96	97.17	4.09	3.44	28.80	1.21
T ₁₇	120.20	36.43	1.13	95.14	4.10	3.47	24.80	1.46
T ₁₈	95.50	23.50	1.00	94.92	3.57	2.81	19.80	1.18
T ₁₉	118.68	39.56	2.26	94.55	4.25	3.04	31.40	1.25
T ₂₀	93.47	51.93	2.02	94.48	4.34	4.03	34.40	1.50
S.Em ±	2.306	1.926	0.081	0.619	0.101	0.143	0.950	0.128
CD at 5%	6.627	5.535	0.233	1.780	0.291	0.411	2.730	0.318

Table-2 : Characterization of different varieties of Aonla (*Emblca officinalis* Gaertn).

Treatment	Moisture (%)	T.S.S (°Brix)	Acidity (%)	Ascorbic acid (mg/100g)	Reducing Sugar (%)	Non Reducing (%)	Total Sugar (%)
T ₁	82.37	6.38	1.42	506.08	2.29	1.83	4.12
T ₂	84.31	8.17	0.95	483.61	2.08	2.41	4.49
T ₃	83.43	6.46	1.17	485.60	2.57	2.09	4.66
T ₄	84.07	7.43	0.89	479.62	2.97	1.35	4.32
T ₅	84.40	6.18	1.23	479.18	2.05	2.60	4.65
T ₆	84.99	8.09	1.03	492.26	2.50	1.76	4.26
T ₇	81.98	5.54	1.27	487.98	2.47	1.62	4.09
T ₈	82.90	7.24	1.01	517.71	2.65	1.43	4.08
T ₉	83.32	8.18	1.08	470.56	2.33	2.23	4.56
T ₁₀	83.59	6.25	1.29	484.77	2.52	2.06	4.58
T ₁₁	85.26	8.12	0.88	498.85	2.68	1.05	3.73
T ₁₂	82.77	8.17	0.86	460.54	2.38	1.17	3.55
T ₁₃	86.49	7.65	1.20	479.44	2.23	1.71	3.94
T ₁₄	82.21	9.11	0.90	496.46	2.55	1.83	4.38
T ₁₅	82.28	8.16	1.39	463.80	2.50	1.43	3.93
T ₁₆	82.37	6.54	1.66	550.44	3.10	1.98	5.08
T ₁₇	83.39	7.86	1.17	510.72	2.11	1.96	4.07
T ₁₈	83.93	5.42	1.30	500.70	3.11	0.27	3.38
T ₁₉	83.64	8.14	1.35	522.34	3.51	1.10	4.61
T ₂₀	82.57	8.06	1.06	505.33	3.04	1.58	4.62
S.Em ±	0.517	0.322	0.033	13.23	0.099	0.114	0.090
CD at 5%	1.487	0.927	0.094	38.04	0.285	0.327	0.258

with each other. While minimum TSS (5.42 °brix) was recorded under JA 118.

The maximum acidity (1.66%) was noted in JA 116 followed by JA 101 (1.42%) which was statistically at par with each other. The minimum acidity (0.86%) recorded in JA 112.

The maximum ascorbic acid (566.87 mg/100g) was

observed in JA 116 followed by JA 118 (520.60 mg/100g). while minimum ascorbic acid (453.12 mg/100 g) was recorded under JA 103.

The maximum reducing sugar (3.51%) was recorded under Chakaiya followed by JA 118 (3.11%) which was statistically at par with each other. While, minimum reducing sugar (2.05%) was noted under JA 105.

**Jawahar Aonla 101****Jawahar Aonla 102****Jawahar Aonla 103****Jawahar Aonla 104****Jawahar Aonla 105****Jawahar Aonla 106****Plate-1 : Genotypes of Aonla**

The maximum non-reducing sugar (2.60%) was noted in JA 105 followed by JA 102 (2.41%) which was statistically at par with each other. The minimum non reducing sugar (0.27%) was observed in JA 118.

The maximum total sugar (5.08%) was recorded under JA 116 followed by JA 103 (4.66%) which were statistically at par with each other. While minimum total sugar (3.38%) was recorded under JA 118.

The weight of the fruit (32.53g) fruit diameter (3.93 cm) fruit length (3.23 cm) was recorded higher in Chakaiya as compared to Desi. Pulp:stone ratio is depends on size of the fruit. Chakaiya was found to be superior followed by Desi as regard pulp:stone ratio. The cultivar Chakaiya showed higher specific gravity (1.07 g/ml) as compared to Desi (1.05 g/ml) Premi et al., 2002). The maximum weight of the fruit were significantly recorded in JA 114 followed by Francis, whereas minimum fruit weight was found in JA 107. Maximum fruit volume was significantly recorded in Francis followed by Chakaiya whereas minimum fruit volume was found in JA 110. The variation in fruit weight and volume may be due to varied potency of cell division, enlargement and development of inter and intra cellular spaces in different cultivars of Aonla. Similar findings have also been reported by (Bharati 2015).

The effect of stone, number on fruit size and weight of Tangerine cv. Khieo Waan and found that number of stone per fruit was significantly correlated with fruit size

(diameter) and fruit weight. Similar findings have also been reported by (Ketsa, 1988).

The physical parameters viz, fruit size, weight, stone weight, specific gravity, moisture content etc in five cultivars of Aonla during growth and development. They observed that Banarasi and Chakaiya have maximum and minimum fruit size and weight respectively where as Krishna and Kanchan cultivars gave maximum and minimum stone weight respectively. Similar findings have also been reported by (Ojha and Pathak, 1992).

Total sugar, reducing sugar, ascorbic acid was highest in osmo air dried Aonla browning and tannin content were least. Indirect solar drying is found better than direct solar drying (Pragathi et al., 2000).

The differential decrease in acidity among cultivars of Aonla namely Chakaya, Krishna, NA-7, NA-10 during storage. Minimum acidity was recorded in cv Krishna (1.73%) followed by NA-10 (1.83%) on 10th day of storage while maximum acidity content was recorded in NA-7 (2.56%) followed by cultivar Chakaiya (2.09%). Similar findings have also been reported by Neeraj et al. (2002).

The physico-chemical composition of two cultivars of Aonla fruits namely Chakaiya and Desi and found a gradual increase in average fruits weight, stone weight, pulp to stone ratio, TSS and ascorbic acid with the advancement of maturity up to 5th November. The maximum total phenol content was found in immature

**Jawahar Aonla 107****Jawahar Aonla 108****Jawahar Aonla 109****Jawahar Aonla 110****Jawahar Aonla 111****Jawahar Aonla 112****Plate-2 : Genotypes of Aonla**

fruits. It was inferred from the observation that Aonla fruits attained maturity in the first fortnight of January and hence this period might be the optimum harvesting stage. Similar findings have also been reported by Gupta et al. (2003).

The seven cultivars namely Krishna, Kanchan, NA-6, NA-7, NA-10, Francis, Chakaiya. Fruit weight was maximum in cv. Krishna followed by NA-10 and NA-6. The minimum fruit weight was recorded in cv. Kanchan. Maximum acidity, ascorbic acid, total mineral, total phenol content were recorded in NA-6. Similar findings have also been reported by Jaiswal et al. (2007).

Aonla was found scattered through Jhorat district of Assam. Fourteen ripe fruits are selected and analysed for physico chemical trait such as stone weight (0.37-1.66g), pulp:stone ratio (3.2114), pulp weight (2.83g-9.41g), TSS (12° brix-19° brix), acidity (2.29%-4.61%), ascorbic acid (400 mg/100g-800 mg/100g) and reducing sugar (3.67%-10.98%) Similar findings have also been reported by Hazarika et al. (2009).

fruits of Chakaiya variety can be used for development of value added products because this variety had a lower content of phenols, TSS, ascorbic acid compare to wild varieties. Similar findings have also been reported by Poonam et al. (2009).

Ascorbic acid content was observed significantly higher in the squash prepared from NA-7, NA-6, and Chakaiya was 159 mg/100ml, 153.10 mg/100ml, and 150.01 mg/100ml respectively. Higher pH was found in

NA-7 was 3.68 followed by NA-6 was 3.54. Similar findings have also been reported by Choudhary et al. (2013).

The chemical and nutritional profiles of fresh Aonla fruits of five varieties viz. Banarasi, Chakaiya, Kanchan, NA-7 and Desi. Fruits of variety Banarasi were the largest in size and had maximum weight, while fruits of Desi variety had the least values with maximum firmness. Moisture content of variety NA-7 was the highest. The fruits of Desi variety were reported to have the maximum ash, fat and fibre contents. Varietal differences significantly ($p < 0.05$) influenced the acidity, ascorbic acid, total polyphenol, total sugar and pectin contents. It was observed that iron and zinc contents were significantly higher in Chakaiya variety while sodium and potassium contents were higher in Kanchan variety. Similar findings have also been reported by Parveen et al. (2015).

The wide spread survey was made to explore the Aonla germplasm and also to determine variability studies in Aonla wild genotypes for fruit character from north-eastern areas of India i.e., Assam, Nagaland, Meghalaya and Manipur during the year of 2014-16. These genotypes were collected from the varied altitude ranging from 800-1850 m above mean sea level. Aonla genotypes were found almost all part of north eastern region, but the intensity varied from place to place according to agro-climatic conditions. Indian gooseberry accessions showed considerable variability with respect to morphological and physico-chemical characters. Wide

**Jawahar Aonla 113****Jawahar Aonla 114****Jawahar Aonla 115****Jawahar Aonla 116****Jawahar Aonla 117****Jawahar Aonla 118****CHAKAIYA****Francis****Plate-3 : Genotypes and Varieties of Aonla.**

variability with respect to fruit weight (1.39 – 5.88g), fruit length (1.27-2.28cm), fruit breadth (1.27-2.44cm), fruit girth (4.16 to 7.22cm), stone weight (0.29 to 0.95g), specific gravity (1.02-1.45), TSS of juice (10.00-21.30°Brix), pH (2.53-3.27), acidity (1.84-3.95), total sugar (8.15-13.15%), Vitamin C (375.00 -1428.50 mg/100 ml of fruit juice), Phenol content (944.85-4516.20 mg/100g of juice) and TSS/acid ratio (3.03-9.72) were observed among the genotypes. The genotype T-12 and T-14, were found superior in terms their physicochemical attributes than the rest of the genotype. Singh et al. (2016).

The physico chemical composition of Aonla and found that average weight of the fruit, stone and pulp were 33.59 g, 8.80% and 91.20%. While average fruit length and width of fruit was found 3.19 cm and 4.19 cm. Edible portions of fruit contain 10% TSS, 2.25% acidity,

546.75mg /100g, 2.60% reducing sugar, 2.23% non reducing sugar, 4.83% total sugar Gaurav et al. (2017).

The Pulp:stone ratio was recorded significantly highest in JA 117 followed by JA 114. Whereas minimum pulp:stone ratio observed in JA 104. The difference in Pulp:stone ratio was may be due to genetic differences, weight and size of the fruit and weight and size of the stone (Chiranjeevi et al. 2018).

The fruit diameter was recorded significantly maximum in JA 114 followed by Francis. The minimum fruit diameter was noted in JA 104. This difference was due to genetically characteristics of varieties and rate of enlargement of mesocarp cells of fruits as well as micro-climatic factors. This observation is in accordance with the results obtained by (Balasubramanyam and Bangaruswamy 1998).

The decrease in total acidity content in Aonla at final stage fruit maturity might due to rapid utilization of organic acids into their salts and sugars either by invertase (Hawker 1968). Ascorbic acid was recorded significantly maximum in JA 116 followed by Chakaiya. The minimum ascorbic acid was found under JA 112. The vitamin-C content increased consistently in linear order with the advancement of harvest maturity. The variation in vitamin-C content may be associated with inherited characters of Aonla cultivars. These findings are in agreement with those of (Bharati 2015).

TSS/acid ratio (3.03-9.72) were observed among the genotypes. The genotype T-12 and T-14, were found superior in terms their physicochemical attributes than the rest of the genotype (Singh et al. 2016).

Conclusions

The present experiment entitled Characterization of different varieties of Aonla (*Emblica officinalis* Gaertn) developed in JNKVV Jabalpur (M.P.) was conducted during 2019–20 at Fruit Research Station, Imliya, Department of Horticulture, JNKVV, Jabalpur (M.P.). The different aonla varieties were characterized in various physical and chemical parameters. It was concluded that the fruit yield per tree, pulp percentage, total sugar, acidity and ascorbic acid were recorded the best performance under JA 116 varieties and fruit weight, fruit diameter, fruit length, specific gravity and TSS were recorded highest with JA 114 varieties.

Acknowledgment

I would also like to express my sincere sense of gratitude to my advisor Dr. D.P. Sharma, Professor of the Department of Horticulture (Fruit Science), College of Agriculture, J.N.K.V.V., Jabalpur for his valuable guidance, kind co-operation, critical suggestions and constant encouragement not only for the thesis work but also during the entire course of my study. I show my gratefulness to my senior Mr. Sevan Das Khunte, Ph. D. Scholar of the Department of Fruit Science IGKV, Raipur (C.G.).

References

1. Ahmed S, Tomar YK, Rawat MS and Rawat VK. (2010). Physico chemical studies of some Aonla cultivars. *Advances in plant science*. 23(5): 45-46.
2. Balasubramanyan S and Bangarusamy U. (1998). Studies on maturity standard of Aonla (*Emblica officinalis* Gaertn.) under rainfed vertisol soil. *South Indian Horticulture Science*. 46(5&6): 347-348.
3. Bharati Killadi, Abhya Dikshit, and Rekha Chaurasia. (2015). Maturity indices in Aonla (*Emblica officinalis* Gaertn.): Physical and biochemical attributes. *Journal of Eco-friendly Agriculture*. 10(2): 207-211.
4. Chiranjeevi BM, Muralidhara BM, Shivanand Hongal and Sneha MK. (2018). Physico chemical characterization of Aonla fruits grown under Bengaluru conditions. *International Journal of Current Microbiology and Applied Sciences*. 7(3): 36113615.
5. Choudhary ML, Verma IM, Jitendra Singh and Atul Chandra. (2013). Studies on biochemical changes in Aonla squash under storage condition. *Progressive Horticulture*. (2): 45-46.
6. Gaurav Singh, Vishen, Sanjay Pathak and Krishna Kumar (2017). Studies on physico chemical composition of Aonla (*Emblica officinalis* G). Fruit and evaluation of ginger extract concentration for preparation of Aonla candy cv chakaya. (6): 353-354.
7. Ghosh SN, Roy S and Bera B. (2013). Study on performance of Aonla cultivars in laterite soil of West Bengal. *Journal of Crop and Weed*. 9(2): 36-38.
8. Gupta, Singh VK, Devi and Shwetambri. (2003). Physico-chemical changes in Aonla (*Emblica officinalis* G.) fruit during growth and development. *Haryana Journal of Horticultural Sciences*. 3(2): 37-39.
9. Hawker JS.(1968). Enzymes involved in developing grape varieties. *Proceedings of the Australian Biochemical Society*. 12(4): 66.
10. Hazarika BN, Deka CB and Choudry S. (2009). Studies on variability on physico chemical characters of different Aonla accessions from Jhorat region of Assam. *Indian journal of horticulture*. 66(2): 190-192.
11. Jaiswal Roopak, Singh Ganesh and Singh AK. (2007). Studies on physico chemical characteristics of Aonla fruit. 7(1): 90-92.
12. Ketsa S. (1988). Effects of fruits size on juice content and chemical compositions of Tangerine. *Journal of Horticulture Science*. 63(1): 171-174.
13. Neeraj Kumar S, Kumar J and Godara RK.(2002). Effect of different polythene bags on phenols, Chlorophyll and carotenoid content of Aonla fruits during room temperature storage. *Haryana journal of Horticulture Science*. 3(1): 189-191.
14. Ojha CM and Pathak RK.(1992). Change in physical component of Aonla. *Progressive Horticulture*. 24(3-4): 176-179.
15. Poonam Mishra, Deepmala Verma, Vijeyta Srivastava, OP Chauhan and GK Rai.(2009). Physico- chemical properties of chakaiya variety of amla (*Emblica officinalis*) and effect of different dehydration methods of quality of powder. *African Journal of Food science*. 3(10): 51-53.
16. Pragathi, Dahiya S and Dhawan SS. (2000). Effect of different drying methods on the nutritional composition of Aonla fruit. *Tropenland writ*. 101(1): 85-87.
17. Premi BR, Sethi Vijay and Bisaria Geeta.(2002). Preparation of instant oil less pickle from Aonla (*Emblica officinalis* Gaertn.). *Indian Food Packer*. 2(5): 72-75.
18. Parveen K and Khatkar BS. (2015). Physico- chemical properties and nutritional composition of Aonla (*Emblica officinalis*) varieties, *International Food Research Journal*. 22(6): 2358-2363.



Studies on Some Morphological, Agronomical Components and Qualitative Characters of Teasle Gourd (*Momordica subangulata* Blume. Subsp. *Renigera*)

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Abstract

Five female clones of teasle gourd were evaluated for some morphological characters viz.; sepal length (mm), sepal width (mm), petal length (mm), petal width (mm), ovary length (mm), ovary diameter (mm), style length (mm), leaf shape, tendril character, stem character, flower colour, stigma head colour, fruit shape, spine character, spine colour at early stage and spine colour at marketable stage. Some agronomical characters viz.; length of main vine (m), no. of vines/plant, no. of leaves/plant, fruit weight at marketable stage (g), ovary diameter (mm), no. of seeds/fruit, no. of fruits/plant, yield/plant (kg) were evaluated also. There were evaluated for seventeen different fruit and fruit quality characters viz., fruit weight at marketable stage (g), ovary diameter (mm), fruit length at marketable stage (cm), fruit breadth at marketable stage (cm), pericarp thickness at marketable stage (mm), TSS in exocarp (°Brix), TSS in mesocarp (°Brix), acidity in exocarp (%), acidity in mesocarp (%), ascorbic acid in exocarp (mg/100g), ascorbic acid in mesocarp (mg/100g), total sugar in exocarp (%), total sugar in mesocarp (%), reducing sugar in exocarp (%), reducing sugar in mesocarp (%), β -carotene in exocarp (mg/100g fresh) and β -carotene in mesocarp (mg/100g). Contents of TSS, acidity and sugar contents were much higher in the mesocarp of the fruit while, ascorbic acid and β -carotene contents were much higher in the exocarp of the fruits. Selection of these characters would be effective for obtaining high qualitative genotype by additive gene effect. The location was research field of the All India Coordinated Research Project on vegetable crops of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India, situated at 23.5° n latitude and 89° e longitude with a mean sea level of 9.75 m. The female clones 'Assam local', 'Purulia local-1', 'Purulia local-2', 'Purulia local-3' and 'Mondouri local', collected from different places of West Bengal and Assam, were evaluated in a randomized complete block design with four replications. Selection of these characters would be effective for obtaining high qualitative genotype by additive gene effect. Selection of these characters would be effective for obtaining high qualitative genotype by additive gene effect.

Key words : Teasle gourd, germplasm, morphological characters, agronomical characters, qualitative characters, yield.

Introduction

Teasle gourd (2n=4x=56) is a cross pollinated crop due to dioecious sex form and conventionally propagated vegetatively hence, its improvement approaches are different than what would be applicable for other sexually propagated and cross-pollinated vegetable crops. Teasle gourd has become a major vegetable in Bangladesh because of the high export potential and demand in the

internal market (Hossain *et al.*, 1996). Export of teasle gourd to Gulf countries has also been started from West Bengal. The crop grows well in warm and humid climate. The optimum temperature for its successful cultivation is 20-35 °C. It requires well-drained light sandy loam soil with good fertility. It is susceptible to water logging. The fruits are oval, about 10-20 cm long with numerous closely set conical spines with light yellow, thick flesh. The fruits are available in the market in the lean period of vegetables

Table-1 : Mean of different flower characters of five female clones.

Genotype	Sepal length (mm)	Sepal width (mm)	Petal length (mm)	Petal width (mm)	Ovary length (mm)	Ovary diameter (mm)	Style length (mm)
Purulia Local-1	9.41	1.80	52.99	37.56	15.48	8.55	6.51
Purulia Local-2	7.32	1.99	48.29	39.69	17.05	8.98	4.56
Purulia Local-3	9.40	1.73	48.46	38.48	16.09	7.49	6.49
Assam Local	5.90	1.73	38.19	25.39	21.52	7.41	4.49
Mondouri Local	8.26	1.80	42.62	21.75	14.98	5.55	4.52
S.E.d	0.22	0.13	0.67	0.93	0.48	0.38	0.31
C.D.	0.51	0.31	1.54	2.16	1.11	0.88	0.72

Table-2 : Morphological characters of five female clones of teasle gourd.

