



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

Frontiers in Crop Improvement

VOLUME 9

SPECIAL ISSUE-IV

AUGUST 2021

Website : www.asthafoundation.in



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



Frontiers in Crop Improvement

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Volume 9

Special Issue-IV

August 2021

NAAS Rating - 4.67

Peer Reviewed, Refereed and Indexed Journal



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Two New Species of *Pseudocercospora* Associated with Foliar Leaf Spots in Forest Flora of North Eastern Uttar Pradesh

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Abstract

Two new species of *Pseudocercospora* Speg. viz., *Ps. rutacearum* on *Glycosmis pentaphylla* (Rutaceae) and *Ps. trewiae-nodiflorae* on *Trewia nodiflora* (Euphorbiaceae) are described, illustrated and compared with allied species.

Key words : Fungi, Follicolous, Hyphomycetes, *Pseudocercospora*.

Introduction

The foliicolous hyphomycetes genus *Pseudocercospora* Speg. was established by Spegazzini (1910) and redefined and expanded by Ellis (1971) and Deighton (1976). Since then a larger number of new species have been added to *Pseudocercospora* which is now one of the largest and best established genera among the cercosporoid fungi. It is characterized by causing usually non-necrotic but distinct Leaf spots and pigmented, obclavato-cylindric, phragmosporous conidia with unthickened scars. In this paper two new species of *Pseudocercospora* viz. *Ps. rutacearum* on *Glycosmis pentaphylla* (Rutaceae) and *Ps. trewiae-nodiflorae* on *Trewia nodiflora* (Euphorbiaceae), collected from North-Eastern Uttar Pradesh (India) are described and illustrated.

Materials and Methods

Specimens were collected from terai belt of North-Eastern Uttar Pradesh. Infected leaves with distinct symptoms were taken in separate polythene bags. The specimens were dried by the method used for preparing herbarium of phanerogamic plants. A part of each specimen was sent in HCIO (Herbarium Cryptogamiae Indiae Orientalis, New Delhi) for accession. Microscopic slides were prepared and examined under microscope and camera lucida drawing were prepared under 15 x eye piece and 45 x objective combinations. The taxonomic determinations were made the help of literature and experts. Descriptions were rendered latin diagnosis as per international rule.

Results and Discussion

On comparing the illustrations, description 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 rutacearum sp. nov. (Fig.-1)

Maculae amphigenae, angulares, veinis limitatae, saepe coalescentes et suborbiculares, 2-4 mm latis, pallide brunneae; *Coloniae* amphiphyllae, effusae, tenuiter velutinae; *Mycelium* internum; Hyphae ramosae, septatae, subhyalinae vel pallide olivaceae; *Stromata* eumorpha, immersa, subepidermibus posita, compacta, pseudoparenchymatosa, pallide brunnea, 20.0-24.5 µm diam.; Conidiophora solitaria, vel in fasciculis axae stomatibus oriunda, macronematosa, mononematosa, septata, non ramosa, laevia, leniter geniculata, recta vel flexuosa, cylindrica, pallide brunnea vel atro olivacea, 52.5-70.0 x 4.5-5.5µm; *Cellulae conidiogenae* integratae, monoblasticae vel polyblasticae, sympodiales, terminales, cicatrices Conidiales non incrassatae; *Conidia* solitaria, sicca, acrogena vel acropleurogena, holoblastica, obclavato-cylindrica, varia in figura et amplitudine, recta vel curvata, non ramosa, 3-20 transverse septata, laevia, tenui tunicata, medio vel atro olivacea, apicem versus acuta vel subacuta, basi subtruncata vel obconico-truncata, hilo non incrassato. 31.0-130.0 x 4.0-6.0 µm.

In foliis vivis *Glycosmidis pentaphyllae* Correa. (Rutaceae); leg. H.S.G.Rao; March, 1991; Gorakhpur (U.P.); GPU Herb. No. HK 40/2640 isotypus, HCIO 41180 holotypus.