Genotype	Leaf shape	Tendrill character	Stem character	Flower colour	Stigma head colour	Fruit shape	Spine character	Spine colour at early stage	Spine colour at marketable stage
Purulia local-1	Cordate, with dentate margin	Tendrill robustness medium, clock wise & anti-clock wise twining, length medium	Angular	Light creamy white with yellow base and black patch at base; yellow tinge on tip of petal	Light yellow, stigma head slightly spread	Oblong/ Shaped	Sharp	Light Green	Green with light yellowish spine colour
Purulia local-2	Cordate, with dentate margin	Tendrill robustness medium, clock wise & anti-clock wise twining, length medium	Angular	Deep creamy white with light yellow base with black patch at base	Light yellow, stigma head slightly spread	Oblong/ Shaped	Moderate	Deep Green	Light Green
Purulia local-3	Cordate, with dentate margin	Tendrill robustness medium, clock wise & anti-clock wise twining, length medium	Angular	Light creamy white with light yellow base with black patch at base	Light yellow, stigma head slightly spread	Oblong/ Shaped	Moderate	Green	Light Green
Assam local	Cordate, with dentate margin	Tendrill robustness medium, clock wise & anti-clock wise, length medium	Angular	Creamy white with deep yellow base with black patch at base	Greenish yellow, stigma head compact	Spindle Shaped	Moderate	Light golden tip with green base	Golden-green with golden spines
Mondouri local	Cordate, with dentate margin, conspicuous teeth	Tendrill robustness medium, clock wise & anti-clock wise length medium	Angular	Deep creamy white with light yellow base with black patch at base	Deep yellow, stigma head slightly spread	Ellipsoid Shaped	Sharp	Deep Green	Green

(April to October). Different approaches for genetic improvement plays the vital role in enhancing the yield potential of any vegetable crop. However, very little research work has so far been done on teasle gourd, the highly nutritive cucurbit.

Materials and Methods

The experiment was laid out in randomized block design with four replications at All India Coordinated Project on Vegetable Crops situated at C Block farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, during the period of 2007 - 08 to 2009-10.

Five diverse female clones of teasle gourd maintained at the AICRP Vegetable Crops, Bidhan Chandra Krishi Viswavidyalaya, Kalyani centre viz., Assam Local, Purulia Local-1, Purulia Local-2, Purulia Local-3 and Mondouri local constituted the plant material for the present investigation. Observations were recorded for some morphological characters viz.; sepal length (mm), sepal width (mm), petal length (mm), petal width (mm), ovary length (mm), ovary diameter (mm), style length (mm), leaf shape, tendrill character, stem character, flower colour, stigma head colour, fruit shape, spine character, spine colour at early stage and spine colour at marketable stage. Some agronomical characters viz.; length of main vine (m), no. of vines/plant, no. of leaves/plant fruit weight at marketable stage (g), ovary diameter (mm), no. of seeds/fruit, no. of fruits/plant, yield/plant (kg) were evaluated also. Observations were recorded for fruit quality characters viz., fruit weight at marketable stage (g), ovary diameter (mm), fruit length at marketable stage (cm), fruit breadth at marketable stage (cm), pericarp thickness at marketable stage (mm), TSS in exocarp ($^{\circ}$ Brix), TSS in mesocarp ($^{\circ}$ Brix), acidity in exocarp (%), acidity in mesocarp (%), ascorbic acid in exocarp (mg/100g), ascorbic acid in mesocarp (mg/100g), total sugar in exocarp (%), total sugar in mesocarp (%), reducing sugar in exocarp (%), reducing sugar in mesocarp (%), β -carotene in exocarp (mg/100g fresh) and β -carotene in mesocarp (mg/100g). The means and their SEM were worked out.

Results and Discussion

Size of different floral parts showed considerable variation among five female clones (Table 1). Sepal length ranged between 5.90 mm (Assam Local) and 9.41 mm (Purulia Local-1), however, sepal width comparatively less variable ranging from 1.73 mm (Assam Local) to 1.99 mm (Purulia Local-2). Petal length was lowest in Assam Local (38.19 mm) and highest in Purulia Local -1 (52.99 mm). It appeared no relationship between flower size and ovary size. Assam Local having smallest flower had the biggest ovary length (21.52 mm) compared to that of the others.

Table-3 : Mean fruit yield and yield components in five female clones.

Female clone	Length of main vine (m)	No. of vines/plant	No. of leaves/plant	Fruit weight at marketable stage (g)	Ovary diameter (mm)	No. of seeds/fruit	No. of fruits/plant	Yield/plant (kg)
Purulia Local-1	10.43	2.31	133.59	58.75	8.55	22.32	25.96	1.52
Purulia Local-2	10.12	2.42	132.69	61.22	8.98	22.61	28.35	1.73
Purulia Local-3	10.06	2.52	135.19	64.86	7.49	22.62	27.58	1.78
Assam Local	11.57	3.01	143.09	56.78	7.41	21.99	20.99	1.18
Mondouri Local	12.23	2.64	144.46	46.30	5.55	22.06	24.91	1.14
S.E.d	0.05	0.11	2.99	1.27	0.38	0.09	1.50	0.11
C.D.	0.13	0.24	6.90	2.93	0.87	0.21	3.46	0.24

Table-4 : Mean fruit and fruit quality characters in five female clones.

Female clone	Fruit weight at marketable stage (g)	Ovary diameter (mm)	Fruit length at marketable stage (cm)	Fruit breadth at marketable stage (cm)	Pericarp thickness at marketable stage (mm)	TSS in exocarp (°Brix)	TSS in mesocarp (°Brix)	Acidity in exocarp (%)	Acidity in mesocarp (%)
Purulia Local-1	58.75	8.55	6.54	4.90	3.39	2.21	6.41	0.19	0.20
Purulia Local-2	61.22	8.98	6.21	6.21	4.25	4.35	5.35	0.15	0.15
Purulia Local-3	64.86	7.49	6.66	4.85	4.50	4.08	5.23	0.26	0.18
Assam Local	56.78	7.41	6.82	4.32	4.13	5.08	8.16	0.19	0.33
Mondouri Local	46.30	5.55	5.55	4.49	3.97	4.35	8.16	0.18	0.17
S.E.d	1.27	0.38	0.14	0.85	0.46	0.10	0.09	0.02	0.03
C.D.	2.93	0.88	0.31	1.97	1.07	0.24	0.20	0.04	0.08

Table-4 : Contd...

Female clone	Ascorbic acid in exocarp (mg/100g)	Ascorbic acid in mesocarp (mg/100g)	Total sugar in exocarp (%)	Total sugar in mesocarp (%)	Reducing sugar in exocarp (%)	Reducing sugar in mesocarp (%)	β-carotene in exocarp (mg/100g fresh)	β-carotene in mesocarp (mg/100g)
Purulia Local-1	278.77	21.67	0.97	1.09	0.86	0.96	2.64	1.18
Purulia Local-2	179.20	12.41	1.38	1.49	1.06	1.11	2.37	0.51
Purulia Local-3	205.46	19.56	1.12	1.48	0.94	0.77	2.61	0.88
Assam Local	103.02	20.21	2.33	5.01	1.27	1.68	1.11	0.84
Mondouri Local	186.49	30.02	2.01	3.03	1.54	1.79	1.33	0.74
S.E.d	5.07	0.39	0.08	0.15	0.04	0.08	0.20	0.12
C.D.	11.71	0.89	0.18	0.35	0.08	0.18	0.47	0.27

Style length also varied considerably among the clones ranging from 4.52 mm (Mondouri Local) to 6.51 mm (Purulia Local-1). General plant characters of five female clones of teale gourd have been presented in Table 2. Leaf shape in all the clones is cordate, with dentate margin. In all the clones, stem is angular in shape, medium robust tendrils are present with both clock wise and anti-clockwise twining habit. Petals are creamy to light creamy white with yellow base and black patch of pollinator guide spot at base. In Purulia Local-1, yellow tinge was found on tip of petal. In four clones, stigma head

was slightly spreading and greenish to light greenish yellow in colour. However, In Mondouri Local stigma head was deep yellow in colour. In Purulia Local-1, Purulia Local-2 and Purulia Local-3, fruits were oblong or oval shaped, in Assam Local it was spindle shaped and in Mondouri Local fruit was ellipsoid in shape. In Purulia Local-1 and Mondouri Local, spines on the fruit were sharp while in other three clones, viz., Purulia Local-2, Purulia Local-3 and Assam Local, the spines were moderate. In Purulia Local-2, Purulia Local-3 and Mondouri Local, spines were green to light green at

marketable maturity stage while it was green with light yellowish spine in Purulia Local-1 and golden-green with golden spines in Assam Local. Teasle gourd is asexually propagated through fleshy roots and this system of propagation offers less chance to create variability. Mean of the eight different characters recorded in the five female clones have been presented in Table 3. The data for different characters viz., length of main vine (m), vines per plant, fruit weight at marketable stage (g), ovary diameter (mm), seeds/fruit, fruits/plant and fruit yield/plant (kg) showed quite a good variation among the female clones, showing the suitability of the genotypes for carrying out the study of genetic variability for different characters. Different characters expressed in clones have been used to study the genetic component of variation for these characters. Similar relationships has also been reported by Krishnaprasad, V. S. R. and Singh, D. P. (1990) and Rasul, M.G. *et al.*, (2004).

Mean of the 17 different fruit and fruit quality characters recorded in the female clones has been presented in Table 4. The data for different characters viz., fruit weight at marketable stage (g), ovary diameter (mm), fruit length at marketable stage (cm), fruit breadth at marketable stage (cm), pericarp thickness at marketable stage (mm), TSS in exocarp (°Brix), TSS in mesocarp (°Brix), acidity in exocarp (%), acidity in mesocarp (%), ascorbic acid in exocarp (mg/100g), ascorbic acid in mesocarp (mg/100g), total sugar in exocarp (%), total sugar in mesocarp (%), reducing sugar in exocarp (%), reducing sugar in mesocarp (%), β -carotene in exocarp (mg/100g fresh) and β -carotene in mesocarp (mg/100g) showed quite a good variation among the female clones, indicating the suitability of the

genotypes for carrying out the study of genetic variability for different characters.

Teasle gourd emerged as high ascorbic acid containing cucurbit and at the same time range of ascorbic acid content was very high between 103.02 mg/100g fresh weight in Assam Local and 278.77 mg/100 g fresh weight in Purulia Local-1 suggesting ample scope for selection in enhancing ascorbic acid content in the fruits. Contents of TSS, acidity and sugar contents were much higher in the mesocarp of the fruit while, ascorbic acid and β -carotene contents were much higher in the exocarp of the fruits (Table 1). These findings abnegate peeling of the fruits during preparation of dishes. Dubey and Gaur (1990) and Awasthi *et al.*, (1988) also estimated different proximate compositions of the fruits of promising clones.

References

1. Krishnaprasad VSR, Singh DP (1990). Studies on morphological and agronomical components of pointed gourd. *Indian J. Hort.* 47: 337-340.
2. Rasul MG, Hiramatsu M, Okubo H (2004). Morphological and physiological variation in kakrol. *J. Faculty Agril. Kyushu Univ.* 49: 1-11.
3. Awasthi GP, Singh I S, Singh A, Singh A (1988). Biochemical composition of promising karonda cultivars. *Prog. Hort.* 20: 190-196.
4. Dubey A K, Gaur GS (1990). Biochemical studies of four strains of kakrol. *Veg. Sci.* 17: 31-37.
5. Hossain MA, Islam M, Ali M (1996). Sexual crossing between two genetically female plants and sex genetics of kakrol. *Euphyt.* 90: 121-125.



Impact of Front Line Demonstration on Yield and Profitability of Mustard in Ratlam District of Madhya Pradesh

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Abstract

Front Line Demonstration is one of the most powerful tools for transfer of technology among the farming community. Front Line Demonstration (FLD), a further advanced methodology has been used to enhance the yield and income of the mustard growers. This crop is primarily raised for its edible oil. It's Seeds contain 35-40 Percent oil and 16-22 percent protein and high level of essential amino acids. The present study was undertaken to find out the yield gap through FLDs on mustard crop. Demonstration were conducted at four location covering 70.00 ha area in a participatory mode using improved cultivar NRCDR-2 during 2017-18 to 2019-20. Results showed that an average yield recorded to be 15.57 to 17.88 q/ha with the mean yield of 16.76 over farmers practices 14.20 q/ha in the year 2019-20. The economic analysis cost of cultivation varied from Rs. 16600 to 19100/ha with an average cultivation cost of Rs. 116833/ha in comparison that of Rs 12900 to 18600/ha with the average value of Rs. 16378/ha under farmer practices. The results clearly indicate the positive effects of FLDs over the existing practices. Benefit: cost ratio was recorded to be higher under demonstrations against control treatments during the years of experimentation.

Key words : Impact, mustard crops, front line demonstration, technology gap.

Introduction

The Front Line Demonstration (FLD) is an applied approach to accelerate the dissemination of proven technologies at farmers fields in a participatory mode with an objective to explore the maximum available resources of crop production and also to bridge the productivity gaps by enhancing the production in national basket. In world, rapeseed-mustard is the third most important oilseed crop after soybean (*Glycine max*) and palm (*Elaeisguineensis* 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 crop after groundnut sharing 27.8% and play important role in the oilseed economy on country. The share of oilseeds is 14.1% out of the total cropped area in India, rapeseed-mustard accounts for 3% of it. In India, rape seed mustard is an important source of edible oil followed by ground nut (Panday *et al.*, 1999). India contributes 28.3% and 19.8% in world acreage and production. India produces around 6.7 mt of rapeseed-mustard next to China (11-12 mt) and EU (10-13 mt) with significant contribution in world rapeseed-mustard industry. In India, rapeseed-mustard occupy 5.99 million ha area with production and productivity of 6.31 million tones and 1053 kg/ha respectively (India stat 2014-15). However, in Madhya Pradesh it is grown in 0.64 mha with production of 0.72 million tonnes. The average productivity of Madhya

Pradesh is 1125 kg ha⁻¹. (Anonymous, 2012). In India, major mustard growing states of the country are Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh. *B. juncea* is the most important oilseed crop of Northern Madhya Pradesh comprising Tikamgarh, Satna, Ratlam, Morena, Bhind, Gwalior, Sheopur and Datia districts contributing more than 80% share in the production of this crop in the state. Rapeseed mustard is the major source of income specially even to the marginal & small farmers in rainfed areas. Because of its low water requirement, rapeseed-mustard crops fit well in the rainfed cropping system. The present study was conducted to impact assessment of front line demonstration on mustard crop in the operational area of the KVK.

Materials and Methods

This research paper is based on the cluster frontline demonstrations conducted by the KVKs in their operational areas. The cluster approach is being promoted with FLDs to realize the visible impact of the technological intervention over a larger areas so that a mass of farmers could be aware with the technology and would be able to adopt the same over due course of time. In this finding, results in terms of productivity and profitability per unit area realized by the farmers are given. Performance of the demonstrating KVKs has been compiled and compared for interpretation and inference. The demonstrations were conducted on 150 farmers'

Table-1 : Yield performance and gap analysis of front line demonstrations on mustard crop.

Year	No. of Demo	Area (ha)	Yield performance (q/ha)		% increase	Technology gap (q/ha)	Extension Gap (q/ha)	Technology Index (%)
			FP	DP				
2017-18	75	40	14.05	16.83	19.79	5.3	2.78	23.95
2018-19	50	20	13.72	15.57	13.51	6.56	1.85	29.64
2019-20	25	10	14.2	17.88	25.92	4.25	3.68	19.20
Average	150	70	13.99	16.76	19.74	5.37	2.77	24.27

Table-2 : Economics performance of Mustard Crops.

Year	Gross return (Rs./q)		Cost of cultivation (Rs./q)		Net Return (Rs./q)		B : C ratio	
	FP	DP	FP	DP	FP	DP	FP	DP
2017-18	49175	60200	12900	13600	36275	46600	3.81	4.43
2018-19	60480	70253	17633	17800	42847	52453	3.43	3.95
2019-20	62835	85845	18600	19100	44235	66745	3.38	4.49
Average	57497	72099	16378	16833	41119	55266	3.54	4.29

fields covering 70 ha area of Ratlam districts in 2017-18 to 2019-20. The necessary step for the selection of site and farmers, lay out of demonstration, etc. were followed as suggested by Chaudhary (1999). The traditional practices were maintained in case of local check. The data output were collected from both FLD plots as well as control plot and finally the extension gap, technology gap, technology index along with the benefit-cost ratio were calculated as suggested by Samui *et al.* (2000).

Technology gap = Potential yield – Demonstration yield

Extension gap = Demonstration yield – Farmers yield

$$\text{Technology index (\%)} = \frac{\text{Technology gap}}{\text{Potential yield}} \times 100$$

Results and Discussion

Yield gap of mustard crop : The data showed in Table-1 that the yield of mustard fluctuated successively over the years in demonstration plot. The maximum yield was reported (15.57 q/ha) during the year 2018-19 and minimum yield was reported in the year 2019-20 (17.88 q/ha) and the average yield of three year was reported 16.76 q/ha over farmer's practice (13.99 q/ha). During three years of study, the per cent increase over farmer's practice was ranging between 13.51 to 25.92. On an average, there was 19.74 per cent increase in yield under FLD plots over farmers' practices followed for cultivation of Mustard. The results are similar with the findings of Tomer *et al.* (2003), Tiwari and Saxena (2001) and Tiwari *et al.* (2003). The data indicated that the positive effect of front line demonstration over the existing practices towards increasing the yield of mustard in Ratlam district of Madhya Pradesh. During the period of study emphasis the need to educate the farmers through various techniques for adoption of improved agricultural production reverse the trend of wide extension gap. An extension gap between demonstrated technology and farmers practices ranges from 1.85 to 3.68 q/ha during different three years

and on average basis the extension gap was 2.77q/ha (Table-1). This gap might be attributed to adoption of improved technology in demonstrations which resulted in higher grain yield than the traditional farmers' practices. More and more use of latest production technologies with high yielding variety will subsequently change this alarming trend of galloping extension gap. The new technologies will eventually lead to the farmers to discontinue the old technology and to adopt new technology. The findings were in line with the findings of Goswami *et al.* (1996) and Hiremath and Nagaraju, (2010). Wide technology gap were observed during different years and this was lowest (4.25 q/ha) during 2019-20 and was highest (6.56 q/ha) during 2018-19. The average technology gap found was 5.37q/ha. The difference in technology gap during different years could be due to more feasibility of recommended technologies during different years. Technology gap imply researchable issues for realization of potential yield, while the extension gap imply what can be achieved by the transfer of existing technologies. Similarly, the technology index for all the demonstrations during different years were in accordance with technology gap. Higher technology index reflected the inadequate proven technology for transferring to farmers and insufficient extension services for transfer of technology. The technology index shows the feasibility of the evolved technology at the farmer's fields and the lower the value of technology index more is the feasibility of the technology. The results were in conformity with the findings of Jeengar, *et al.* 2006 and Mitra and Samajdar (2010). The probable reason that could be attributed to the high feasibility of mustard production technology was that the participant farmers were given opportunity to interact with the scientist and they were made to adopt recommended practices and skills during the process of demonstration.

Different variables like seed, fertilizers, labourers and pesticides were considered as critical inputs for the

demonstrations as well as farmers practice. The inputs and outputs prices of commodities prevailed during the study of demonstrations were taken for calculating gross return, cost of cultivation, net return and benefit: cost ratio (Table-2). Economic returns as a function of grain yield and MSP sale price varied during different years. Maximum returns (Rs. 85,845/-ha) during the year 2019-20 was obtained due to higher grain yield and MSP sale rates as declared by Government of India. The higher additional returns and effective gain obtained under demonstrations could be due to improved technology, nonmonetary factors, timely operations of crop cultivation and scientific monitoring. The highest benefit: cost ratio (BCR) was 4.49 during the year 2019-20 might be due to higher MSP sale rate declared by Government of India. It depends on grain yield and MSP. Overall average BCR was found to be 4.29 among the demonstrated plots. The results confirm the findings of frontline demonstrations on oilseed and pulse crops by Yadav *et al.* (2004) and Lathwal (2010).

Conclusions

It was thus, concluded that the use of scientific method of Mustard cultivation can reduce the technological gap to a considerable extent thus leading to increase productivity of mustard in Ratlam districts of Madhya Pradesh. On the basis of the result obtained in present study it can be concluded that use of improved method of mustard cultivation can reduced the technology gap to a considerable extent thus leading to increase productivity of mustard in the district. Extension gap ranged between 1.85 to 3.68 q/ha which emphasis the need to educate the farmers through various means like village level training, on campus training, method demonstration, front line demonstration, etc. Technology index which shows the feasibility of the technology demonstrated has depicted good performance of the intervention. For realizing higher productivity and profitability per unit area by cultivating hybrid mustard, suitable varieties, integrated nutrient management, integrated pest management play a greater role to the farmers. District specific technology modules again can make a difference for enhancing productivity.

The concept of front line demonstration may be applied to all farmer categories including progressive farmers for speedy and wider dissemination of the recommended practices to other members of the farming community.