Leaf spots amphigenous, angular, vein limited, sometimes coalescing with each other and sub-circular, 2-4 mm wide, light brown; *Colonies* amphiphyllous, effuse and finely velvety; *Mycelium* of hyphae branched, internal, septate, sub-hyaline to light olivaceous;

Stromata developed immersed, sub-epidermal, composed of compact pseudo-parenchymatous cells, light brown, 20.0-24.5 µm in diam.; *Conidiophores* solitary to in loose groups, arising from stromata, macronematous, mononematous, septate, unbranched, smooth walled, slightly geniculate, straight to flexuous, cylindrical, light brown to dark olivaceous, 52.5-70.0 x 4.5-5.5 µm; *Conidiogenous cells* integrated, mono to polyblastic, sympodial, terminal, scars-unthickened; *Conidia* solitary, dry, acrogenous to acropleurogenous, holoblastic, obclavate-cylindrical, variable in shape, straight to curved, unbranched, 3-20 transversely septate, smooth, thin walled, mid to dark olivaceous, apex acute to sub acute, base sub-truncate to obconicotruncate, hilum unthickened, 31.0-130.0 x 4.0-6.0 µm.

On living leaves of *Glycosmis pentaphylla* Correa. (Rutaceae); leg. H.S.G. Rao; March, 1991; Gorakhpur (U.P.); GPU Herb. No. HK 40/2640 isotype, HCIO 41180 holotype.

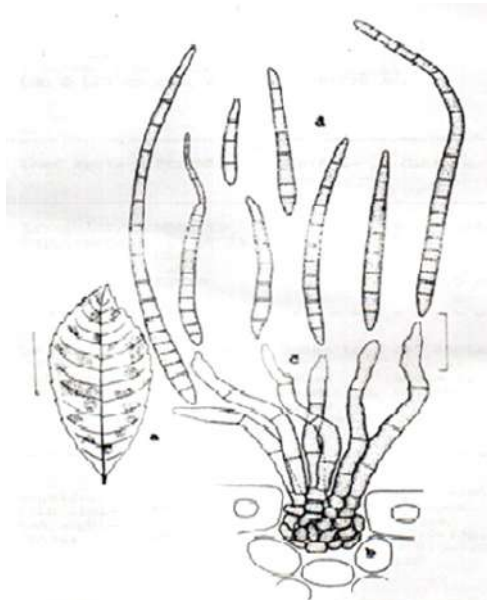


Fig.-1 : *Pseudocercospora rutacearum* sp. nov.

a. leaf spots, b. stroma, c. conidiophore, conidia.
Scales : a-20 mm; b, c, d: 20 µm

The literature shows that *Pseudocercospora* has not been recorded so far on the host species or genus in question. However, some species of *Pseudocercospora* have been described on different genera of the host family. Rutaceae, viz., *Ps. clausenae* (Thirun & Chupp) Liu & Guo (1989) on *Clausena wildenovii*, *Ps. correicola* Sutton & Pascoe (1988) on *Correa reflexa*, *Ps. fagarae* (Yamam.) Deighton (1976) on *Fagara* sp., *Ps. tagaricola* Sawada ex Goh & Hsieh in Hsieh & Goh (1990) on *Zanthoxylum nitidum*, (Kar & Mandal) Deighton (1987) and *Ps. mirryicola* Kumar & Kamal (1981) on *Murraya koenigii*, *Ps. oxyphyllii* (Pavgi & Singh) Deighton (1987)

on *Zanthoxylum oxyphyllum* and *Ps. xanthoxyli* (Cooke) Guo & Liu (1991) on *Z. clavaharculis*. Out of these only *Ps. fagarae* and *Ps. xanthoxyli* are comparable with the fungus in question due to some similarities of conidiophores and conidium morphology. This comparison (Table-1), however, shows that our collection is distinct due to its vein limited and amphigenous leaf spots, lightly coloured stromata, conidiophores borne singly or in loose fascicles and more septate conidia. Therefore, it has been described and illustrated herewith as a new species.