References

1. Chaudhary B.N. 1999. KrishiVigyan Kendra- A guide for KVK managers. *Division of Agricultural Extension*, ICAR, 73-78.
2. Goswami S.N., Choudhary A.N., and Khan A.K. 1996. Yield gap analysis of major oilseed of Nagaland. *Journal of Hill Research*. 9(1): 85-88.
3. Hiremath S.M., Nagaraju M.V. 2010. Evaluation of on-farm front line demonstrations on the yield of chilli. *Karnataka Journal of Agricultural Science*. 23(2): 341-342.
4. Jeengar K.L., Panwar P, Pareek O.P. 2006. Front line demonstration on maize in Bhilwara District of Rajasthan. *Current Agriculture*. 30(1/2): 115-116.
5. Lathwal O.P. 2010. Evaluation of front line demonstrations on blackgram in irrigated agro ecosystem. *Annals of Agricultural Research*, 31(1&2): 24-27.
6. Mitra Biplab, Samajdar Tanmay. 2010. Yield gap analysis of rapeseed-mustard through front line demonstration. *Agricultural Extension Review*. 12(6): 16-17.
7. Panday. I. D, Basudeo Singh and J.N. Sachan. 1999. Brassica Hybrid research in India: status and prospects. Proceedings of the tenth international rape seed congress. Canberra, Australia.
8. Samui SK, Maitra S, Roy DK, Mandal AK, Saha D. 2000. Evaluation of front line demonstration on groundnut. *Journal of Indian Society of Coastal Agricultural Research*. 18(2): 180-183.
9. Tiwari K.B., Saxena A. 2001: Economic analysis of FLD of oilseed in Chhindwara. *Bhartiya Krishi Anusandhan Patrika*.; 16(3&4): 185-189.
10. Tiwari R.B., Singh V., Parihar P. 2003. Role of FLD in transfer of gram production technology. *Maharashtra Journal of Extension Education*. 22(1): 19.
11. Tomer L.S., Sharma B.P., Joshi K 2003. Impact of front line demonstration of soybean in transfer of improved technology. *Journal of Extension Education*. 22(1): 139.
12. Yadav D.B., Kamboj B.K., Garg R.B. 2004. Increasing the productivity and profitability of sunflower through front line demonstrations in irrigated agroecosystem of eastern Haryana. *Haryana Journal of Agronomy*. 20(1&2): 33-35



Effect of Feeding Mineral Mixture on Blood Serum Biochemical Profile in Crossbred Cattle

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Abstract

Present investigation was carried out at gowshala dairy farm of Department of Animal Husbandry & Dairying, Banaras Hindu University, Varanasi U.P. for this trial 24 infertile crossbred cows were selected and divided into two equal groups viz. control and treatment. Cows were subjected to β -carotene incorporated mineral-vitamin supplemented for 45 days. Blood samples were collected by puncturing jugular vein at neck. Serum was separated from collected blood samples and analyzed for certain biochemical parameters cholesterol and total protein. These serum biochemical constituents were compared with serum levels in control group and treatment group and it is found that the cholesterol & total protein content was higher in treatment group.

Key words : Blood serum profile, biochemical analysis, blood serum total protein, blood serum cholesterol, mineral mixture.

Introduction

Minerals and vitamins have a direct or indirect impact on animal productivity and reproduction. The link has been proven via study into the patho-biological consequences of deficiency as well as supplementation for disease treatment. Some vitamins are essential for supporting healthy immune function and acting as anti-stress agents. As a result, an immune competency test is beneficial for assessing vitamin needs. Immune function has higher requirements than production or reproduction (Xin *et al.*, 1991 and Weiss, 1998). Mineral deficiencies and imbalances during the periparturient period are either associated with metabolic disorders, foetal membrane retention (Gupta *et al.*, 2005), dystocia, abortion, weak calf syndrome (Logan *et al.*, 1990), milk fever, and vulval discharge (Husband, 2006), or have a negative impact on the cow's subsequent fertility. Such problems may most likely be avoided if the primary aetiology was addressed by balanced food and mineral supplements during early pregnancy and the early post-partum period, when the animals are most vulnerable to the stress of high nutritional demand and drain (Mandali *et al.*, 2002). In dairy animals milk production can be boosted by addition of chelated minerals in daily ration (Bhosale *et al.*, 2021)

Minerals have an intermediary role in the coordinated action of hormones and enzymes at the subcellular level, hence regulating reproductive and

production processes in domestic animals. Minerals such as calcium, phosphorus, and magnesium have an impact on an animal's capacity to use other micro minerals. Nutritional deficits in animals cause mineral depletion and abnormal enzymatic activity, which affects normal reproductive behaviour. The nutritional status of minerals and other elements may be determined using a biochemical profile, which can aid in the diagnosis and treatment of infertility in animals. The anestrus condition in dairy cows not only has a significant impact on the cattle's fertility, but it also costs the farmer a lot of money. Mineral imbalances or deficiencies might be one of the causes of anestrus in animals.

During the estrus cycle, some biochemical elements in blood serum have been linked to the fertility state of cows and their reproductive behaviour. Many authors' studies imply that adequate blood levels of numerous biochemical constituents are required for the correct function of many physiological systems, including the reproductive system. The goal of this study was to see if there was a link between various serum biochemicals, such as mineral status, and repeat breeding condition in dairy cows. Changes in these metabolites' levels have been linked to reproductive failure. The levels of serum cholesterol and total protein in crossbred cows have been investigated in order to determine their probable participation and utility.

Materials and Methods

The study was planned and conducted at gowshala dairy farm of Department of Animal Husbandry & Dairying, Banaras Hindu University, Varanasi (U.P) on 24 cross-bred non-cyclic, non-pregnant cattle. This cows which were not observed in estrus for atleast six months considered as non-cyclic animals. On the basis of clinical observations, cattle affected with any kind of infectious causes or structural pathological abnormalities were excluded from the study. Cattle were selected of same breed, all cattle are cross bred (sahiwalxH.F.) Age of all cattle was around 3-6 years. Body weight of all cattle around 350-500 kg. Body condition of cattle is good muscular, attractive, shiny hair coat and active eyes.

Housing and Feeding : The experimental animals were maintained in loose housing system under group Management practice with proper drainage, soft bedding, feeding and watering facilities. The nutrient requirements of all experimental animals were mostly met with *adlibitum* green fodder and measured amount of concentrate minerals as feed additives. The composition of minerals were presented in table-1 and 2. The green fodders, grown in the Institute farm, were supplied according to the seasonal availability. During summer and rainy seasons

Table-1 : Rovimix Cal-P strong (DSM nutritional product) (each 100 g contain).

Minerals/Ingredients	Quantity
Calcium	26 g
Phosphorus	14.25 g
Rovimix vitamin B ₁₂	400 mcg
Rovimix vitamin D ₃	16000 IU

Table-2 : Rovimix ovn dairy premix (DSM nutritional products).

Mineral/Ingredients	Quantity
Rovimix vitamin-A	2.000 MIU
Rovimix vitamin-D3	0.400 MIU
Vitamin-E	20.000 MIU
Biotin	0.400 gm
Niacin	10.000 gm
Beta-carotene	10.000 gm
Iron	12.000 gm
Copper	4.000 gm
Manganese	15.000 mg
Zinc	16.000 gm
Magnesium	80.000 gm
Cobalt	0.400 gm
Iodine	0.300 gm
Selenium	0.120 gm
Chromium	0.500 gm
Potassium	5.000 gm
Sodium	6.000 gm

predominantly maize and sorghum were fed whereas in winter, fodders like barseem, oat, were fed. Feedings were spread in 3 to 4 feeding during day and night. The concentrate was fed @1.5 kg/day/animal for body maintenance in general. Concentrate mixture had 20% CP and 70% TDN consisted of 33% maize, 21% ground nut cake (oiled), 12% mustered cake (oiled) 20% wheat bran, 11% de-oiled rice bran, 2% mineral mixture and 1% common salt.

Treatment Details :

1. 50 gm Rovimix ovn dairy premix (DSM nutritional products) in evening.
2. 50 gm Rovimix Cal-P strong (DSM nutritional product) in morning.

Collection of blood and serum : About 10 ml of blood samples were drawn from the Jugular vein with 18g sterilized needles from each animal, (both experimental and control). Blood samples were transferred immediately in dry, sterilized glass test tubes and kept at 45° angle in room temperature after proper coding. Serum samples were collected carefully into different sterilized micro-centrifuse tubes with the help of sterilized Pasteur pipettes and kept at -20°C temperature till analysis.

Blood Biochemical Parameters : Serum total protein gm/dl and cholesterol gm/dl were estimated from each serum samples. The level of total protein was determined by the Biuret method as described by Wotton (1964). The level of serum cholesterol was estimated in Micro lab 200 Auto analyser using commercial kits.

Observations used for heat detection & Breeding : All the cows were checked and parameters like duration of onset of estrous post protocol, total duration of estrous and the signs of estrous like-restlessness and mounting behavior, discharge and its amount, bellowing and tonicity of uterus were recorded. All cows were artificially inseminated with frozen semen of high fertility.

Statistical analysis : The Data obtained during investigation were subjected to statistical analysis using independent t-test (Student, 1908).

Results and Discussion

The use of a mineral-vitamin premix containing -carotene has been tested to improve the reproductive performance of infertile cows. The experimental treatment group's animals reacted effectively to the treatment regimen. In the therapy group, 50 percent of the animals developed oestrus signs, with a mean interval of 22 days.

Blood serum total protein (gm/dl) : The overall mean of blood serum total protein (gm/dl) is presented in table 3 and it is depicted from the data that the values differ

Table-3 : Blood serum total protein (gm/dl).

Days	Mean $\pm$ SE		SEM	C.D.	P value
	T ₀	T ₁			
0	7.79 $\pm$ 0.27	7.82 $\pm$ 0.17	0.22	0.60	0.463
45	7.24 $\pm$ 0.17 ^b	9.31 $\pm$ 0.14 ^a	0.16	0.52	0.001
Overall mean	7.01 $\pm$ 0.22 ^b	8.57 $\pm$ 0.16 ^a	0.19	0.56	0.232

^{ab}Within a column means without common superscript differs (P<0.05).

Table-4 : Blood serum cholesterol (gm/dl).

Days	Mean $\pm$ SE		SEM	C.D.	P-value
	T ₀	T ₁			
0	131.17 $\pm$ 0.17	131.50 $\pm$ 0.15	0.16	0.42	0.080
45	132.91 $\pm$ 0.15 ^b	147.53 $\pm$ 0.41 ^a	0.28	0.91	0.004
Overall mean	132.04 $\pm$ 0.16 ^b	139.51 $\pm$ 0.28 ^a	0.22	0.66	0.042

^{ab}Within a column means without common superscript differs (P<0.05).

significantly ($p<0.05$) among the treatments. The initial values at 0th day was 7.79 $\pm$ 0.27 and 7.82 $\pm$ 0.17 gm/dl for control (T₀) and treatment group (T₁), respectively & it differ non- significantly. But after completion of feeding trial the results was 7.24 $\pm$ 0.17 blood serum total protein in anoestrus condition was 7.0886 $\pm$ 0.323 gm/dl for control group and 9.31 $\pm$ 0.14 gm/dl for treated group & it differ significantly higher ($p<0.001$). The observation corroborated with the findings of Naidu and Rao (1982), Chetty and Rao (1986), Kabir *et al.* (2001).

Several researchers (Patil and Deshpande, 1979; Naidu and Rao, 1982; Agarwal *et al.*, 1985; Singh and Vadnere, 1987) discovered a direct link between animal mineral status and physiological functions and observed disorders, and blamed altered mineral and enzyme levels for loss of production and reproduction. When compared to cattle and buffaloes in normal estrus, anoestrus cattle and buffaloes have lower levels of blood insulin, Ca, P, Mn, I, Co, Fe, Cu, and the Ca:P ratio.

Blood serum cholesterol (gm/dl) : The mean values of blood serum cholesterol (gm/dl) for groups T₀ and T₁ is presented in table-4 and it differ significantly ($p<0.05$). During 0th day of experiment the values was 131.17 $\pm$ 0.17 for T₀ and 131.50 $\pm$ 0.15 for T₁. This values was at par with each other. But at the end of experimental period the values was 132.91 $\pm$ 0.15 for T₀ and 147.53 $\pm$ 0.41 for T₁. The statistical analysis shows significant difference ($p<0.05$) within the different groups. Similar findings were reported by Nayyar *et al.*, 2002.

This might be because Selenium (Se) improves cell viability, immunological response, and muscle contraction, which leads to early uterine involution through anti-oxidative activity. Increased levels of vitamin E, α -carotene, and decreased lipid peroxidation (Nayyar *et al.*, 2002); increased levels of glucose, cholesterol, triiodothyronine, and thyroxine (Nayyar *et al.*, 2003); and

improved blood biochemical composition (Nayyar *et al.*, 2003). (Anita *et al.*, 2004).

Conclusions

Vitamins and minerals are one of the most significant components in dairy animal production and reproduction. The majority of periparturient diseases in dairy cattle and buffaloes are caused by vitamin and mineral deficiencies. Effective mineral and vitamin supplementation throughout the transition period to meet the high demand caused by nutritional loss during this stage of life.

In this investigation, a total of 24 infertile crossbred cows were chosen to induce oestrus in order to rectify anoestrosis using vitamin-permix containing α -carotene. After the therapy, 8 out of 24 animals showed signs of oestrus. Fifty percent of the animals given carotene integrated vitamin-permix (treatment group) displayed oestrus signs. 16.66 percent of the animals under supervision went into heat in control group.

References

1. Agarwal S.K., Pandey, N.N. and Shanker, U. (1985). Serum protein, inorganic phosphorous and blood glucose in relation to different phases of reproduction in crossbred cattle. *Indian J. Anim. Reprod.*, 6: 23-25.
2. Anita, Singh, S.P.S. and Nayyar, S. (2004). Vitamin E and selenium influence the blood biochemical constituents in postpartum anoestrus buffaloes. *Indian J. Anim., Sci.*, 74(4): 376-378.
3. Bhosale, T.R., Antre, G.R., Kumar, D. and Pandey, R.K. (2021). Effect of Chelated Minerals Supplement on Milk Yield and Composition of Sahiwal and Hariana Cows. *Asian Journal of Dairy and Food Research*. DOI: 10.18805/ajdfr. DR-1598.
4. Chetty, A.V. and Rao, A.R., Levels of blood constituents in anoestrus condition. *Livestock Adv.* 1986; VI: 34-37.
5. Gupta, S., Gupta, H.K. and Soni, J. (2005). Effect of vitamin E and selenium supplementation on concentrations of plasma cortisol and erythrocyte lipid peroxides and the

- incidence of retained foetal membranes in crossbred dairy cattle. *Theriogenology*, 64: 1273-1286.
6. Husband, J. (2006). Retained fetal membranes and vulval discharges in a dairy herd. *UK Vet.*, 11(1): 39-42.
 7. Kabir, K.K., Varshney, J.P., Rawal, C.V.S., Srivastava, R.S., and Ansari, M.R. (2001). Comparative efficacy of herbal preparations in the management of anoestrus in non descriptive rural buffaloes. *Indian Journal of Animal Reproduction*, 22: 143-145.
 8. Logan, F.F., Rice, D.A., Smyth, J.A. and Ellis, W.A. (1990). Weak calf syndrome and parenteral selenium supplementation. *Vet. Rec.*, 126: 163-164.
 9. Mandali, G.C., Patel, P.R., Dhami, A.J., Rawal, S.K. and Christi, K.S. (2002). Biochemical profile in buffaloes with periparturient reproductive and metabolic disorders. *Indian J. Anim. Reprod.*, 23(2): 130-134.
 10. Naidu, K.V. and Rao, A.R. (1982). A study on the etiology of anoestrus in crossbred cows. *Indian Vet. J.*, 59: 781-784.
 11. Nayyar, S., Gill, V. K., Malik, V.S., Roy, K.S. and Singh, R. (2003). Vitamin E and selenium improve the blood biochemical composition of anoestrus buffalo heifers. *Indian J. Anim. Sci.*, 73(6): 654-656.
 12. Nayyar, S., Gill, V.K., Singh, N., Roy, K.S. and Singh, R. (2002). Levels of antioxidant vitamins in anoestrus buffalo heifers supplemented with vitamin E and selenium. *Indian J. Anim. Sci.*, 72(5): 395-397.
 13. Patil, R.V. and Deshpande, B.R. (1979). Changes in body weight, blood glucose and serum proteins in relation to the appearance of postpartum oestrus in Gir cows. *J. Reprod. Fertil.*, 57: 25-27.
 14. Singh, S. and Vadnere, S.V. (1987). Induction of oestrus by supplementation of different minerals in postpartum anoestrus crossbred cows. *Indian J. Anim. Reprod.*, 8: 46.
 15. Student. (1908). The probable error of a mean. *Biometrika*, 1-25.
 16. Weiss, W.P. (1998). Requirements of fat-soluble vitamins for dairy cows: a review. *J. Dairy Sci.*, 81: 2493-2501.
 17. Wotton, J.A. 1964. Principal of animal physiology. 2nd edn., macmillan publishing co., Inc New York.
 18. Xin, Z., Waterman, D.F., Hemken, R.W. and Harmon, R.J. (1991). Effects of copper status on neutrophil function, superoxide dismutase, and copper distribution in steers. *J. Dairy Sci.*, 74: 3078-3085.



Some New Species of *Pseudocercospora* Associated with Foliar Spots in Forest Flora of Nepal Himalayas

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Abstract

Two new species of *Pseudocercospora* Speg., are described, illustrated and compared with allied taxa. These are *Ps. asteracearum* on *Ageratum conyzoides* (Asteraceae) are *Ps. hedyotigena* on *Hedyotis hispida* (Rubiaceae).

Key words : Fungi, foliicolous hyphomycetes, *Pseudocercospora*.

Introduction

The foliicolous hyphomycete genus *Pseudocercospora* was established by Spegazzini (1910) to accommodate *Septonema vitis* Lev., comprises several hundred species (Howksworth, Sutton and Ainsworth, 1983) mostly transferred from *Cercospora* Fresenius (1863) (Pollack, 1987). Most species have been interpreted as host specific, the majority confined to a single genus or even to single species however, some species may have a wide host range. According to Deighton (1976) there are probably five hundred species described in *Cercospora* which should be transformed to the genus *Pseudocercospora*. The species of this genus are particularly common in tropical, subtropical and warm temperate countries. It is characterized by usually non-necrotic but distinct leaf spots and coloured, obcalvato-cylindric, phragmosporous conidia with unthickened hila corresponding to similar scars of the conidiogener loci.

Nepal Himalayas supporting turnover of rich vegetation all the year around are characterised with diverse set of climatic and weather conditions and vegetational composition. This all provides an ideal opportunity for incidence of a variety of microorganism including fungi. The foliar fungi of forest flora which merit major concern in forest pathology have not been paid an adequate attention. In addition to a few fragmentary reports (Munjal & Kapoor, 1963; Singh, 1968, 1971; Singh & Nisha, 1973 a, 1974, 1976). However Verma & Kamal (1986 a, b; 1987 a, b) Verma *et. al.* (1990), Budathoki *et. al.* (1989), Kamal *et. al.* (1989) and Khan *et. al.* (1991) have contributed very significantly to the foliicolous fungi of this region by describing several new taxa. From amongst these, this communication describes and illustrates two novel species of *Pseudocercospora* Speg. viz. *Ps. asteracearum* on *Ageratum conyzoides*

(Asteraceae) and *Ps. hedyotigena* on *Hedyotis hispida* (Rubiaceae).

Materials and Methods

Fungi described here in this paper were collected from the forest flora of Nepal Himalaya. Infected leaves with distinct symptoms were taken to the laboratory in separate polythene bags. The specimens were dried by the method used for preparing herbarium of phanerogamic plants. A part or each specimens was sent in HCIO (Herbarium Cryptogamiae Indiae Orientalis, New Delhi) for accession. Microscopic slides were prepared in lactophenol cotton blue mixture after taking free hand sections of infected leaf portions with the help of a sharp razor blade. The slides were examined under microscope and camera lucida drawings were prepared under 15 x eye piece and 45 x objective combinations. The taxonomic determinations were made with the help of literature and experts. Descriptions were rendered latin diagnosis as per international rule.

Results and Discussion

On comparing the illustrations, descriptions and measurements of the fungi under study with the allied taxa, they were found to be hitherto undescribed. These are being described and discussed as follows :

Pseudocercospora asteracearum Rao (Fig.-1)

Maculae amphigenae, primo parvae (1-3) mm diam. angulares, veinis limitatae, deinde coalescentes et extensae in margine, brunneolo fuscae; *Coloniae* hypophyllae, effusae; *Mycelium* internum; *Hyphae* laevis, ramosae, septatae, sub-hyalinae, pallide olivaceae; *Stromata* eumorpha, parce immersa, sub-stomatibus posita, atro brunnea, pseudoparenchymatosa, 22.5-27.5 µm diam.; *Conidiophora* in fasciculo stomatibus oriunda, macronematosa, mononematosa, non ramosa, septata,

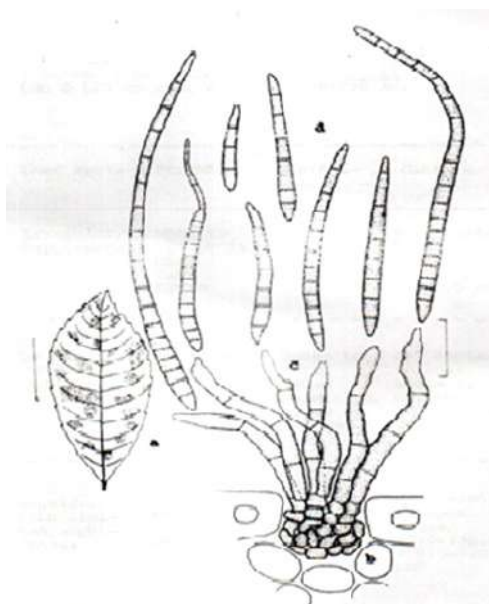


Fig.-1 : *Pseudocercospora asteracearum* sp. nov.

a. leaf spots, b. stroma, c. conidiophore, conidia.

Scales : a-20 mm; b, c, d: 20 μ m

laevia, apicem versus leniter geniculata, erecta, recta vel flexuosa, cylindrica, raro apicem versus, leniter inflata, atro olivacea, 97.0-340.0 x 3.0-6.0 μ m; *Cellulae conidiogenae* integrate terminales, sympodiales, polyblasticae, denticulatae, cicatrices conidiales non incrassatae; *Conidia* solitaria, sicca, holoblastica, acropleurogna, cylindrical vel obclavatocylindrica, recta vel leniter flexuosa, non ramosa, 5-12 transverse septata, tenui tunicate, laevia, pallide olivacea, apicem versus subacuta vel obtusa, basi obconicotruncata, hilo non incrassata, 37.0-92.5 x 2.5-7.5 μ m.

In foliis vivis *Agerati conizoidis* L. (Asteraceae); leg. H.S.G. Rao; February, 1989; Narainghat Forest, Nepal; GPU Herb. No. HK 69/2669 isotypus, HCIO 41151 holotypus.

Leaf spots amphigenous, primarily small (1-3 mm diam.), angular and vein limited, later coalescing and spreading along the margin, brownish black; *Colonies* hypophyllous, effuse; *Mycelium of hyphae* internal, branched, smooth walled, septate, sub-hyaline to light olivaceous; *Stromata* well developed, partly immersed, substomatal, dark brown, pseudoparenchymatous from which conidiophores arise in dense fascicle, 22.5-27.5 μ m in diam.; *Conidiophores* emerging from stroma in fascicles, macronematous, mononematous, unbranched, septate, smooth walled, slightly geniculate in the apical region, erect, straight to sinuous, cylindrical, few conidiophores slightly swollen at the tip, dark olivaceous, 97.0-340.0 x 3.0-6.0 μ m; *Conidiogenous cells* internal, integrated, terminal, sympodial, polyblastic, denticulate,

scars-unthickened; *Conidia* solitary, dry, acropleurogenous, cylindrical to obclavato- cylindrical, straight to slightly flexuous, unbranched, 5-12 transversely septate, thin and smooth walled, light olivaceous, sub-acute to obtuse apex and obconicotruncate base, hilum unthickened, 37.0-92.5 x 2.5-7.5 μ m.

On living leaves of *Ageratum conizoides* L. (Asteraceae); leg. H.S.G. Rao; February, 1989; Narainghat Forest, Nepal; GPU Herb. No. HK 69/2669 isotype, HCIO 41151 holotype.

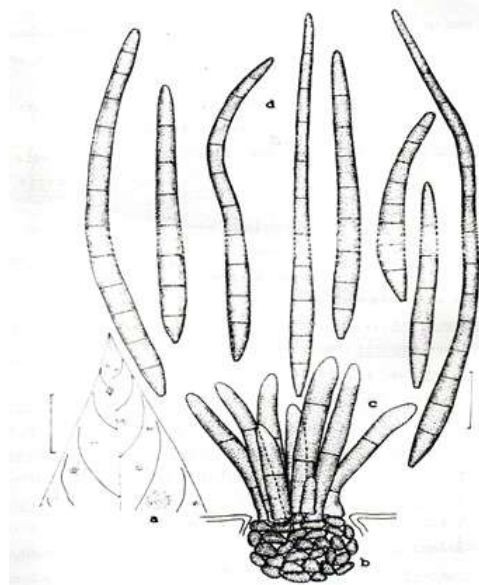
A perusal of literature indicate that none of the *Pseudocercospora* species described so far has been recorded on the host species of genus in question. However, several species of *Pseudocercospora* have been recorded earlier of different genera of the host family, Asteraceae, viz., *Ps. blumeae-balsemiferae* (Sawada) Goh and Hsieh (1989) on *Blumea balsamifera*, *Ps. blumeae* (Thimen) Deighton (1976) on *B. eriantha*, *Ps. chrysanthemicola* (Yen) Deighton (1976) on *Chrysanthemum sinense*, *Ps. cosmicola* (Kar and Mandal) Deighton (1987) on *Cosmos caudatus*, *Ps. elephantopin* Goh and Hsieh in Hsieh and Goh (1990) on *Elephantopus mollis*, *Ps. eupatorii* (Peck) Braun and Castaneda (1991) on *Eupatorium* sp., *Ps. eupatoriiformosani* (Saw.) Yen apud Yen and Lim (1980) on *Eupatorium formosanum*, *Ps. eupatoriicola* (Govindu and Thirum.) Khan and Shamsi (1983) on *Eupatorium rheveesi*, *Ps. mikaniigena* Yen and Lim (1983) on *Mikaniacordata*, *Ps. mirandensis* (Chupp) Castaneda and Braun in Braun and Castaneda (1991) on *M. auriculata*, *Ps. platycaryae* Goh and Hsieh (1989) on *Platycarya strobilacea*, *Ps. pterocauli* (Petrak) Deighton (1976) on *Pterocaulon* sp., *Ps. synadrellae* (Yen and Gilles) Deighton (1976) on *synadrella* sp., *Ps. tagetis-erectae* Goh and Hsieh (1989) on *Tagetis erecta*, *Ps. vernoniacearum* Shukla and al. (1982) on *Vernonia* sp., *Ps. noveboracensis* Goh and Hsieh in Hsien & Goh (1990) and *Ps. cinereae* (Pavgi and Singh) Deighton (1976) on *Vernonia cinerea*, *Ps. wedeliae* (Kar and Mandal) Deighton (1976) on *Wedelia wellichii*. A comparison of morphotaxonomic features of these species with our collection shows that the latter is distinct due to its unbranched multiseptate and geniculate conidiophores which are much longer than in other species under comparison. Therefore, this fungus has been described and illustrated herewith as a new species.

***Pseudocercospora hedyotigena* Rao (Fig.-2)**

Maculae plerumque in margine hypogaeae, saepe amphigenae, irregulares, plerumque atro brunneae, 2-3 mm latis; *Conloniae* hypophyllae, effusae; *Mycelium* internum; Hyphae ramosae, septatae, pallide olivaceae,

Table-1 : Comparison of distinct morphotaxonomic features of *Ps. guettardae* (Chupp) Species Deighton, *Ps. hemidioidiae* (Toro) Deighton and *Ps. hedyotigena* Rao.

Species	Leaf spots	Stromata	Conidiophores	Conidia
<i>Ps. guettardae</i> (Chupp) Deighton	Epigenous, angular, ve-in limited	30–75 µm in diam.	Very dense fascicles, unbranched, septa not visible, geniculate 10-35 x 2.0-3.5 µm	Indistinctly 1 -5 septate, 20-55x 2.0-3.5 µm
<i>Ps. hemidioidiae</i> (Toro) Deighton	Hypogenous, irregular	Lacking	Non-fasciculate, branched, multi septate, geniculate, 20-125 x3-5 µm	Multi septate, 40-130x2-4 µm
<i>Ps. Hedyotigena</i> Rao	Amphigenous, irregular	21-30 µm in diam.	Fasciculate, sometimes branched, septate, non-geniculate, 66-166 x2.5-6.5 µm	3-7 septate, 24.50-83.0x 2.5 -5.5 µm

**Fig.-2 : *Pseudocercospora hedyotigena* Rao.**
a. leaf spots, b. stroma, c. conidiophore, conidia.
Scales : a-20 mm; b, c, d: 20 µm

laevis, tenui tunicatae; *Stromata* eumorpha, parce immersa, cellulae compactae et pseudoparenchymatosae composita, pallide brunnea, 21. 0- 30.0 µm diam.; *Conidiophora* in fasciculo oriunda, mononematosa, macronematosa, non ramosa, vel saepe ramosa, septata, laevia, non geniculata, plerumque erecta, recta vel leniter curvata, cylindrica vel sub-cylindrica atro alivacea, 66.0-166.0 x 2.5-6.5 µm; *Cellulae conidiogenae* integratae, sympodiales, polyblasticae, terminales, leniter denticulatae, cicatrices conidiales non incrassatae; *Conidia* solitaria, sicca, acropleurogena, holoblastica, cylindrica vel subcylindrica et obclavatocylindrica, recta vel curvata, non ramosa, 2-7 transverse septata, laevia, tenui tunicata, pallide olivacea, apicem leniter acuta vel obtusa, basi obconicotruncata, hilo abbessea, 24.5-83.0 x 2.5-5.5 µm.

In foliis vivis *Hedyotis hispidae* Retz. (Rubiaceae); leg. H.S.G. Rao; November, 1989; Narainghat Forest,

Nepal; GPU Herb. No. HK 57/2657 isotypus, HClO 41144 holotypus.

Leaf spots mostly hypogynous, sometimes amphigenous, irregular, mostly on marginal areas, dark brown, 2-3 mm in wide; *Colonies* hypophyllous, effuse; *Mycelium of hyphae* internal, branched, septate, light olivaceous, thin and smooth walled; *Stromata* well developed, partly immersed, composed of compact pseudoparenchymatous cells with conidiophores arising in dense fascicles, light brown, 21.0-30.0 µm in diam.; *Conidiophores* fasciculate, mononematous, macronematous unbranched or sometimes branched, septate, smooth, non geniculate, mostly erect, straight to slightly curved, cylindrical to sub-cylindrical, dark olivaceous, 66.0-166.0 x 2.5 – 6.5 µm; *Conidiogenous cells* integrated, sympodial, polyblastic, terminal, slightly denticulate, scars-unthickened; *Conidia* solitary, dry, acropleurogenous, holoblastic, cylindrical to subcylindrical and obclavatocylindrical, straight to curved, unbranched, 2- 7 transversely septate, smooth, thin walled, light olivaceous, apex slightly acute to obtuse, base obconicotruncate, hilum absent, 24.5- 83. 0 x 2.5 – 5.5 µm.

On living leaves of *Hedyotis hispida* Retz. (Rubiaceae); leg. H.S.G. Rao; November, 1989; Narainghat Forest, Nepal; GPU Herb. No. HK 57/2657 isotype, HClO 41144 holotype.

A perusal of literature indicates that none of the *Pseudocercospora* species described so far have been recorded on the host species or genus in question. However, several *Pseudocercospora* species have been recorded earlier on different genera of the host family Rubiaceae, viz., *Ps. adinicola* (Kar & Mandal) Deighton (1976) on *Adena cordifolia*, *Ps. anthocephali* (Koboyashi) Deighton (1990) on *Anthocephalus chinensis*, *Ps. borrieriae* (Ell. and Ev.) Deighton (1976) and *Ps. ubatubensis* (Chupp and Viegas) Deighton (1976) on *Borreria* sp., *Ps. gardenia* (Biedijn) Deighton (1976) on *Gardenia* sp., *Ps. guettardae* (Chupp) Deighton (1975) on *Guettarda* sp., *Ps. hemidioidiae* (Toro) Deighton (1976)

on *Hemidioidia* sp., *Ps. ixorae* (Solh.) Deighton (1976) on *Ixora* sp., *Ps. meynaelaxiflorae* Kamal and al. (1985) on *Meyna laxiflora*, *Ps. ixoricola* (Yen) Yen apud Yen and Lim (1980); *Ps. paederiae* Sawada ex Goh and Hsieh (1990) on *Paederias candens*, *Ps. pavettae-indicae* (Govindu and Thirum.) Yen and al. (1982) on *Pavetta indica*, *Ps. morindae* (H. Syd.) Sarbajana (1989) on *Morinda tinctoria*, *Ps. saketensis* Mukerjee and Singh (1983) on *Anthocephalus cadamba*, *Ps. sarcocephali* (Viennot- Bourgin) Deighton (1976) on *Sarcocephalus* sp. and *Ps. xeromphidicola* Kamal and al. (1980). Out of these species, only *Ps. guettardae* and *Ps. hemidioidiae* are comparable with our collection due to somewhat similarities in morphotaxonomic features. This comparison (Table-1) shows that our fungus is distinct due to its having amphigenous leaf spots, smaller stromata as well as fasciculate, sparingly branched, non geniculate and distinctly septate conidiophores. Therefore, the fungus in question has been treated herewith as a new species.

Acknowledgement

Author is thankful to Principal B.R.D.P.G. College, Deoria and Head, Department of Botany D.D.U. Gorakhpur University, Gorakhpur for laboratory and literature facilities. Their sincere thanks are also due to the curator HCIO, New Delhi for accession to the specimens and Dr. H.D. Bharti Department of Botany, Bipin Bihari P.G. College, Jhansi for extending helpful suggestions in preparing the manuscript.

References

- Braun, U. and Urtiga, R. (2012). New species and new records of cercosporoid hyphomycetes from Cuba and Venezuela (part 1). *Mycotaxon* 3: 301-329.
- Budathoki, U., Verma, R.K. and Kamal (1989). New species of *Phaeoramularia*, *Pseudocercospora* and *Stenella* from Nepal. *Indian Phytopath.* 42: 53-67.
- Deighton, F.C. (1976). Studies on *Cercospora* and allied genera VI. *Pseudocercospora* Speg. *Pantospora* Cif. And *Cercoseptoria* Petr. *Mycol. Pap.* 140: 1- 156.
- Fresenius, G. (1863). Beitrage zur Mykologie. Frankfurt.
- Howksworth, D.L. Sutton, B.C. and Ainsworth, G.C. (1983). Ainsworth Bisby's Dictionary of the fungi, 7th edn. Kew: International Mycological Institute.
- Hernandez-Gutierrez, A. and Dianese, J.C. (2008). New cercosporoid fungi from the Brazilian Cerrado 1. Species on hosts of the families Anacardiaceae. *Mycotaxon* 106: 41-63.
- Hernandez-Gutierrez, A. and Dianese, J.C. (2009). New cercosporoid fungi from the Brazilian Cerrado 2. Species on hosts of the subfamily Caesalpinioideae, Faboideae and Mimosoideae (leguminosae. Lat.). *Mycotaxon* 107: 1-24.
- Kamal (2010), Cercosporoid fungi of India. Bishan Singh Mahendra Pal Singh Publication, Deharadun. pp. 372.
- Kamal, Khan, M.K. and Budathoki, U. (1989). A peculiar foliicolous hyphyomycetes from Kathmandu Valley, Nepal. *Ana Net.* 15: 5.
- Khan, M.K., Budathoki, U. and Kamal (1991). New foliicolous hyphyomycetes from Kathmandu Valley, Nepal. *Indian Phytopath.* 44: 21-29.
- Munjal, R.L. and Kapoor. J.N. (1963), Hyphomycetes from Himalayas, *Indian Phytopath.* 16; 85- 93.
- Pollack, F. C (1987). An annotated compilation of Cercospora names Mycological Memoir 12: 1–22.
- Singh, S.C. (1968). Some parasitic fungi collected from Kathmandu Valley, Nepal. *Indian Phytopath.* 21: 23- 30.
- Singh, S.C. (1971). Additions to the parasitic Microflora of Nepal. *Nep. Sci. Mag.* 1: 12.
- Singh, S.C. and Nisha (1973a). Note on some *Cercospora* of Nepal. *I.J. Sci. (T.C. Sci. Assn.)*, 5: 22- 24.
- Singh, S.C. and Nisha (1973b). Notes on some *Cercospora* of Nepal. II. *J. Tri. Univ.* 8: 91–99.
- Singh S.C. and Nisha (1974). *Exobasidium butleri* in Nepal. *Indian Phytopath.* 27: 387-389.
- Singh, S.C. and Nisha (1976). A contribution to the parasitic microflora of Nepal. *J. Sci. (T. C. Sci. Assn.)* 6: 11-14.
- Spegazzini C. (1910). Mycetes Argentinenses, Ser. V An. Mus. nac. *Hist. nat. B. Aires* 20: 329-467.
- Srivastava, D.K. (2013). Some taxa of foliicolous hyphomycetes genus *Pseudocercospora combreti* and *Ps. Pouzolziae* from Azamgarh district of North Uttar Pradesh, India. *Indian J. of Scientific Research*, 4: 175-177.
- Srivastava, S.L. and Topal, R. (1985). A new species of *Pseudocercospora* from Garhwal Himalayas, *Acta. Bot. Indica*, 13: 111-112.
- Verma, R.K. and Kamal (1986a). Studies on foliicolous Ascomycotina I *Proc. nat. Acad. Sci. India* 56: 140-145.
- Verma, R.K. and Kamal (1986 b). *Paraaoria himalayana* gen. et spt nov, A foliicolous coelomycete from Nepal. *Trans. Br. myol. Soc.* 87: 645-647.
- Verma, R. K. and Kamal (1987a). Studies on Foliicolous Ascomycotina-II genus *Actinocymbe*. *Indian Phytopath.* 40: 410-413.
- Verma R.K. and Kamal (1987 b) Studies on Foliicolous Ascomycotina III-Some interesting Bitunicati. *Indian Phytopath.* 40: 459-465.
- Verma, R.K., Ramesh Chand and Kamal (1990). Two new species of *Uncinula* from Nepal. *Mycol. Res.* 94: 128-130.



Evaluation of Constrains of Chickpea Production in Rajasthan with Reference to Gangour Variety

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Abstract

Constrains of Chickpea Production in Rajasthan with Reference to Gangour Variety was evaluated in this study. The evaluation was based on a household survey of Bengal gram grower in 4 villages of Bikaner District of Rajasthan. The survey revealed that improved chickpea variety showed distinctly superior performance over local cultivars but it also has some constrains viz., chickpea growers were not getting satisfactory price of their produce in both Gangour and local variety grower. Another problem faced by chickpea grower is, require more water with reference to Gangour and problem of labour with reference to local variety.

Key words : Constraints, improved variety, local variety.

Introduction

Chickpea (*Cicer arietinum* L.), is also known as garbanzo bean or Bengal gram, is an old growing pulse and one of the seventh Neolithic founder crops in the Fertile Crescent of the Near East (Lev-Yadun, *et al.* 2000). Globally, it is the third most important pulse crop in area and production, next to dry beans and field pea (FAO, 2011). Chickpea is an important legume that plays prerequisite role in terms of food and nutritional security of people in the developing countries like India, contributing to protein intake, mainly for the vegetarian population. It is a good source of carbohydrates and protein, together constituting about 80% of the total dry seed mass in comparison to other pulses (Chibbar, *et al.* 2010, Geevani, 1989). It is cholesterol free and is a good source of dietary fibres, vitamins and minerals (Wood and Grusak, 2007). It contains 23 percent protein, 64 percent carbohydrates, 47 percent starch, 5 percent fat, 6 percent crude fibre, 6 percent soluble sugar and 3 percent ash (Aykroyd and Doughty, 1982). Being a leguminous crop, it contributes in improving soil fertility by nitrogen fixation into the soil. This property has an added benefit to farmers by reducing external applications of nitrogenous fertilizers and in turn cuts cost of production and thus is environment friendly crop.

South and Southeast Asia contributes about 81 percent to the chickpea production in globe, with India as the principal chickpea producing nation (84% share in the region). The chickpea area marginally expended from 6.4 million ha to 9.93 million ha during the period 2000-01 to

2013-14. However, the production expanded substantially from 5.47 to 9.53 million tonnes due to the rise in grain yields from 853 kg/ha to 960 kg/ha (Reddy and Reddy, 2010, Indian Institute of Pulses Research, 2013-14). In spite of large area and production there are many constraints of acreage, production and productivity in India as well as in Rajasthan. Area of pulses does not expand incredibly as compared to wheat and rice. It includes various constraints such as unavailability of high yielding seeds, insufficient knowledge of package and practice, less input use, insufficient irrigation facilities and it mostly depends on rains, insufficient fertilizers and minerals use. Usage of improved seeds is one of the important factors for accelerating productivity when compared with other yield attributing inputs. Its genetic potential for higher yield is still under estimation process as a result of strong and dominating effects of economy. The fact is that the ultimate aim of chickpea growers is to get higher remunerative income through use of superior varieties, disease and insect resistance and other characteristics (Umretiya, 2015).

So, there is need to develop a high yielding variety which can grow in rain fed condition and give more profitability to farmers.

ARS, Shree Ganganagar of SKRAU, Bikaner has developed the 'Gangour' variety of chickpea under AICRP (All India Coordinated Research Project) which is very popular in the chickpea growing area and gradually replacing all existing (Local/Traditional) varieties. Under the present circumstances, this study is aimed to address such issues.

Table-1 : Constraints in chickpea production with reference to local variety.

Constraints	Percentage of Garret value	Ranking
Lack of knowledge about diseases insect and pest of crop	27.85	8
Lack of knowledge insecticide pesticide and its doses	28.50	7
Desired fertilizer not available	39.12	6
Water supply not available when Needed	55.03	4
Inadequate water supply	58.09	3
Problem about human labour During harvesting	71.49	2
Not getting the satisfactory price	76.50	1
Lack of marketing Facilities	45.36	5

Table-2 : Constraints in chickpea production with reference to Gangour variety

Constraints	Percentage of Garret value	Ranking
Lack of knowledge about diseases insect and pest of crop	12.43	10
Lack of knowledge about insecticide/pesticide and its doses	56.37	6
Desired fertilizer not available	19.70	9
Water supply not available when needed	58.43	5
Inadequate water supply	52.05	7
Problem about human labour during harvesting	61.40	3
Not getting the satisfactory price	78.80	1
Lack of marketing facilities	36.00	8
More severe to disease pest attack	59.51	4
Water requirement is more than early variety	69.80	2

In spite of these qualitative and quantitative features, there are several constraints in production of Gangour variety as well as local variety, which are discussed in this study.