Pseudocercospora trewiae-nodiflorae sp. nov. (Fig.-2)

Maculae hypogaeae, primo parvae, 1-2 mm diam., denide orbiculares or suborbiculares, 4-12 mm diam. descretae, superne brunneo albae, inferne pallide brunneae; *Coloniae* hypophyllae, effusae; *Mycelium* internum; Hyphae ramosae, septatae, hyalinae vel olivaceae; *Stromata* eumorpha, immersa, pseudoparenchymatosa, pallide brunnea, 20-27 µm diam., *Conidiophora* in fasciculo stomatibus oriunda, caespitosa, macronematosa, mononematosa, non ramosa, 1-2 septata, laevia, non geniculata, erecta, recta vel leniter curvata cylindrica, apicem versus obtusa, atro olivacea, 12-53 x 3.5-6.7 µm; *Cellulae conidiogenae* integratae, terminales, monoblasticae, sympodiales, non geniculatae, cicatrices conidiales non incrassatae; *Conidia* solitaria, sicca, holoblastica, acropleurogena, obclavate-cylindrica, recta vel curvata, non ramosa, 5-15 transverse septata, laevia vel tenui tunicata, subhyalina vel pallide olivacea, apicem versus subacuta vel obtusa, basi obconicotruncata, hilo abbessea, 63.0-158.0 x 3.50-7.75 µm.

In foliis vivis *Trewiae nodiflorae* L. (Euphorbiaceae); leg. H.S.G. Rao; November, 1989; Nichlaul Forest, Maharajganj (U.P.); GPU Herb. No. HK 98/2698 isotypus, HCIO 41172 holotypus.

Leaf spots hypogenous, primarily small, 1-2 mm diam., later circular to sub-circular, 4-12 mm diam., discrete, upper brownish white and lower light brown; *Colonies* hypophyllous, effuse; *Mycelium of hyphae* internal, branched, septate, hyaline to light olivaceous; *Stromata* developed, immersed, pseudoparenchymatous, light brown, 20-27 µm in diam.; *Conidiophores* arising in fascicles from stromata, caespitose, macronematous, mononematous, unbranched, 1-2 septate, smooth, not geniculate, erect, straight or slightly curved, cylindrical, tip rounded, dark olivaceous, 12-53 x 3.5-6.7 µm; *Conidiogenous cells* integrated, terminal, monoblastic, sympodial, not denticulate, scars-unthickened; *Conidia* solitary, dry, holoblastic, acropleurogenous, obclavate-cylindrical,

Table-1 : Comparison of distinct morphotaxonomic features of *Ps. fagarae* (Yamam.) Deighton and *Ps. xanthoxyli* (Cooke) Guo & Liu as well as *Ps. rutacearum* sp. nov.

Species	Leaf spots	Stromata	Conidiophores	Conidia
<i>Ps. fagarae</i> (Yamam. Deighton)	Irregular hypogenous	None to 100 µm in diam dark brown	Fasciculate, 15-40 x 3-5 µm	3-11 septate apex blunt, 25-100 x 1.5-3.0 µm
<i>Ps. xanthoxyli</i> (Cooke) Guo & Liu	Circular to irregular, amphigenous	30-60 µm in diam black	Dense to very dense fascicles, 10-30 x 3-4 µm	3-7 septate, apex acute to obtuse, 20-75 x 2-4 µm
<i>Ps. rutacearum</i> sp. nov.	Angular, limited, vein amphigenous	20.0-24.5 µm in diam., light brown	Singly borne or in loose fascicles, 52.5-70.0 X 4.5-5.5	3-20 septate, apex acute, 31.0-130.0 x 4.0-6.0 µm

straight or curved, unbranched, 5-15 transversely septate, smooth and thin walled, sub-hyaline to light olivaceous, apex sub-acute to obtuse, base obconicotruncate, hilum absent, 63.0-158.0 x 3.5-7.75 µm.