Materials and Methods

The study is based on primary data as well as on secondary data. The primary data was collected through well structured, pretested and comprehensive schedules from 120 chickpea growers in Rajasthan. Secondary data was collected from different government agencies like RSSOCA and area, production and yield was collected from different secondary sources like Rajasthan statistical abstract, therefore Rajasthan state purposively selected, due to higher production, Bikaner district of Rajasthan was selected. Then, two tehsils were selected on the basis of production. From each selected tehsil, two villages were chosen randomly. From each of the village, 15 farmers were interviewed who were growing the Gangour variety and other 15 who were growing local/traditional variety. Total of 120 farmers were interviewed for this study. Garrett's ranking technique was used to identify the preferred traits and constraints in the production of chickpea varieties in study area. For the calculation the M.S. Excel was used.

Results and Discussion

Constraints in chickpea production in Rajasthan :

This section presents the constraints faced by the farmers in chickpea production by using the Garrett's ranking

technique both with reference to Gangour and local variety.

Table-1 showed constraints in production of chickpea with reference to Gangour variety. The results revealed that about 76.50 percent farmers faced the problem of not getting satisfactory price of their produce because they are getting fewer prices as compared to MSP. About 71.49 percent farmers faced the problem about human labour during the harvesting because the labours are not available at the time of harvesting which delay the sowing of the next crop. Inadequate water supply when needed was another major problem because the light is not available always during the irrigation. Lack of marketing facility was on fifth rank which also a major constraint faced by the farmers because market is not available near their village, so extra transportation charge was given by them.

Table-2 shows constraints in production of chickpea Gangour variety. The results revealed that about 78.8 percent farmers faced the problem of not getting satisfactory price of their produce same as faced by the local variety growing farmers because they are getting less price as compared to MSP. About 69.8 percent farmers faced the problem of requiring more water than the local variety because water requirement of Gangour variety is higher than the local variety. Problem of human labour during the harvesting was another major problem faced by the farmers because the labours are not available at the time of harvesting which delay the sowing of the next crop. More severity to pest and disease attack was also a major problem faced by the farmer because

the intensity of wilt disease is higher in case of the gangour variety. Inadequate water supply when needed was on fifth rank because the light is not always available during the irrigation.

The Gangour variety growers faced more constraints than local variety grower because local variety growers had no knowledge about the Gangour variety. The same result was found by Thombre A. P., *et al.* (2009), Kumar, P., *et al.* (2010), and Sharma., *et al.* (2003) in their study.

Conclusions

Growers of both cultivars don't fetch satisfactory prices whereas gangour require more irrigation whereas local cultivars need more labour. But in overall comparison, cultivation of gangour is more economical and profitable as compare to local cultivars.

References

1. Lev-Yadun, S., Gopher, A., and Abbo, S. (2000). The cradle of agriculture. *Science*, 288(5471), 1602-1603.
2. FAO F. (2011). Food and Agriculture Organization.
3. Chibbar, R.N., Ambigaipalan, P. and Hoover, R. (2010). Molecular diversity in pulse seed starch and complex carbohydrates and its role in human nutrition and health. *Cereal chemistry*, 87(4), 342-352.
4. Geervani, P. (1989). Utilization of chickpea in India and scope for novel and alternative uses. *Uses of Tropical Grain Legumes*, 27, 47.
5. Wood, J.A., and Grusak, M.A. (2007). Nutritional value of chickpea. *Chickpea breeding and management*, 101-142.
6. Aykroyd, W.R., and Doughty, J. (1982). Legumes in human nutrition. Food and Agriculture Organization of the United Nations. *FAO food and nutrition paper*, 20, 1-152.
7. Reddy, A., and Reddy, G.P. (2010). Supply side constrains in production of pulses in India: Case study of lentils. *Agricultural economics research review*, 23, 129-136.
8. Anonymous. (2013-14). E- Pulse Data Book of Indian Institute of Pulse Research.
9. Umretiya, K. (2015). A Comparative Study on Adoption of Improved Chickpea Varieties in Indore District of Madhya Pradesh (Doctoral dissertation, RVSKVV, Gwalior (MP)).
10. Thombre, A.P., Ghulghule, J.N., and More, S.S. (2009). Constraints faced by pulse growers in production and marketing and suggestions made by them in Marathwada region of Maharashtra. *Agriculture Update*, 4(1/2), 73-75.
11. Kumar, P., Peshin, R., Nain, M.S., and Manhas, J.S. (2010). Constraints in pulses cultivation as perceived by the farmers. *Rajasthan J. of Ext. Edu.* 18, 33-6.
12. Sharma, H.O., Singh, R.P., and Patidar, M. (2003). Production constraints in adoption of improved chickpea technology in Madhya Pradesh. *Indian Journal of Pulses Research*, 16(2), 125-127.
13. Garrett, H.E. and R.S. Woodworth, (1969). Statistics in Psychology and Education, Bombay, Vakils, Feffer and Simons Pvt. Ltd., P: 329.



Impact Assessment of Micro and Macro Mineral Mixture Supplement on Milk Composition

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Abstract

Present study was conducted at Dairy farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. To study the role of micro and macro minerals supplement on milk composition and yield. Total 18 crossbred cows was selected and randomly divided into 3 uniform groups of 6 each. Animals in group T₂ were supplemented with 50 gm micro minerals/cow/day and in group T₃ were supplemented with 50 gm macro minerals/cow/day as whereas cows in group T₁ kept as control. All the cows was fed *ad libitum* green fodder and measured quantity of concentrate mixture. The milk composition was analyzed on pre-experiment and post experiment of this trial. i.e. 0th and 45th day in laboratory. In this investigation highest milk fat % was recorded in T₃ (Treatment group) 3.48% followed by T₂ (Treatment group) 3.31% and lowest in T₁ (control group) 3.18%. Highest SNF % was recorded in T₃ (Treatment group) 8.33% followed by T₂ (Treatment group) 8.18% and lowest in T₁ (control group) 7.9%. Highest milk protein % was recorded in T₃ (Treatment group) 3.46% followed by T₂ (Treatment group) 3.38 % and lowest in T₁ (control group) 3.12%. Highest milk density % recorded in T₃ (Treatment group) 32.22% followed by T₂ (Treatment group) 31.97 % and lowest in T₁ (control group) 30.62%. In study Fat, SNF, Protein and Density was analyzed by using two factorial Complete Randomized Design and treatments are differ significantly.

Key words : Ekomilk machine, macro minerals, micro minerals, milk composition and mineral mixture.

Introduction

India is the world's largest producer of milk and has the largest animal population. However, the animal output of Indian cattle is extremely low in other areas. Low productivity is mostly caused by involuntary culling due to low fertility, poor health, and feed issues, all of which have an impact on the animals' profitability. Balanced diet is critical for maintaining animal health and allowing them to produce at their maximum capacity. Minerals and vitamins are essential for metabolism, lactation, reproduction, and even microbial fermentation in the rumen, among other things (Bhandari, Garg *et al.*, 2014). Many experts have reported metabolic illness and mineral deficit in all types of dairy cows due to inadequate content and bioavailability of various important macro and micronutrients. Mineral deficiencies affect more than 90% of animals at the subclinical level (Underwood and Suttle, 1999). Garg and Bhandari reported that mineral deficiency caused poor animal productivity and imbalanced reproductive behaviour, and that mineral supplementation corrected these ailments (2005). Subclinical or marginal mineral deficiencies in livestock may be a greater problem than acute mineral deficiencies because specific clinical symptoms do not exist to allow the producer to identify the

deficiency. Animals, on the other hand, continue to grow and reproduce, albeit at a slower rate. The trace mineral also reduces farm animal immunity. According to NDDB survey work in various states, Zn, Cu, S, Mn, and Co were deficient in dairy animal ration (Bhandari Garg *et al* 2006). As a result, animals rely on feed and fodders to meet their mineral and vitamin requirements. The majority of feed ingredients available for dairy animals are deficient in one or more minerals. As a result, the current study was designed with the goal of determining the effects of micro and macro mineral mixture feeding on the milk production and composition of crossbred cattle.

Materials and Methods

The present trial was carried out to study the effect of mineral mixture feeding on cross bred cow's milk composition with diet containing different feed supplements. The study was conducted on crossbred lactating cows maintained at dairy farm, Department of Animal Husbandry and Dairying, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment was carried out for a period of 45 days (November, 2016 to December, 2016) 45 days i.e. winter season.

Treatment details : Total 18 crossbred lactating cows was randomly selected. All Cows was selected according to their same characteristics and attributes in respect of body weight, age, milk production and lactation period to maintain the similarity in the trial. All the cows was randomly divided into 3 groups with 6 animals in each group. All the animals fed on green fodder (*ad libitum*) and measured amount of concentrate mixture. Group I, II and III was supplemented with 0, 50 gm (micro minerals) and 50 gm (macro minerals) per head per day respectively. The composition of micro and macro mineral supplement is presented in table-1 and 2 respectively.

Table-1 : Composition of Mineral Mixture (micro- nutrient) Supplements @ /100 gm Contain.

Vitamin D ₃	16000 IU
Vitamin B ₁₂	400 MCG
Phosphorus	14.25 GM
Calcium	26.000 GM

Table-2 : Composition of Mineral Mixture (macro-nutrient) Supplements@ /Kg contain.

Minerals	Quantities
Vitamin A	2.500 MIU
Vitamin D ₃	0.260 MIU
Vitamin E	14.00 MIU
Biotin	0.400 gm
Niacin	100 gm
Ferrous	25 gm
Copper	5 gm
Manganese	14 gm
Zinc	18 gm
Magnesium	30 gm
Cobalt	0.360 gm
Iodine	0.800 gm
Selenium	0.140 gm
Chromium	0.180 gm
Potassium	60 gm

Milk Composition

Milk fat : Percentage of milk fat was estimated by using Gerber's method in IS: 1224 (1977).

Specific gravity : Sp. Gr. of milk determined by mixing the sample of milk in a jar and lower the lactometer gently into milk to float. Read the scale of lactometer and note down the temp. If temp. is above or below the standard temp. (60°F) the lactometer reading is corrected by adding 0.1 for each degree temp. (CLR). Sp. Gr. Of milk = 1 + .

Total solids in milk : Total solids in milk were determined by following Richmond's Formula: T.S. = + 1.2 F + 0.14

Where,

T.S. = Represents total solids % in milk;

G = Corrected lactometer reading of milk at 60° F

F = % fat in milk

Solid Not fat (SNF) : The SNF in milk sample was calculated by subtracting milk fat from total solids in the milk.

Milk Protein : The protein in the milk sample was determined by following method of AOAC, 1995.

Density percentage (DEN %) : Density percentage in milk was measured by using electronic 'ekomilk' machine.

Statistical analysis : Data was analyzed for milk composition, yield and growth using the model of the Two Factorial CRD Statistical analysis and simple calculation for mean is done by formula given below,

Here :

= represents the summation

x = represents scores

n = represents number of scores.

Results and Discussion

Effect of mineral mixture supplements on milk of composition cows :

Milk fat percentage : Fat % was recorded at pre experiment (0th day) and post experiment (45th day). The overall average fat % in T₁ (control), T₂ and T₃ group was 3.06 %, 3.21 % and 3.25 % respectively at 0th day. Average fat % was recorded at 45th day (post experiment) with an overall average 3.18 %, 3.31 % and 3.48 % in T₁ (control) T₂ and T₃ group respectively. In three group Fat % of T₃ (Treatment) group was increase followed by T₂ (Treatment) and T₁ (control) group. To see the effect of various mineral mixtures on milk fat % different types of variances were analyzed and presented in table-3. The milk fat % in various groups differ significantly (P< 0.05).

SNF (Solid Non Fat) Percentage : SNF % was recorded on 0th day and it is observed that overall average for SNF was 7.78 % for T₁ (control) group, 8.03 % for T₂ group and 8.2 % for T₃ group. Average SNF % was also recorded on 45th day and the overall average SNF % is 7.9 % for T₁ (control) group, 8.18 % for T₂ group and 8.33 % for T₃ group. In three group SNF % of T₃ (Treatment) group was increase followed by T₂ (Treatment) and T₁ (control) group. The data related to SNF % was presented in table 4 to see the effect of various mineral mixtures on milk. The milk SNF % in various groups differ significantly (P< 0.05).

Protein Percentage : The data related to milk Protein % is presented in table 5 and it is depicted from data the overall average protein % for group T₁, T₂ and T₃ was 3, 3.15 and 3.23 % respectively on 0th day. Average protein % was also recorded at 45th day and the overall average

Table-3 : Effect of minerals mixture supplement on milk fat percentage.

Cow Numbers	T ₁		T ₂		T ₃	
	0 Day	45 Day	0 Day	45 Days	0 Day	45 Days
1	3.1	3.2	3.3	3.4	3.2	3.3
2	2.9	3	3.4	3.5	3.1	3.4
3	3	3.2	3	3.1	3.2	3.5
4	3.1	3.1	3.3	3.4	3.3	3.5
5	3.1	3.3	3.1	3.2	3.5	3.7
6	3.2	3.3	3.2	3.3	3.2	3.5
Total	18.4	19.1	19.3	19.9	19.5	20.9
Mean	3.066	3.183	3.216	3.316	3.25	3.483

The milk fat % in various groups differ significantly (P< 0.05).

Table-4 : Effect of minerals mixture supplement on milk Solid not fat percentage.

Cow Numbers	T ₁		T ₂		T ₃	
	0 Day	45 Days	0 Day	45 Days	0 Day	45 Days
1	7.8	8	8.1	8.3	8.2	8.3
2	7.6	7.8	8	8.1	8.4	8.5
3	7.7	7.8	8.1	8.2	7.9	8.1
4	7.9	8	7.9	8.1	8.3	8.4
5	7.8	7.8	8	8.2	8.3	8.5
6	7.9	8	8.1	8.2	8.1	8.2
Total	46.7	47.4	48.2	49.1	49.2	50
Mean	7.78	7.9	8.03	8.18	8.2	8.33

The milk SNF % in various groups differ significantly (P< 0.05).

Table-5 : Effect of minerals mixture supplement on milk protein percentage.

Cow Numbers	T ₁		T ₂		T ₃	
	0 Day	45 Days	0 Day	45 Days	0 Day	45 Days
1	2.9	3	3.1	3.3	3.3	3.5
2	2.8	2.9	3.3	3.4	3.3	3.5
3	3	3.2	2.9	3.2	3.2	3.5
4	3.1	3.2	3.1	3.4	3.3	3.4
5	3.2	3.3	3.3	3.5	3.2	3.5
6	3	3.1	3.2	3.5	3.1	3.4
Total	18	18.7	18.9	20.3	19.4	20.8
Mean	3	3.12	3.15	3.38	3.23	3.46

The milk protein % in various groups differ significantly (P< 0.05).

Table-6 : Effect of minerals mixture supplement on milk density percentage.

Cow Numbers	T ₁		T ₂		T ₃	
	0 Day	45 Days	0 Day	45 Days	0 Day	45 Days
1	28.1	28.8	29.8	32.2	31.6	32.3
2	27.9	29.6	29.6	31.7	30.6	32
3	31.3	32.2	30	32.3	30.2	32.6
4	30.1	32.2	30.6	32.2	30.1	32.1
5	28.2	29.8	29.6	31.2	28.6	30.1
6	28.6	31.1	31	32.2	32.6	34.2
Total	174.2	183.7	180.6	191.8	183.7	193.3
Mean	29.03	30.62	30.1	31.97	30.62	32.22

The milk den% in various groups differ significantly (P< 0.05).

3.12, 3.38 and 3.46 for group T₁, T₂ and T₃ respectively. In three group protein % of T₃ (Treatment) group was increase followed by T₂ (Treatment) and T₁ (control) group. To see the effect of various mineral mixtures on milk protein % different types of variances were analyzed.

Density Percentage : The milk density was analyzed on 0th day and the values are furnished in table-6. The overall average density % was 29.03, 30.1 and 30.62 % for group T₁, T₂ and T₃ respectively. Average Density % was also recorded on 45th day, the overall average for group T₁, T₂ and T₃ was 30.62, 32.2 and 32.22% respectively. In three group DEN % of T₃ (Treatment) group was increase followed by T₂ (Treatment) and T₁ (control) group. To observe the effect of various mineral mixtures on milk density % different types of variances were analyzed.

Conclusions

Post completion of this 45-day trial, it was discovered that mineral mixture supplement significantly increased milk yield, milk fat, SNF, protein, TSS, and density. According to the findings of this study, mineral mixture meets the macro and micro nutrient requirements of the animal's body, thereby improving milk quality and quantity. T₃ (Treatment group) had the highest milk fat percent at 3.48 percent, followed by T₂ (Treatment group) at 3.31 percent, and T₁ (Control group) had the lowest at 3.18 percent. T₃ (Treatment group) had the highest milk SNF percent at 8.33 percent, followed by T₂ (Treatment group) at 8.18 percent, and T₁ (Control group) had the lowest at 7.9 percent. T₃ (Treatment group) had the highest milk protein percent at 3.46 percent, followed by T₂ (Treatment group) at 3.38 percent, and T₁ (Control group) had the

lowest at 3.12 percent. Milk DEN percent was highest in T₃ (Treatment group) at 32.22 percent, followed by T₂ (Treatment group) at 31.97 percent, and lowest in T₁ (Control group) at 30.62 percent. In study of FAT%, SNF%, Protein % and DEN% analysis of variance days and treatment are significant.

References

1. Bhandari BM, Garg MR and Sherasia PL (2014). Mineral status of feeds, fodders and dairy animals in Jalgaon district of Maharastra state. *Sch. J. Agric. Vet. Sci.* 1(4A): 222-226.
2. Bhandari BM, Garg MR, Kumar Satish S and Sherasia PL (2006). Assesment of mineral status and developing area specific mineral mixture for milch animals of Kerala. *Proceeding of XIIIth animal nutrition conference held at Anand Agriculture University, Anand, January 7-9*, pp:35
3. Garg MR and Bhandari BM (2005). Recent advance on optimum use of available feed resources and feeding strategies for economic milk production. *Proceeding of CLFMA's 47th national symposium on safety first: "farm to fork" held at Goa, September 15-16, 2005*, pp: 119-129
4. Gomez, K.A., and Gomez, A.A. (1984). *Statistical procedures for agricultural research*. John Wiley & Sons.
5. Indian Standard, I.S. 1224 (Part I). (1977) Determination of Fat by Gerber Method. *Part I. Milk (First Revision)*. Indian Standard Institution, ManakBhavan, New Delhi.
6. Patel, K.J., and Boghra, V.R. (2018). Modifications in Richmond formula for calculating Solids-not-fat/Total solids percent in cows' milk in Gujarat State. *Asian Journal of Dairy and Food Research*, 37(4), 278-282.
7. Redfearn, E.C. (1903). *U.S. Patent No. 745,521*. Washington, DC: U.S. Patent and Trademark Office.
8. Underwood EJ and Suttle NF (1999). *The Mineral Nutrition of Livestock*. 3rd ed. *CAB International Publishing Co.*



Impact of Integrated Nutrient Management on Cluster Bean Soil Properties, Growth and Yield (*Cyamopsis tetragonoloba* L.) Sadabahar Cv. Pusa Sadabahar

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Abstract

On the central research farm of Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, an experiment was conducted during the Kharif (July-October) season 2016-17 to study "Response of Integrated Nutrient Management on Soil Properties, Growth, and Yield of Cluster bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Sadabahar." The soil in the experimental region is Inceptisol, and the soil texture is sandy loam (sand percentage 62.25, silt percentage 32.25, 24.52 percent clay, and 13.23 percent clay). The statistical analysis was carried out using a 322-factorial randomised block design with three factors: three levels of NPK (at 0, 50, and 100 percent ha⁻¹), two levels of FYM (at 0 and 100 percent ha⁻¹), and two levels of rhizobium (at 0 and 100 percent). T11 – [L2 F1 Z1] (@ 100 percent NPK) was the most effective treatment. ha⁻¹ + 100 percent FYM ha⁻¹ + 100 percent rhizobium) shown a considerable increase in soil fertility status enrichment. The combination of NPK, FYM, and rhizobium resulted in a pH of 6.89, EC 0.225 dS m⁻¹. Observations of organic carbon 0.88 percent, particle density 2.66 Mg m⁻³, bulk density 1.05 Mg m⁻³, and available N 334.12 kg ha⁻¹, available P 34.76 kg ha⁻¹, and available K 214.74 kg ha⁻¹ in post-soil of NPK, FYM, and rhizobium fertilisers revealed a significant increase in organic carbon 0.88 percent, particle density 2.66 Mg m⁻³, and bulk density 1.05 Mg m⁻³. In the therapy combination T11 – [L2F1 Z1], there was a significant increase in. The treatment combination [T11 – L2 F1 Z1] (@ 100 percent NPK ha⁻¹ + 0 percent FYM ha⁻¹ + 100 percent rhizobium) had the highest cost benefit ratio of 1:2.85, as well as the best net return (100438 ha⁻¹) and the highest pod yield (77.22 q ha⁻¹).

Key words : Soil nutrients, yield attributes, FYM, rhizobium, NPK and cluster bean.

Introduction

During the kharif season, cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] is a common legume crop grown mostly under rainfed conditions in Rajasthan's desert and semi-arid regions. It is a drought-resistant and resilient crop. Its deep penetrating roots allow the plant to effectively utilise available moisture, making it more suitable for rainfed agriculture. Even at moderate salinity and alkalinity levels, the crop thrives. Cluster beans are unlike any other legume crop in terms of hardness and drought tolerance (Kherawat *et al.* 2013).

Cluster bean is farmed mostly in Rajasthan, Haryana, Punjab, Uttar Pradesh, and Madhya Pradesh in India. Rajasthan is the most populous state in India, both in terms of land and production. It covers over 82.1% of India's land area and produces 70% of the country's output. Gujarat and Haryana are in second and third place, respectively. Rajasthan covers 30 lakh hectares, produces 15.46 lakh tonnes, and has a productivity of 515 kg ha⁻¹. (Anonymous 2010-11). Rajasthan guar is mainly grown in Barmer, Churu, Sriganganagar, Nagaur, Jalore, Sikar, Jaisalmer, Bikaner, Jaipur, Jhunjhunu and Alwar districts.

Nitrogen : Nitrogen is essential for the production of chlorophyll and amino acids, which contribute to the building blocks of protein and, as a result, plant growth. Inadequate nitrogen can severely lower yield and degrade the quality of produce. Cluster bean is a legume crop that can fix atmospheric nitrogen through its effective root nodules. The majority of nitrogen is provided by rhizobium found in the root nodules, therefore the crop does not require supplemental nitrogen during its initial growth and development stage. Cluster bean cultivars yielded more crude protein, crude fibre, ash percentage, carbohydrates, leaf area per plant, dry matter, and green fodder after nitrogen was applied (Ayub *et al.* 2010).

Phosphorus : The second most critical nutrient that must be supplied to the soil to support plant development and crop productivity is phosphorus (Singh *et al.* 2000). Photosynthesis, respiration, energy storage, cell elongation, and crop quality are all enhanced by phosphorus. Plants with a deficiency may have thin, erect, and wiry stems, and their leaves may turn a bluish-green colour. Phosphorus is an essential component of the majority of enzymes, which play critical roles in energy conversion, carbohydrate metabolism, fat metabolism,

Treatment details

Treatment	Treatment Combination	Symbol
T ₀	N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₀ F ₀ Z ₀
T ₁	N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₀ F ₀ Z ₁
T ₂	N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₀ F ₁ Z ₀
T ₃	N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₀ F ₁ Z ₁
T ₄	N ₁₀ P ₂₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₁ F ₀ Z ₀
T ₅	N ₁₀ P ₂₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₁ F ₀ Z ₁
T ₆	N ₁₀ P ₂₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₁ F ₁ Z ₀
T ₇	N ₁₀ P ₂₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₁ F ₁ Z ₁
T ₈	N ₂₀ P ₄₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₂ F ₀ Z ₀
T ₉	N ₂₀ P ₄₀ K ₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₂ F ₀ Z ₁
T ₁₀	N ₂₀ P ₄₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 0 g Kg ⁻¹ seed	L ₂ F ₁ Z ₀
T ₁₁	N ₂₀ P ₄₀ K ₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Rhizobium</i> @ 20 g Kg ⁻¹ seed	L ₂ F ₁ Z ₁

and plant respiration. It promotes early root development and growth, which aids in the rapid establishment of seedlings. It boosts rhizobium activity and promotes the production of root nodules. As a result, it aids in the fixation of more nitrogen from the atmosphere in root nodules..Hand book of Agriculture by ICAR, (2010).

Potassium : After nitrogen and phosphate, potassium is the third most important necessary nutrient. Potassium activates about 60 enzymes and catalyses the system involved in photosynthesis, carbohydrate metabolism and translocation, membrane permeability, stomatal control, and water usage enzymatically. Other advantages of K include plant tolerance to pests, disease, and stressors such as drought, cold, salt, and sodicity, as well as increased crop quality features (Kherawat *et al.* 2013).

Farm yard manure : Organic manure, such as FYM, is the oldest and cheapest source of fertiliser that has been used since ancient times. Unlike chemical fertilisers, which contain only one, two, or three plant nutrients, using FYM on the field to increase soil fertility is an old technique. FYM appears to increase crop yields directly, either by speeding up the respiratory process with increased cell permeability and hormonal growth activity, or by combining both of these processes. FYM delivers both macro and micronutrients to plants. It improves physical-chemical properties of soil, such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients, increased cation exchange capacity, stimulation of soil flora and fauna, and so on, by supplying nitrogen, phosphorus, potassium, and micronutrients like Fe, S, Mo, Zn, and so on, in available form to plants through biological decomposition. 0.5 percent N, 0.2 percent P₂O₅, and 0.5 percent K₂O make up a

well-decomposed FYM. Hand book of Agriculture by ICAR, (2010).

Rhizobium : The usage of biofertilizers is more environmentally friendly. They can contribute significantly to the fixation of atmospheric nitrogen, and biofertilizers enrich and improve soil fertility. Rhizobium inoculants suited for diverse leguminous crops are the most important biofertilizers in India. The symbiosis between legumes and Rhizobium species is responsible for the majority of biological nitrogen fixation in agriculture.

Materials and Methods

On the department of Soil Science and Agricultural Chemistry's research farm, a field experiment was undertaken. Allahabad, Uttar Pradesh, India, SHUATS Inceptisol and alluvial are the two types of soil found in the trial location. Three components were used in the statistical analysis: three levels of NPK @ 0, 50, and 100 percent ha⁻¹, two levels of FYM 0 and 100 percent ha⁻¹, and two levels of rhizobium 0 and 100 percent ha⁻¹, respectively.

Physical and chemical analysis : The soil samples were preserved in polythene bags for analysis of physical and chemical properties.

Physical analysis : The physical analysis was done with the help of Bouyoucous Hydrometer method for textural class and copper cylinder method for bulk and particle density. The results of analysis are as under.

Chemical Analysis : The chemical analysis of pre sowing was done for pH, EC, available nitrogen, phosphorus, potassium, and organic carbon (%). The results and various methods employed are represented under the following table.

Table-1 : Physical analysis of pre sowing soil samples.

Particulars	Method employed	Result
Sand (%)	Bouyoucos Hydrometer method (1927)	62.25
Silt (%)		24.52
Clay (%)		13.23
Textural class	Bouyoucos Hydrometer method Bouyoucos (1927)	Sandy loam
Soil Colour	Munsell colour chart	
Dry Soil		Pale brown
Wet Soil		Olive brown
Bulk density (Mg m ⁻³)	Black (1965)	1.41
Particle density (Mg m ⁻³)	Black (1965)	2.50

Table-2 : Chemical analysis of pre sowing soil samples.

Parameters	Method employed	Result
Soil pH (1:2)	Digital pH meter (Jackson 1958)	7.40
Soil EC (dSm ⁻¹)	Digital EC meter (Wilcox 1950)	0.31
Organic carbon (%)	Walkley and Black (1947)	0.48
Available nitrogen (Kg ha ⁻¹)	Kjeldhal Method (Subbaih and Asija, 1956)	260.06
Available phosphorus (Kg ha ⁻¹)	Colorimetric method (Olsen <i>et al.</i> 1954)	23.30
Available potassium (Kg ha ⁻¹)	Flame photometric method (Toth and Prince, 1949)	135.60

Table-2 : Response of effect of different levels of NPK, FYM and *Rhizobium* post-harvest soil properties of cluster bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Sadabahar.

Treatment combination	Bd (Mg m ⁻³)	Pd (Mg m ⁻³)	pH (1:2 w/v)	EC (dSm ⁻¹)	O.C. (%)	N (kg ha ⁻¹)	P ₂ O (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)
(I ₀ +F ₀ +R ₀)	1.14	2.24	7.35	0.192	0.62	275.09	21.89	131.67
(I ₀ +F ₀ +R ₁)	1.09	2.33	7.15	0.195	0.66	294.29	23.09	146.64
(I ₀ +F ₁ +R ₀)	1.13	2.33	7.32	0.205	0.69	288.00	23.69	142.89
(I ₀ +F ₁ +R ₁)	1.10	2.41	7.12	0.208	0.73	296.38	25.18	154.12
(I ₁ +F ₀ +R ₀)	1.10	2.44	7.09	0.223	0.72	297.42	26.38	157.86
(I ₁ +F ₀ +R ₁)	1.11	2.45	7.02	0.225	0.76	312.10	27.13	169.09
(I ₁ +F ₁ +R ₀)	1.09	2.54	7.09	0.235	0.78	313.77	29.00	172.83
(I ₁ +F ₁ +R ₁)	1.09	2.54	7.09	0.235	0.81	314.20	29.08	180.55
(I ₂ +F ₀ +R ₀)	1.09	2.63	7.05	0.235	0.81	316.53	30.57	187.15
(I ₂ +F ₀ +R ₁)	1.07	2.63	7.02	0.245	0.84	318.82	31.77	196.25
(I ₂ +F ₁ +R ₀)	1.07	2.63	6.99	0.245	0.86	320.48	33.87	206.52
(I ₂ +F ₁ +R ₁)	1.05	2.66	6.89	0.255	0.88	334.12	34.76	214.74
F-test	NS	NS	NS	NS	S	S	S	S
S. Em (±)	0.24	0.24	0.38	0.24	0.0004	1.71	0.13	0.55
C. D. at 5%	0.48	0.49	0.77	0.49	0.0008	3.47	0.27	1.11

Results and Discussion

The physical and chemical parameters of post-harvest soil are generally altered by the interaction effects of NPK and FYM, as shown in Table-3

Physical properties : On bulk density (Mg m⁻³) and particle density (Mg m⁻³), the interaction effects of NPK and FYM were not significant. In T₀- (L₀+N₀) @ 0 percent NPK ha⁻¹ + @ 0 percent FYM ha⁻¹, the maximum particle density and bulk density following crop harvest were 2.66 Mg m⁻³ and 1.14 Mg m⁻³, respectively.

Chemical properties of post-harvest soil : During the investigation, it was discovered that the highest pH was

7.35 (T₀-(L₀+N₀) @ 0 percent NPK ha⁻¹ + @ 0FYM ha⁻¹) and the lowest was 6.89 (T₈-(L₂+N₂) @ 100 percent NPK ha⁻¹ + @ 10 qFYM ha⁻¹). When we compare the pH of the pre-sowing soil sample, which was 7.40, to the pH of the soil after crop harvest, we can see that the pH after crop harvest has decreased. The pH of the post-harvest soil is somewhat lower when the NPK and FYM doses are increased. The fall in pH could be attributed to increased crop growth, which requires more respiration. Carbon dioxide is produced by respiration and combines with water in the soil to make carbonic acid.

Electric conductivity (dSm⁻¹), organic carbon (percent), and accessible nitrogen, phosphorus, and

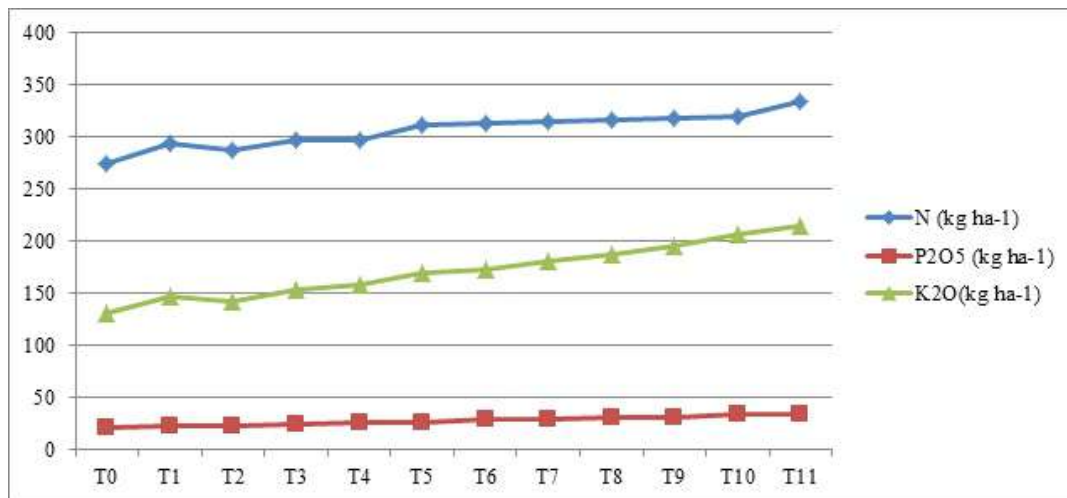


Fig.-1 : Effect of different levels of NPK FYM and *Rhizobium* on post-harvest soil chemical properties of cluster bean.

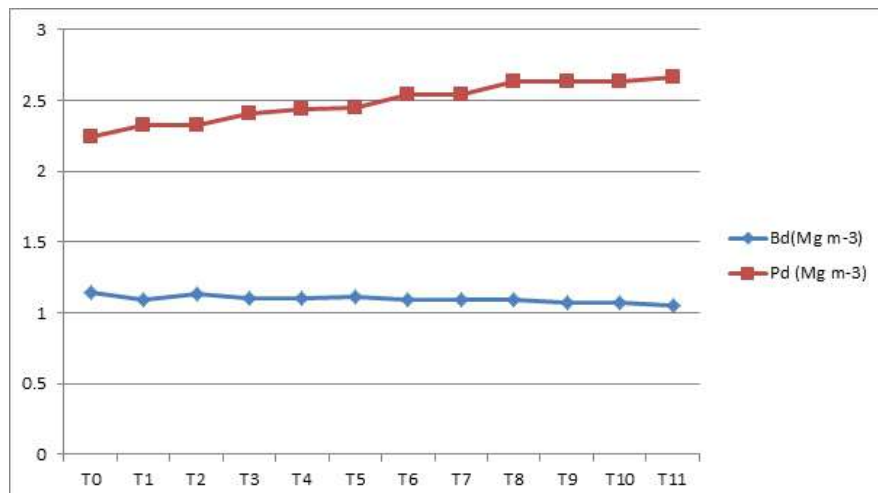


Fig.-2 : Effect of different levels of NPK FYM and *Rhizobium* on post-harvest soil physical properties of cluster bean.

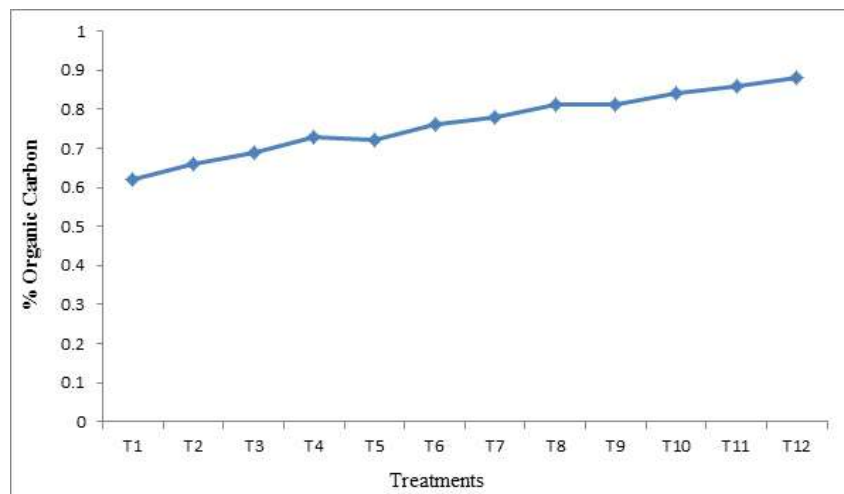


Fig.-3 : Effect of different levels of NPK FYM and *Rhizobium* on post-harvest soil chemical properties of cluster bean.

potassium (kg ha⁻¹) were all measured. Different treatment combinations of NPK and FYM have a substantial impact on chemical characteristics.

The maximal chemical parameters of after crop harvest soil were recorded as electric conductivity (dSm⁻¹), organic carbon (percent), accessible nitrogen, phosphorus, potassium (kg ha⁻¹), and electric conductivity

(dSm⁻¹) 0.255, 0.88, 334.12, 34.76, 214.74, respectively. Available electric conductivity (dSm⁻¹) was determined to be insignificant, while available organic carbon (percent), nitrogen, phosphorus, and potassium (kg ha⁻¹) were determined to be significant.

Conclusions

The treatment combination T11-(I2+V2+R1) @100% NPK ha⁻¹ + @ FYM 10 t ha⁻¹ + Rhizobium @ 20 g/ Kg seed was found to be the best treatment, giving the highest benefit of 100438 with the highest cost benefit ratio 1:2.85 for cluster bean. It could be recommended for profitable production of cluster bean (*Cyamopsis tetragonoloba* L.) Var. pusa Sadabahar and good for soil phy Soil health and cluster bean production benefit from integrated nutrient management.

Acknowledgement

Authors are sincerely thankful to the Hon'ble Prof. (Dr.) Gautam Ghosh, Head of department (Agronomy), Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, U. P., for providing all necessary facilities.

References

1. Anonymous 2010-11. Rajasthan Agriculture Statistics at a glance. Department of Agriculture Government of Rajasthan.
2. Ayub, M., Khalid, M., Tariq, M., Nadeem, M.A., and Naeem, M., 2011. Effect of different seeding densities and nitrogen levels on growth, forage yield and quality attributes of Cluster bean (*Cyamoposis tetragonoloba* Tuab.) *Journal of Agricultural Technology*. 7(5): 1409-1416.
3. Black, C.A. 1965. Methods of soil analysis VOL. I. Am. Soc. Agron. Madison, Wisconsin, U.S.A.
4. Brady, N.C. and Weil, R.R. 1996. The nature and properties of soils (11th ed.). Prentice Hall, New York.
5. Buoyoucos, G.J. 1952. A recalibration of the hydrometer method for making mechanical analysis of soil, 43, 434.
6. Fisher, R. A. 1950. Technique of analysis of variance. Handbook of Agricultural statistics B-29-110.
7. Jackson, M. L. 1958. Soil chemical analysis, Prentice Hall, Inc, Englewood Cliffe, N.J.
8. Jaiswal P.C. 2006. Soil ,Water and plant Analysis, Manual Practical.
9. Kherawat, B. S., Munna lal, Agarwal, M., Yadav, H. K. and Kumar, S. 2013. Effect of applied potassium and manganese on yield and uptake of nutrients by cluster bean (*Cyamopsis tetragonoloba*). *Journal of Agricultural Physics* 13 (1): 22-26.
10. Muthuaval, P.C., Udayasooriyan, R., Natesan, P.P. and Ramaswami 1998. Introduction to soil analysis, *Tamilnadu agriculture University, Coimbatore-641002*
11. Olsen, S.R., Cole, C.V., Watnahe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate U.S. Deptt. Agr. Circ. 939.
12. Panda, S.C., 2011. Handbook of agriculture PP; 310-321.
13. Toth, S.J. and A.L. Prince 1949. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. *Soil sci*. 67: 439-445.
14. Walkey, A. and Black, I. A. 1947. Critical examination of rapid method for determining organic carbon in soils, effect of variance in digestion conditions and of inorganic soil constituents. *Soil sci pp*. 632: 251
15. Wilcox L.V. 1950. Electrical conductivity, Amer. *Water works Assoc. J.* 42: pp 775-776.



Line x Tester Analysis in Sweet Corn (*Zea mays* L. Sp. *Saccharata*) hybrids for Various Qualitative and Quantitative Characters

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Abstract

In the present study, 45 hybrids were developed using line x Tester mating design and about 66 genotypes comprising of 45 sweet corn hybrids, 18 parental lines and 3 standard checks (Priya, Madhuri and Sugar-75) were evaluated in RBD in three different environments (E₁ at Instructional Farm, RCA, Udaipur during Kharif-2019, E₂ at ARS, Banswara during Kharif-2019 and E₃ at Instructional Farm, RCA, Udaipur during Rabi-2019-20) in RBD with three replications for twenty diverse traits. On the basis of specific combining ability effects, among the selected best five hybrids, sweet corn hybrids L₅ x T₂ and L₆ x T₃ were best for green cob yield, green fodder yield and green cob weight plant⁻¹ while the hybrid L₁₀ x T₁ was best for green cob yield, green cob weight plant⁻¹ and TSS content of green grain. Combining ability analysis for green cob yield and green cob weight/plant revealed that lines L₂, L₃, L₇, L₈, L₁₁, L₁₂ and L₁₃ were good general combiners over the three environments. Sweet corn hybrid L₅ x T₂ was identified to exhibit highest and positively significant specific combining ability effect for green cob yield (4090.05) over the three environments.