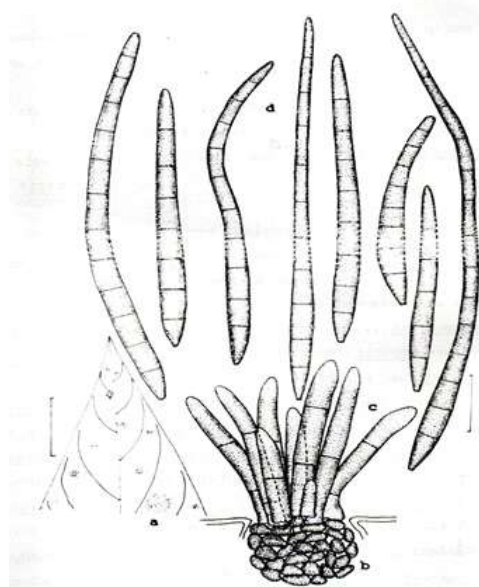


Fig.-1 : *Pseudocercospora trewiae-nodiflorae* sp. nov.
a. leaf spots, b. stroma, c. conidiophore, conidia.
Scales : a-20 mm; b, c, d: 20 µm

On living leaves of *Trewia nodiflora* L. (Euphorbiaceae); leg. H.S.G. Rao; November, 1989; Nichlaul Forest, Maharajganj (U.P.) GPU Herb. No. HK 98/2698 isotype, HCIO 41172 holotype.

Review 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 species of *Pseudocercospora* have been described on different genera of host family, Euphorbiaceae, viz., *Ps. transvaalensis* (H. Syd.) Deighton (1976) on *Acalypha* sp., *Ps. acalyphicola* (Petrak) Deighton (1976) and *Ps. acalyphicola* Yen apud Yen & Lim (1980) on *Acalypha indica*, *Ps. baliospermi* (Chaudhury) Deighton (1976) on *Baliospermum montanum*, *Ps. breyniae-rhamnoidis* (Thirum & Govindu) Deighton (1976) on *Breynia rhomboidis*, *Ps. brideliicola* Yen and al. (1982), *Ps. brideliae* Deighton (1976) on

Bridelia micrantha, *Ps. crotonis* (Ell. & Ev.) Deighton (1976) on *Croton* sp., *Ps. cluytiae* (Kalchbr. & Cooke) Deighton (1976) on *Cluytia* sp. *Ps. caperoniae* (Olive) Deighton (1976) on *Caperonia castaneifolia*, *Ps. mucunicola* (Cif. & Frag) Deighton (1976) on *Dalechampia* sp., *Ps. euphorbiae-piluliferae* Yen and al. (1982) on *Euphorbia pilulifera*, *Ps. petila* Goh & Hsieh in Hsien & Goh (1990) on *Euphorbia pulcherrima*, *Ps. phyllanthi-reticulati* (Sawada ex Deighton) Kamal & Gupta (1986) on *Fluggea macrocarpa*, *Ps. heveae* (Vincens) Deighton (1976) on *Hevea* sp., *Ps. hurae* (Stev.) Deighton (1976) on *Hura* sp. *Ps. jatrophae-curcas* (Yen) Deighton (1976) on *Jatropha* sp. *Ps. jatrophae* (Atk.) Das & Chattopadhyay (1990) on *Jatropha urens*, *Ps. kirganeliae* (Thirum. & Govindu) Deighton (1976) on *Kirganelia hurifolia*, *Ps. macarangicola* Deighton (1976) on *Macaranga hurifolia*, *Ps. macarangae* (H. & P. Syd.) Deighton (1976) in *Macaranga tanarius*, *Ps. bakeriana* Deighton (1976) on *Mallotus maluccanus*, *Ps. mallaticola* Goh & Hsieh in Hsieh & Goh (1990) on *Mallotus japonicus*, *Ps. neoboutoniae* (Hansf.) Deighton (1976) on *Neoboutonia* sp., *Ps. plunkettii* (Chupp) Castaneda & Braun in Braun & Castaneda (1991) on *Plukenetia* sp., *Ps. phyllanthiniruri* (Yen) Yen apud Yen & Lim on *Phyllanthus niruri*, *Ps. phyllanthi* (Chupp) Deighton (1976) on *Phyllanthus medarasapatensis*, *Ps. phyllanthi-reticulati* (Sawada) Deighton (1976) on *Phyllanthus reticulatus*, *Ps. entebbeensis* (Deighton) Deighton (1976), *Ps. leonensis* (Deighton) Deighton (1976), *Ps. newtonensis* (Deighton) Deighton (1976) and *Ps. phyllanthi-pentandri* (Yen & Gilles) Yen on *Phyllanthus* sp., *Ps. putranjivae* Kamal and al. (1980) on *Putranjiva roxburghii*, *Ps. sebeferi* Sawada ex Goh & Hsieh in Hsieh & Goh (1990) and *Ps. stellingiae* (Ell. & Ev.) Yen and al. (1982) on *Sapium sebiferum*, *Ps. sebastianiae* (Baker & Dale) Deighton (1976) on *Sebastiania* sp. and *Ps. securinegae* (Togashi & Katsuki) Deighton (1976) on *Securinega* sp. Out of these species only *Ps. jatrophae* and *Ps. macarangae* are comparable with the fungus in question due to some similarities in conidial morphology. The comparison presented in table 2 shows that our collection is distinct from *Ps. jatrophae* in the former having developed stromata, unbranched and shorter conidiophores as well as obclavate cylindrical and