Key words : Combining ability, green cob yield, lines, sweet corn, TSS

Introduction

Sweet corn has high nutritional values, delicate texture and sweet taste within pericarp and endosperm and is treated as vegetable. The flavor, texture and sweetness of sweet corn kernels is due to presence of some endosperm mutant which alter the starch biosynthesis pathway in endosperm. The most useful mutations among them, *sh2*, *bt1*, *su1* and *se*, function either by accumulating sugar at the expense of starch or by changing types and proportions of different polysaccharides stored in endosperm (Boyer and Shannon 1984). Total sugar content in sweet corn at milky stage ranges from 25-30% as compared to 2-5% of normal corn (Sadaiah *et al.*, 2013). Popularity of sweet corn is increasing in the national and international market due to the sweetness and tenderness of its kernels and its appetizing taste, which has in turn resulted in its increased cultivation in the country, ensuring good return to the farmers. Further, the left over plant after the harvest of cobs can be used as fresh or dry fodder for the animals. Sweet corn breeding aims to improve quality and appearance as well as cob yield however, the genetic base of sweet corn breeding programme is relatively narrow and related inbreds often are crossed to make hybrids that meet the strict market requirements on quality and appearance (Tracy, 1994). Sweet corn breeders have often focused on improving

quality and ear appearance, rather than on enhancing yield (Tracy, 1994). But emphasis on kernel sweetness along with yield needs to be considered as the major objective of sweet corn improvement. The quality parameters are relatively more important especially because of direct consumption of sweet corn as vegetable and the preference of the consumers. Keeping in view the above facts and the growing demand of sweet corn in the domestic and international market, development of hybrids exhibiting hybrid vigor using parents with superior combining ability has been taken as objective of first importance of the research.

Materials and Methods

Eighteen diverse sweet corn inbred lines, collected from different parts of the country were used as parents (fifteen females and three testers) (Table-1). The crosses were made in line x tester mating design at Instructional Farm, RCA, Udaipur during *kharif* 2018. Total 66 genotypes comprising of 45 sweet corn hybrids, 18 parental lines and 3 standard checks (Priya, Madhuri and Sugar-75) were evaluated in RBD in three different environments (E₁ at Instructional Farm, RCA, Udaipur during Kharif-2019, E₂ at ARS, Banswara during Kharif-2019 and E₃ at Instructional Farm, RCA, Udaipur during Rabi-2019-20) in RBD with three replications.

Recommended agronomic practices were used to

Table-1 : List of genotypes used.

S. No.	Symbol	Pedigree	S. No.	Symbol	Pedigree
1.	L ₁	SC-7-2-1-2-6-1	10.	L ₁₀	BAJ-SC-17-2
2.	L ₂	SC-18728	11.	L ₁₁	BAJ-SC-17-1
3.	L ₃	BAJ-SC-17-6	12.	L ₁₂	DMSC-28
4.	L ₄	BAJ-SC-17-10	13.	L ₁₃	Mas Madu (sh2 sh2)
5.	L ₅	BAJ-SC-17-12	14.	L ₁₄	MRCSC-12
6.	L ₆	BAJ-SC-17-9	15.	L ₁₅	SC-33
7.	L ₇	BAJ-SC-17-11	16.	T ₁	SC-35
8.	L ₈	BAJ-SC-17-8	17.	T ₂	SC-32
9.	L ₉	BAJ-SC-17-4	18.	T ₃	DMRSC-1

Table-2 : Five best sweet corn hybrids for green cob yield on the basis of specific combining ability effects over the three environments.

S. No.	Sweet corn Hybrids/parents	SCA effects	Economic heterosis (%)	Mean green cob yield kg ha ⁻¹
1.	L ₅ x T ₂	4090.05**	35.12**	15,222.22
2.	L ₁₅ x T ₃	3584.42**	-19.2**	9,101.11
3.	L ₁₀ x T ₁	3551.09**	30.47**	14,695.56
4.	L ₆ x T ₃	3463.68**	1.28	11,407.78
5.	L ₉ x T ₁	1999.60**	38.92**	15,646.67

Table-3 : Five best sweet corn hybrids for green fodder yield on the basis of specific combining ability effects over the three environments.

S. No.	Sweet corn Hybrids/parents	SCA/GCA effects	Economic heterosis (%)	Mean fodder yield kg ha ⁻¹
1.	L ₄ x T ₂	13,377.43**	86.24**	37,163.33
2.	L ₁₃ x T ₂	8,799.65**	75.11**	35,061.11
3.	L ₅ x T ₂	8,237.06**	44.16**	28,765.56
4.	L ₆ x T ₃	7,598.84**	-1.11	19,732.22
5.	L ₈ x T ₃	6,938.47**	14.23*	22,794.44

raise a healthy crop. Observations were recorded for 20 yield attributing quantitative and qualitative characters like days to 50 per cent tasseling, days to 50 per cent silking, plant height, ear height, number of leaves/ plant, length of leaf, breadth of leaf, days to green cob harvest, number of ear/ plant, ear length, ear girth, number of grain rows/ ear, number of grains/ row, 100 fresh seed weight, green cob weight/ plant, moisture per cent of green grain, green cob yield, green fodder yield, TSS content of green grain and protein content. Ten plants were taken from each row for recording observations from each replication. TSS content was recorded using hand refractometer.

Estimation was done over the three environments on pooled basis. Estimates of standard heterosis was calculated according to Virmani *et al.* (1982) and the significance of heterosis was tested using 't' test. The analysis of variance for general and specific combining ability effects over the environments and in three individual environments was done for different characters under the study using line x tester mating design provided by Kempthorne (1957).

Results and Discussion

The general combining ability effects are considered to be the function of the additive gene effects and additive x additive type of non allelic interactions. Combining ability analysis for green cob yield and green cob weight/ plant revealed that lines L₂, L₃, L₇, L₈, L₁₁, L₁₂ and L₁₃ were good general combiners over the three environments. Similarly, for green fodder yield, lines L₁, L₂, L₃, L₄, L₇, L₁₁, L₁₂ and L₁₃, for TSS content of green grain, lines L₁, L₅, L₇, L₁₀, L₁₁, L₁₃ and L₁₄ and for protein content, line L₁₂ were identified as superior general combiners over the three environments on the basis of general combining ability analysis. Among the testers, T₁ was identified as good general combiner for green cob yield, green cob weight plant⁻¹ and TSS content of green grain on the basis of general combining ability estimates over the three environments. Similarly testers T₁ and T₂ were reported as superior combiners for green fodder yield on the basis of general combining ability analysis in pooled environments.

Sweet corn hybrid $L_5 \times T_2$ was identified to exhibit highest and positively significant specific combining ability effect for green cob yield (4090.05) over the three environments (Table-2). The five best sweet corn crosses which possessed significantly positive specific combining ability effects for green cob yield on pooled basis were $L_5 \times T_2$, $L_{15} \times T_3$, $L_{10} \times T_1$, $L_6 \times T_3$, and $L_9 \times T_1$, among which $L_5 \times T_2$, $L_{10} \times T_1$ and $L_9 \times T_1$ exhibited positively significant standard heterosis over the best check Sugar-75. The sweet corn hybrids $L_5 \times T_2$, $L_{15} \times T_3$ and $L_6 \times T_3$ were cross between poor general combining ability effects parents, while the hybrids $L_{10} \times T_1$ and $L_9 \times T_1$ were cross between poor x good and average x good general combining ability effects parents. For green fodder yield, the best five sweet corn hybrids that showed maximum and positively significant specific combining ability effects were $L_4 \times T_2$ followed by $L_{13} \times T_1$, $L_5 \times T_2$, $L_6 \times T_3$ and $L_8 \times T_3$ on pooled basis (Table-3). The sweet corn hybrids $L_4 \times T_2$ and $L_{13} \times T_1$ were cross between parents with good general combining ability effects while the hybrids $L_6 \times T_3$ and $L_8 \times T_3$ were cross between parents with poor general combining ability effects. Hybrid $L_5 \times T_2$ was cross between the parents with poor x good general combining ability effects. Analysis for green cob weight plant⁻¹ identified $L_5 \times T_2$, $L_{10} \times T_1$, $L_{15} \times T_3$, $L_6 \times T_3$ and $L_7 \times T_1$ as top five sweet corn hybrids to exhibit highest and positively significant specific combining ability effects on pooled basis. Hybrids $L_5 \times T_2$, $L_{15} \times T_3$ and $L_6 \times T_3$ were produced by crossing both parents with poor general combining ability effects, while $L_{10} \times T_1$ was cross between parents with poor x good general ability combining ability effects. The hybrid $L_7 \times T_1$ was cross between both parents with good general combining ability effects. Analysis for TSS content of green grain over the three environments identified $L_{14} \times T_2$, $L_{12} \times T_1$, $L_2 \times T_3$, $L_1 \times T_3$ and $L_{10} \times T_3$ as the best five sweet corn hybrids possessing highest and significantly positive specific combining ability effects. The sweet corn hybrids $L_{14} \times T_2$, $L_1 \times T_3$ and $L_{10} \times T_3$ were cross between good x poor general combining ability effects parents, $L_{12} \times T_1$ between poor x good general combining ability effects parents while $L_2 \times T_3$ between parents with average x poor combining ability effects. Ola *et al.* (2018), Chinthiya *et al.*

(2019), Nanditha *et al.* (2019), Sharma *et al.* (2019) and Tesfaye *et al.* (2019) reported similar results for combining ability analysis on maize.

Acknowledgement

The corresponding author is highly thankful to Department of Science and Technology for providing financial support in terms of Inspire scholarship.

References

1. Boyer C.D. and Shannon J.C. 1984. The use of endosperm genes for sweet corn improvement. *Plant Breeding Reviews* 1: 193-161.
2. Chinthiya, A., Ganesan, K.N., Ravikesavan, R. and Senthil, N. 2019. Combining ability and association studies on different yield contributing traits for enhanced green cob yield in sweet corn (*Zea mays* Ssp *saccharata*). *Electronic Journal of Plant Breeding* 10 (2): 500-511.
3. Kempthorne, O. 1957. An introduction to genetic statistics. New York: John Wiley and sons, Inc; London: Chapman & Hall, Ltd.
4. Nanditha, G., Ganesan, K.N. and Ravikesavan, R. 2019. Heterosis and combining ability studies in single cross hybrids synthesized with diverse inbred lines of maize (*Zea mays* L.). *Electronic Journal of Plant Breeding* 9 (4): 1503-1511.
5. Ola, B., Dubey, R.B., Singh, M. and Ameta, K.D. 2018. Combining ability analysis in medium maturing yellow seeded maize (*Zea mays* L.) hybrids. *Journal of Pharmacognosy and Phytochemistry* 7 (3): 1354-1359.
6. Sadaiah, K., Reddy, V.N. and Sudheer Kumar, S. 2013. Heterosis and combining ability studies for sugar content in sweet corn (*Zea mays saccharata* L.). *IJSRP*, 3: 1-5.
7. Sharma, P., Kamboj, M.C. and Punia, M. S. 2019. Assessment of combining ability effects using quality protein maize donors as testers for yield and yield traits in maize. *Electronic Journal of Plant Breeding* 10 (4): 3365-3368.
8. Tesfaye, D., Abakemal, D. and Habte, E. 2019. Combining ability of highland adapted double haploid maize inbred lines using line x tester mating design. *East African Journal of Sciences* 13 (2): 121-134.
9. Tracy, W.F. 1994. Sweet corn. In: A. R. Haullauer (ed.) Specialty types of maize. CRC Press, Boca Raton, Fla, pp 147-187.
10. Virmani, S.S., Aquino, R.O. and Khush, G.S. 1982. Heterosis breeding in Rice (*Oryza sativa* L.).



Assessment of Diversity Using RAPD Markers in Speciality Corn (*Zea mays* L.) Genotypes

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Abstract

The present study was carried out using twenty diverse speciality corn genotypes of QPM, sweet corn, pop corn and baby corn. The material was planted during *kharif*, 2015, at Instructional Farm of Rajasthan College of Agriculture, Udaipur. Observations were recorded for twenty yield contributing characters and ten morphological characters. Variability parameters and correlation coefficient were computed. DNA was isolated with CTAB extraction buffer method and isolated DNA was used as template for amplification of DNA using fifteen randomly selected decamer primers. Molecular characterization through RAPD analysis revealed high polymorphism and marked genetic diversity among the speciality corn genotypes as also reflected by their morphological differences. Hence molecular characterization appeared to be precise, quick and effective tool in analyzing genetic diversity and identification of germplasm.

Key words : Speciality corn, morphological, molecular, RAPD, primers and correlation

Introduction

Maize (*Zea mays* L.) is one of the most important and highly evolved coarse cereal crops and currently cultivated over 9.23 m ha area with 23.67 m t production with an average yield of 25.64 q ha⁻¹ (Govt of India, 2015). For morphological and molecular diversity knowledge about germ plasm diversity and genetic relationships among breeding materials could be an invaluable aid in crop improvement strategies (Mohammadi and Prasanna, 2003). The genetic diversity is analyzed by using morphological as well as molecular markers. Most of the conventional breeding programmes are based on evaluation and characterization through morphological traits, which are largely affected by environmental fluctuations. However, molecular techniques are effectively used for detecting differences in the DNA of individual plants so as to assess variability amongst cultivars for identification of potential parental lines. These differences in general are called molecular markers. DNA markers provide a direct measure of genetic diversity and go beyond diversity based on agronomic traits or geographic origin (Dreisigacker *et al.*, 2005), thus help in better germ plasm management and develop more efficient strategies for crop improvement. Therefore the present study was carried out with objectives to assess genotypic diversity through morphological characterization and analysis of molecular diversity using Randomly Amplified Polymorphic DNA (RAPD) marker using 20 diverse *elite* lines/hybrids viz., nine QPM, seven sweet corn, three pop corn and one baby corn.

Materials and Methods

The material was planted during *kharif*, 2015, at Instructional Farm of Rajasthan College of Agriculture, Udaipur. A comprehensive study was made to record specific observation/ phenotypic markers in terms of “descriptors” for each genotype. It included characters viz., leaf angle and attitude, density of spikelet, kernel shape, colour of top of the grain, row arrangement of cobs, anthocyanin in brace root, anthocyanin in tassel, silk and anthers. Further in order to evaluate different germ plasm in terms of morphological characters, twenty observations were recorded on five randomly selected plants in each replication viz., days to 50 per cent tasseling, days to 50 per cent silking, plant height, tassel length, grain rows/cob, tip sterility, cob height, ear length, ear girth, grains/rows, ear/ plant, shelling percentage, kernel sweetness, test weight, grain yield, stover yield, biological yield, harvest index, leaves/plant and grain protein content.

DNA extracted from different speciality corn genotypes were compared using RAPD methodology. DNA was extracted from young leaves (3–4 weeks old) using CTAB method (Doyle and Doyle, 1990). DNA was amplified by using decamer random oligonucleotide primer in a DNA thermo cycler (Biometra). The amplified samples were separated on agarose gel electrophoresis (1.2%). The bands were scored for their presence or absence. A set of 15 decamer oligonucleotide RAPD primers were used for PCR amplification.

Table-1 : Important plant descriptors of speciality corn germplasm.

S. No.	Speciality corn	Leaf		Anthocyanin in			Density of spike let	Kernel shape	Colour of top of grain	Row arrangement	Anthocyan in in brace root
		Angle	Attitude	Tassel	Silk	Anther					
A. QPM											
1	HQPM-1	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present
2	HQPM-5	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present
3	HQPM-4	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present
4	HQPM-7	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present
5	PQMH-1	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present
6	VQPM-9	Wide	Droopy	Present	Present	Present	Dense	Round	Y.with cap*	Straight	Present
7	BPCH-6	Wide	Droopy	Present	Present	Present	Sparse	Round	Orange	Straight	Present
8	VEHQ 14-1	Wide	Droopy	Present	Present	Present	Dense	Round	Y.with cap*	Straight	Absent
9	MMHQPM 6-12-13	Wide	Droopy	Absent	Absent	Absent	Dense	Round	Orange	Straight	Present
B. Sweet corn											
10	Sugar 75	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Yellow	Straight	Present
11	Misthi	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Yellow	Straight	Absent
12	Sugar Candy	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Yellow	Straight	Present
13	Madhuri	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Orange	Straight	Present
14	Win Orange	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Yellow	Straight	Absent
15	Priya	Wide	Droopy	Absent	Absent	Absent	Dense	Shrunken	Orange	Straight	Absent
16	Bajaura SC	Wide	Droopy	Absent	Present	Absent	Dense	Indented	Yellow	Straight	Present
C. Pop corn											
17	Amber Pop Corn	Wide	Droopy	Present	Present	Present	Dense	Round	Orange	Spiral	Present
18	VLAmerPop Corn	Wide	Droopy	Present	Present	Present	Dense	Round	Orange	Straight	Present
19	Bajaura Pop Corn	Wide	Droopy	Present	Present	Present	Dense	Round	Orange	Straight	Present
D. Baby corn											
20.	HM-4	Wide	Droopy	Present	Present	Present	Dense	Round	Yellow	Straight	Present

Leaf angle: Angle between stem and leaf blade, Tassel angle: Angle between main axis and lateral branches *Yellow with cap.

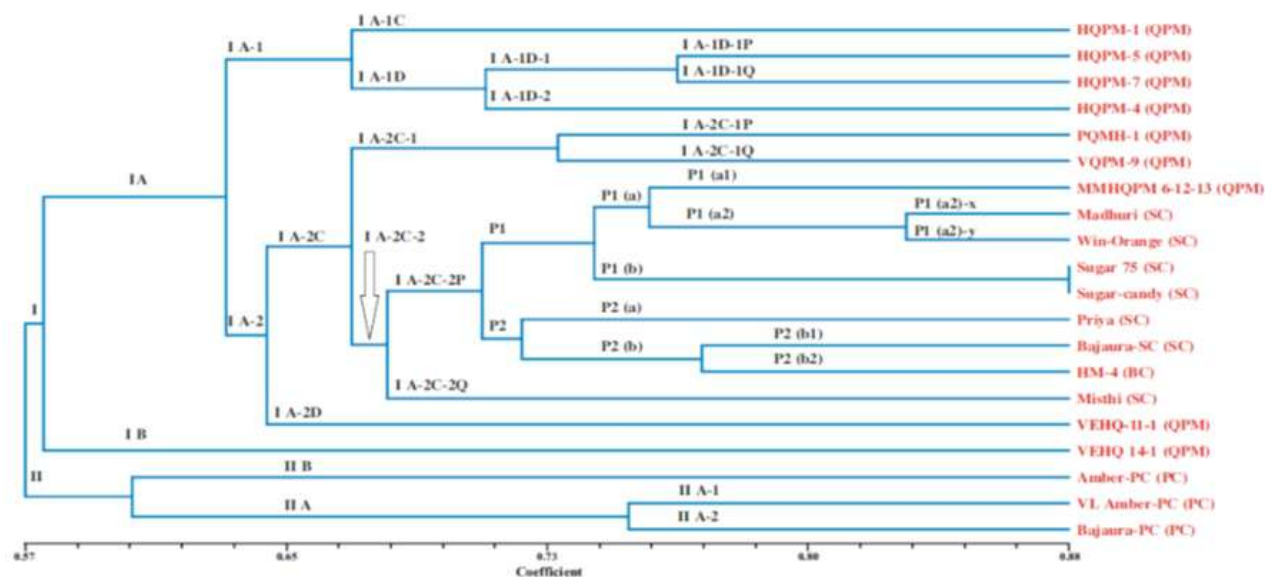


Fig-1 : Dendrogram generated for speciality corn genotypes using UPGMA Cluster based on Jaccard Similarity Coefficient (RAPD analysis).

Result and Discussion

Morphological characterization revealed that all descriptors, except leaf angle and attitude can be used for distinguishing amongst four group of speciality corn (Table-1). Amongst nine QPM genotypes, anthocyanin in tassel, silk and anthers, tassel angle and attitude, density of spike lets, colour of top of grain, row arrangement and anthocyanin in brace could be used as morphological descriptors. Similarly in sweet corn genotypes, anthocyanin in silk, tassel angle and attitude, colour of top of grain, kernel shape and anthocyanin in brace could be used as morphological descriptors. However, in pop corn genotypes most of morphological descriptors were same except the row arrangement and intensity of anthocyanin pigment in tassel, silk, anthers and brace roots. On the basis of present comprehensive study it could be concluded that characterization of speciality corn genotypes through morphological descriptors may assists plant breeders in identifying genotypes for crop improvement and seed production programmes. However, for better precision the crop needs to be studied in multi location trials.

For molecular characterization, 15 primers were screened, out of which 10 primers produced amplification. A total of 82 scorable bands were produced, out of which 69 bands were polymorphic and level of polymorphism was as high as 82.95 per cent. This might be causing marked morphological differences. Each evaluated

primer, produced 5 to 12 fragments. Size of fragments ranged between ~200 bp to ~3000 bp. The average number of bands per primer was found to be 8.2. The average numbers of polymorphic bands per primer were 6.9.

Jaccard's Similarity Coefficient value for RAPD primers ranged from 0.44 to 0.88. Based on dendrogram generated through UPGMA method (Fig 1), most of the genotypes were classified into two main clusters. First cluster included 17 genotypes while second cluster possessed only three genotypes of pop corn. Distinct bands with variable intensity were recorded for QPM genotypes (VQPM-9, VEHQ-14-1, MMH QPM-6-12-13, VEHQ-11-1, HQPM-7 and HQPM-1), sweet corn genotypes (Misthi, Bajaura sweet corn, Priya, Madhuri and Sugar-75) and pop corn genotypes (Amber pop corn, Bajaura pop corn and V.L. Amber pop corn).

The result showed probable association between dendrogram obtained by RAPD analysis and morphological characters. Except HQPM-7 and HQPM-1 all the remaining seven genotypes of QPM corn were genetically diverse as evident from morphological and molecular studies. Amongst sweet corn varieties Misthi, Sugar-75, Bajaura sweet corn, Madhuri and Priya were also distinct at morphological as well as molecular level with respect to one or more characters as also evident from their band patterns. All the three pop corn genotypes were also different with respect to descriptors and band patterns. Similar results were reported by Sharma (2014) and Sumathi *et. al* (2005).

The maximum similarity value of 0.88 was observed in Sugar 75 and Sugar candy. While amongst total speciality corn genotypes maximum similarity coefficient was recorded between sweet corn and baby corn genotypes (Bajaura sweet corn and HM-4). Molecular characterization through RAPD analysis revealed high polymorphism and marked genetic diversity as well as similarity among the speciality corn genotypes as also reflected by their morphological differences. Hence molecular characterization appeared to be precise, quick and effective tool in analyzing genetic diversity, similarity and identification of germplasm.

References

1. Doyle, J.J. and Doyle, J.L. 1990. A rapid total DNA preparation procedure for fresh plant tissue. *Focus* 12: 13-15.
2. Dreisigacker, S.P., Zhang, M.L., Warburton, B., Skormand, D., Hoisington, A.E. and Melchinger, R. 2005. Genetic diversity among and within CIMMYT wheat landrace accessions investigated with SSRs and implications for plant genetic resources management. *Crop Science* 45: 653-661.
3. Govt. of India, 2015. Directorate of economics and statistics, Department of Agriculture and cooperation, Ministry of Agriculture, Government of India.
4. Mohammadi, S.A. and Prasanna, B.M. 2003. Analysis of genetic diversity in crop plants-salient statistical tools and considerations. *Crop Science* 43: 1235-1248.
5. Sharma., R. 2014. Assessment of Morphological, Biochemical and Molecular Diversity in *Zea mays* L. *Ph.D. Thesis, Department of MBBT, MPUAT, Udaipur.*
6. 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). *Journal Madras Agriculture* 92(10): 612-617.



Estimation of Soil Physical Properties in Rajasthan's Sri Ganganagar District

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Abstract

In 2016-17, a study of the physical qualities of soil in the Sri Ganganagar district's blocks Raisinghnagar and Sri Vijayanagar was conducted. The study's major goals were to conduct a survey, gather data, and analyse the physical attributes of soil. For the analysis, eight sampling points were chosen. Particle density ranges from 2.40-2.66 gcm⁻³, bulk density ranges from 1.08-1.23 gcm⁻³, water retention capacity ranges from 43.40-60.50 percent, and specific gravity ranges from 1.74-2.39 percent in soil samples obtained at depths of 0-15cm, 15-30 cm, and 30-45cm. A soil texture classification ranging from sandy soil to sandy loam soil. It was obvious that the soil has a high water retention capacity and is in good physical shape. Almost all plants thrive in soil.

Key words : Sri Ganganagar district, physical properties, tropical crops, soil, etc.

Introduction

Soil is a dynamic natural body made up of mineral and organic materials, with distinct chemical, physical, mineralogical, and biological qualities, that has a changeable depth across the earth's surface and serves as a medium for plant growth (Thakre *et al.*, 2012). Soil is primarily made up of 50% pore space (air and water) and 50% solid phase. The soil phase is mostly made up of 45 percent mineral stuff and 5% organic matter. Soil analysis can enhance crop productivity and reduce fertiliser waste, reducing environmental impact and leading to bias through optimum production. Primary, secondary, and micronutrient deficiencies have been identified in intensively cultivated areas. Soil development is both a positive and negative activity. The physical and chemical breakdown of materials, plants, and animal structures is the most common destructive process. As a result, more soluble and volatile compounds are lost in part. Constructive forces create new mineral and organic chemical compounds with new distribution or association features, structural qualities, and chemical compositions. These variables have an impact on plant growth in the soil (Pujar *et al.*, 2012). The hydro-physical features of soil may aid in the development of effective water management systems for orchard production increase and stabilisation in the region. A good understanding of the capacity, intensity, and rate variables (rate of water movement through soil) of moisture availability in the soils, as well as the interaction between them, will be required to formulate a sound management strategy to optimise water usage efficiency.

Rainfall less than 400mm in Sri Ganganagar district, texture sandy to sandy loam, high proportion of soluble salt, and high pH value. It contains varied amounts of calcium carbonate and is low in organic content. These soils are pale brown in colour, have a single grain, are deep, and well drained. A million hectares of land are affected by poor soils (saline and alkaline). The supply of ground water is limited due to a lack of rainfall. The crops are suffering as a result of the high temperatures and high wind speeds. Potassium levels in the soil are high. Pockets of micro elemental deficits, particularly zinc and sulphur, have also been discovered. The results of this study were effective in determining the deficit of certain elements and, as a result, the application of fertilisers based on their status.

To properly fulfil the notion of soil health and quality analysis, a complete research for characterisation and evaluation of soils is required. A study of soil resources inventory for land use planning in the Sri Ganganagar region of Rajasthan was done with this goal in mind.

Materials and Methods

Sri Ganganagar is a district in Rajasthan, India's westernmost state. The district headquarters are in Sri Ganganagar. Sri Ganganagar district is situated between 28.8 and 30.60 degrees north latitude and 72.2 and 75.30 degrees east longitude. Sri Ganganagar is located where the Sutlej River flows into Rajasthan. The Gang canal and the Bhakhra canal tributaries irrigate this area. Surface soil from farmer's fields in several villages in Raisinghnagar block and Sri Vijaynagar of Sri Ganganagar district was sampled at random to depths of

Table-1 : Soil textural classes of soil of Sri Ganganagar regions, Rajasthan.

Villages	% Sand	% Silt	% Clay	Textural Class
7KSD (V ₁)	69.8	15.5	14.7	Sandy loam
6TK (V ₂)	73.3	18.5	8.20	Sandy loam
Slampura (V ₃)	84.8	7.3	7.9	Sandy
6PTD (V ₄)	87.3	5.9	6.8	Sandy
40GB (V ₅)	60.3	24.5	15.2	Sandy loam
28GB (V ₆)	75.7	10.0	11.0	Sandy loam
22GB (V ₇)	74.5	9.5	12.5	Sandy loam
46GB (V ₈)	67.3	19.6	13.1	Sandy loam

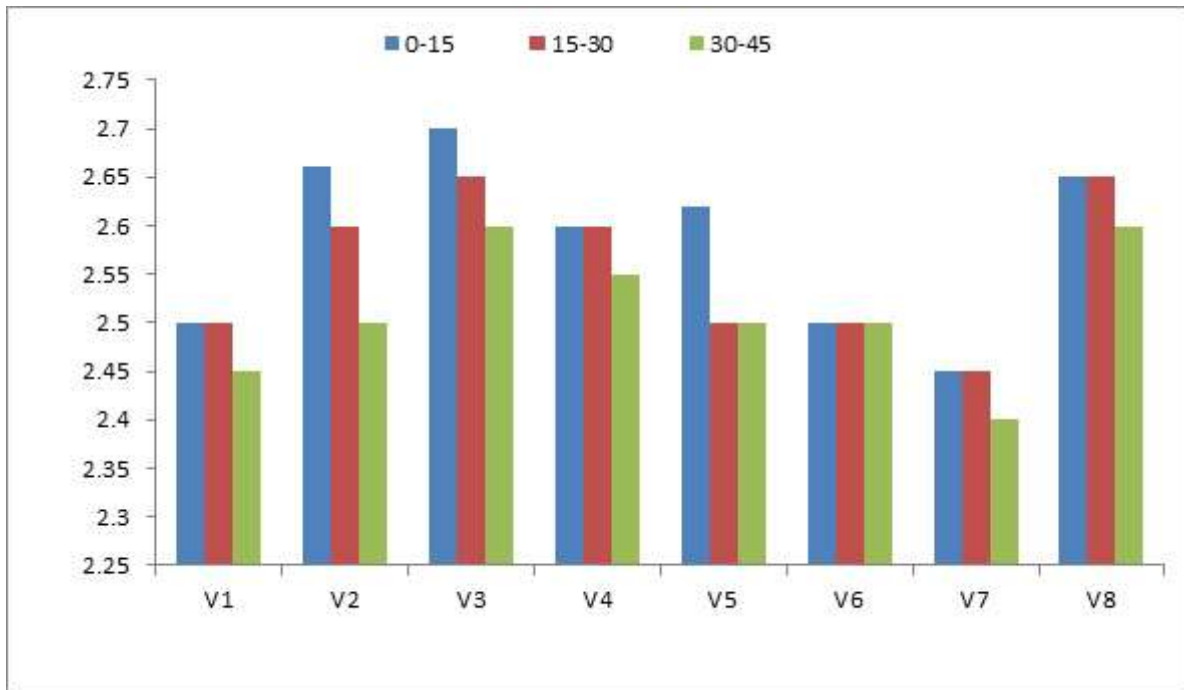


Fig-1 : Particle density values of soil of Sri Ganganagar regions, Rajasthan.

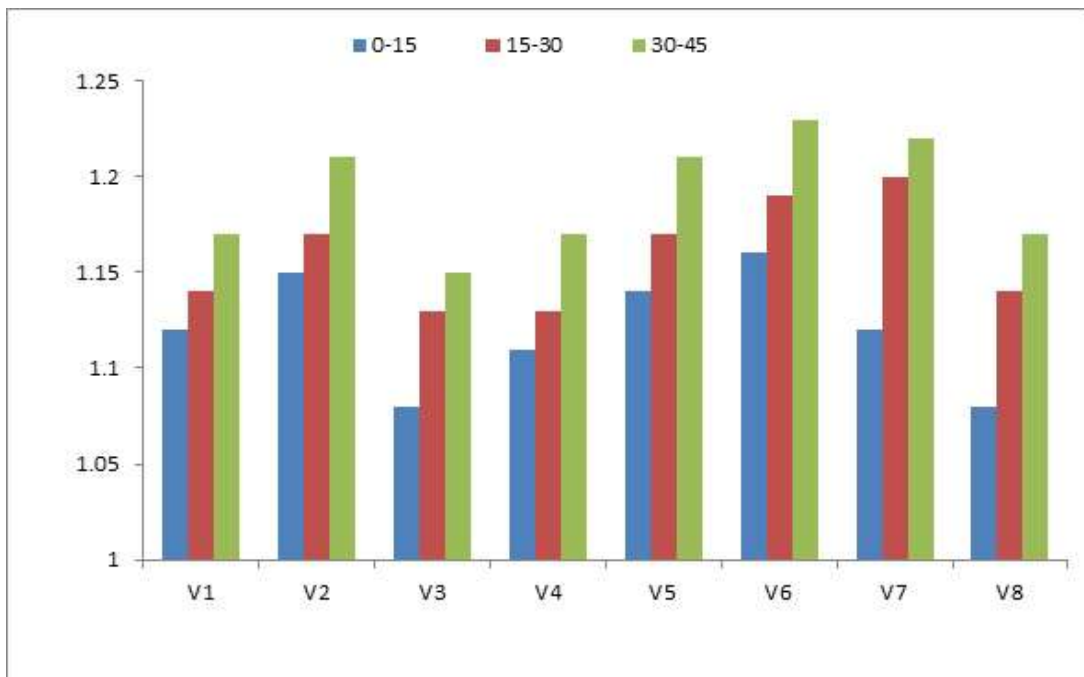


Fig-2 : Particle density values of soil of Sri Ganganagar regions, Rajasthan.

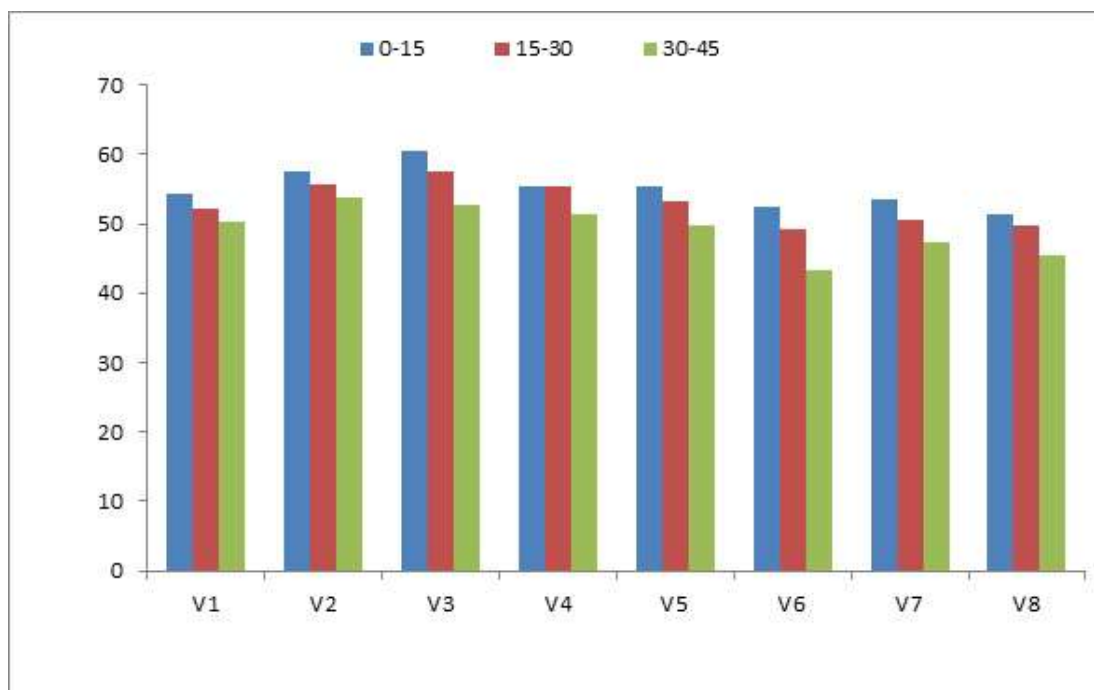


Fig-3 : Water holding capacity values of soil of Sri Ganganagar regions, Rajasthan.

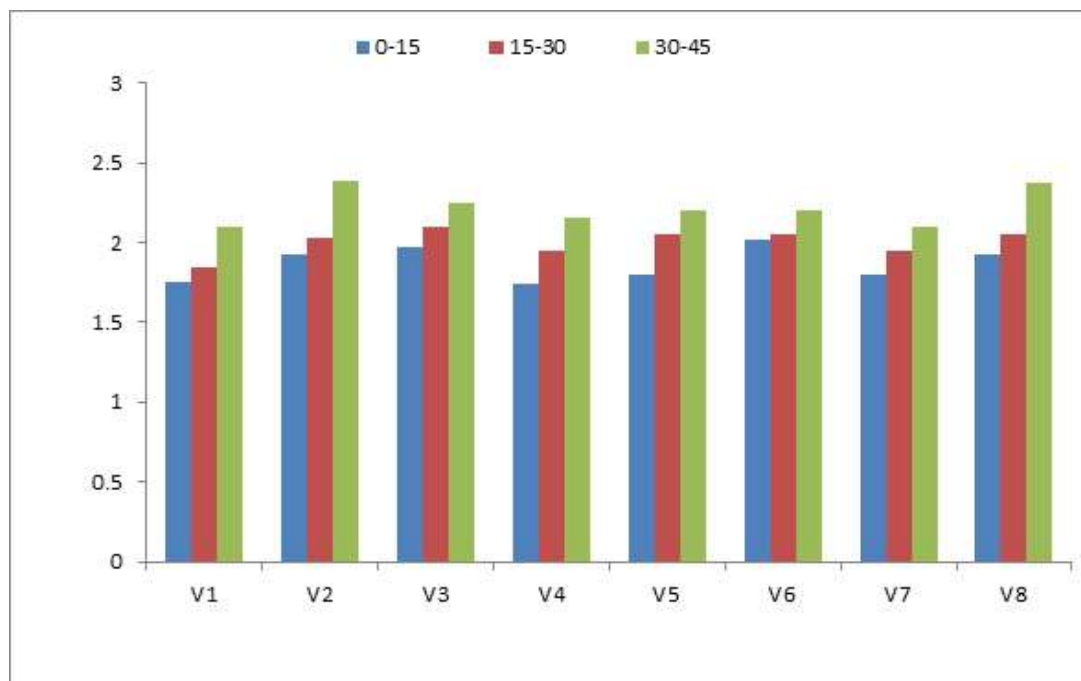


Fig-4 : Specific gravity values of soil of Sri Ganganagar regions, Rajasthan.

0-15 cm, 15-30 cm, and 30-45 cm, 24 soil samples were taken from two tehsils in Sri Ganganagar, and four villages from each block were chosen: 7KSD (V1), 6TK (V2), Slampura (V3), 6PTD (V4), 40GB (V5), 28GB (V6), 22GB (V7), and 46GB (V8) (V8). The soil sample was carefully mixed, and a half kilogramme of composite samples from farmer's fields in several communities were collected for analysis.

Results and Discussion

Figures 01 to 04 show observations of particle density, bulk density, percent pore space, specific gravity, and water holding capacity of the following soils, whereas table No.01 has statistical data on soil texture. Particle density is maximum at depth 15-30 cm (2.65 gcm⁻³) in 46GB (V8) village and lowest at depth 30-45 cm (2.40

gcm⁻³) in 22GB (V7) village. Soil Similar findings have been reported by others (D.J. Oyedele 2009). At both elevations, the bulk density in communities and depths was found to be significant. The highest value of is found in 22GB (V6) at depths of 30-45cm (1.23gcm⁻³) while the lowest value is found in 46GB (V8) at depths of 0-15cm (1.08gcm⁻³). Similar findings have been reported by others (Chaudhari 2013). The maximum water holding capacity was discovered in Slampura (V3) village at depths of 0-15cm (60.50%) and the lowest in 28GB (V6) village at depths of 30-45cm (43.40 percent). Similar findings have been reported by others (Sujatha *et al* 2016). Saturation of soil, as measured by specific gravity, was maximum in 6TK (V2) at depths of 30-45cm (2.39) and lowest in 6PTD (V4) village soil at depths of 0-15cm (1.74). Sandy soil and sandy loam soil were the soil texture groups (Table.1), which differed depending on location. Below are data graphs and tables from the analysis.

Conclusions

The current investigation of physical characteristics of Sri Ganganagar district soil samples revealed differences in physical characteristics. The top depth (0-15cm) of the soil had a higher particle density than the middle and lower depths (Viji 2012). The bulk density of the soil increased with depth, which could be due to the fact that bulk density was influenced by the calcareous and saline nature of the soils (Pravin R. Chaudhari *et al* 2013) . The water holding capacity of the soil decreased as depth was increased, possibly due to the presence of less organic matter in lower levels compared to the top soil (Sujatha *et al* 2016). Because specific gravity does not describe the actual situation of a water saturated soil, where the pore water is saline and this dissolved salt will start precipitating during the processing of the soil sample, specific gravity declines with depth. The weight and volume of the precipitated soil will then be added to the weight and volume of the original soil solids (Osama *et al* 2008). Because the effect of sand content on soil bulk density was found to be greater than that of the other soil

parameters, the texture of the soil varies from sandy loam to sandy clay loam.

References

1. Adamu, G.K., and Aliyu, A.K. 2012. Determination of the influence of texture and organic matter on soil water holding capacity in and around Tomas irrigation scheme, Dambatta local Government Kano state. *Research Journal of Environmental and Earth Sciences* 4(12): 1038-1044.
2. Anonymous.1971. Munsell soil colour chart, *Munsell color companyinc. 2241 N, Calvert street, Baltimore, marytanel* 21212, USA
3. Bouyoucos, G.J. (1927). The hydrometer as a new method for the soil texture.
4. Brady, N.C. and Weil, R.R. 1996. The nature and properties of soils (11th ed.). Prentice Hall, New York.
5. Buoyoucos, G.J. 1952. A recalibration of the hydrometer method for making mechanical analysis of soil, 43, 434.
6. Jaiswal P.C. 2006. Soil ,Water and plant Analysis, Manual Practical.
7. Muthuaval, P.C., Udayasooriyan.R., Natesan. P.P. and Ramaswami.1998. Introduction to soil Analysis, *Tamilnadu agriculture University,Coimbatore-641002*
8. Oyedele, D.J, Awotoye. O.O and Popoola. S.E. (2009). Soil physical and chemical properties under continuous maize cultivation as influenced by hedgerow trees species on an alfisol in South Western Nigeria. *African Journal of Agricultural Research*, 4(7): 736-739
9. Patel, K.P. (2015) Analysis of Soil Quality Using Physico-Chemical Parameters of ShehraTaluka District :Panchmahals (Gujarat). *Indian journal of applied sciences*, 5(9) : 66-468.
10. Pujar, K.G. *et al.*, 2012. Analysis of physico- chemical and heavy metal concentration in soil of bijapur taluka, Karnataka, *Sci. Revs. Chem. Commun.* 2(1): 76-79.
11. Shivakumar D. and Srikataswamy. S. (2012). Study of Physico-chemical characteristics of industrial zone soil-A case study of Mysore city, Karnataka, India. *International Journal of Environmental Sciences*, 3(1): 315-320.
12. Sujatha, K.N, Kavya. G, Manasa. P and Divya. K. (2016) Assessment of Soil Properties to Improve Water Holding Capacity in soils of Telangana region. *International Research Journal of Engineering and Technology*, Volume: 03 Issue: 03.
13. Thakre, Y.G., Choudhary, M.D., and Raut, R.D. 2012.Physicochemical Characterization of Red and Black soils of Wardha Region.*International Journal of Chemical and Physical Sciences*, 1(2): 60-66.