Table-2 : Comparison of distinct morphotaxonomic features of *Ps. jatrophae* (Atk.) Das & Chattopadhyay *Ps. macarangae* (H. & P. Syd.) Deighton and *Ps. trewiae-nodiflorae* sp. nov.

Species	Stromata	Conidiophores	Conidia
<i>Ps. jatrophae</i> (Atk.) Das & Chattopadhyay	Lacking	Branched, tip rounded, 10-35 x 2-3.5 µm	Acicular or thread like, septa indistinct, tip acute, 41-170 x 1.5-2.5 µm
<i>Ps. macarangae</i> (H. & P. Syd.) Deighton	Less developed	Unbranched, tip conic, 50-180 x 3.0-4.5 µm	Obclavate cylindrical, 3-9 septate, tip obtuse to conic, 15-85 x 3.0-5.5 µm
<i>Ps. trewiae-nodiflorae</i> sp. nov.	Developed, 20-27 µm in diam.	Unbranched, tip rounded, 12-53 x 3.5-6.7 µm	Obclavate cylindrical, 5-15 septate, tip obtuse to conic, 63.0-158.0 x 3.50-7.75 µm

distinctly septate conidia. It is also different from *Ps. macarangae* in the former having shorter conidiophores and much longer conidia. Therefore, this collection has been treated herewith as a new species.

Acknowledgement

Author are thankful to the curator, HCIO, New Delhi for accession to the specimen and Dr. H. D. Bharti, Department of Botany, Bipin Bihari P.G. College, Jhansi (U.P.) for their help in taxonomic determinations and helpful suggestions in preparing manuscript. Their thanks are also due to The Principal, B.R.D.P.G. College, Deoria and Head, Department of Botany, D. D. U. Gorakhpur University Gorakhpur for providing laboratory and library facilities.

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Estimation of Heterosis by Understanding Genetic Architecture for Grain Yield and its Attributing Traits Using in Bread Wheat (*Triticum aestivum* L.)

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Abstract

The present investigation was undertaken to study the heterosis for grain yield and its contributing traits in bread wheat. The experimental material consisted of twelve parents (8 lines and 4 testers) and 32 F₁'s produced from line x tester mating design and evaluated in randomized block design for eleven characters. The heterobeltiosis for grain yield ranged from -42.75 to 27.96%, while standard heterosis ranged from -33.83 to 60.43%. The cross combinations viz., J -16-14 x RAJ4328 (27.96%), MP3382 x GW499 (24.85%) and AKAW4927 x GW496 (21.33%) exhibited the highest desirable heterosis over better parent. The cross AKAW4927 x GW496 (60.43%) exhibited highest significant heterosis towards positive direction over standard check (GW451) followed by MP3382 x GW499 (55.04%) and DDW88 x RAJ4328 (52.68%). These were found to offer best possibilities of their further exploitation for developing high yielding varieties of bread wheat.

Key words : Wheat, heterosis, heterobeltiosis, standard heterosis, grain yield, line x tester analysis

Introduction

Wheat's 'King of cereal' due to its vast acreage, dominance in world economy as agri-trading commodity and providing food security to the 40% of global population (Bhutto *et al.* 2016). Wheat beginning can be traced to a clan of wild grasses *Triticeae*, the seed of which had a flavor that was pleasing to primitive people. Wheat belongs to the genus *Triticum* of Poaceae family & order *Poales* and believed to be originated from South West Asia (Lupton, 1987), having a somatic chromosome number of cultivated species $2n=6x=42$ hexaloid. It is grown successfully during *Rabi* season. During recent past, exploitation of hybrid vigour and selection of parents on the basis of combining ability effects have opened a new line of approach in crop improvement. Application of biometrical techniques like line x tester analysis has appeared to be the best and vastly useful breeding tool, which gives generalized picture of genetic potentialities of the parents for hybrid breeding.

The first important step in the exploitation of heterosis is to know its magnitude and direction. The aim of estimation of heterosis in the present investigation was to spot out the best combination of parents giving high degree of economic heterosis as well as its exploitation to get better transgressive segregants and characterization of parents for their genotypic worth for future use in breeding programme. The degree of heterosis varied from cross to cross for all the traits studied. Considerably high heterosis in certain hybrids and low in others

revealed that nature of gene action varied with the genetic architecture of the parents involved. Such nature as well as magnitude of heterosis helps in identifying superior cross combinations for its exploitation commercially to isolate better transgressive segregants from segregating generations. The commercial usefulness of a hybrid would primarily depend on its performance in comparison with the best existing cultivars of that crop species.

Materials and Methods

The initial experimental material comprised of eight lines which were used as female parent for hybridization namely, J-16-14, VA2017-04, VA2017-05, GW519, AKAW4927, DDW88, MP3382, PBW757 and testers which were used as male parent for hybridization namely, GW496, HD2932, RAJ4328 of bread wheat were selected on the basis of phenotypic performance. The experimental material consisting of 45 entries, including 12 parents, 32 crosses and 1 standard check used in randomized block design with three replications during *Rabi* 2020-21 at the Wheat Research Station, Junagadh Agricultural University, Junagadh. A single row plot of 2.5 meters was allotted randomly to each entry. The row-to-row and plant-to-plant distance was kept 22.5 cm and 10 cm, respectively. The observations on five randomly selected plants in each genotype of three replications were recorded for Observations were recorded on days to heading (days), number of effective tillers per plant, days to maturity (days), plant height (cm), number of spikelets per main spike, grain filling period (days), length of main spike (cm), 100- grain weight

Table-1 : Analysis of variance (mean square) for line x tester design for grainyield and its contributing characters in bread wheat.

Source	d.f.	Days to heading	Number of effective tillers per plant	Days to maturity	Plant height	Number of spikelets per main spike	Grain filling period	Length of main spike	100-grain Weight	Grain yield per plant	Biological yield per plant	Harvest index
Replications	2	1.73	8.51**	8.27	24.75	2.77	6.42	1.22*	0.66**	21.44**	74.02**	54.78
Genotypes	43	20.43**	30.76**	15.52**	59.98**	7.99**	35.41**	2.37**	0.57**	22.94**	205.97**	148.18**
Parents	11	5.14**	30.53**	36.02**	70.14**	10.35**	70.04**	2.03**	0.26*	10.57**	220.72**	161.89**
Hybrids	31	20.11**	27.13**	6.69	58.31**	7.40**	23.98**	2.45**	0.67**	27.76**	206.76**	140.90**
Parents vs. Hybrids	1	198.50**	146.09**	63.52**	0.04	0.10	8.99	3.38**	0.80**	9.70*	19.02	223.32**
Error	86	1.44	1.63	6.31	8.46	1.20	3.71	0.37	0.11	1.45	15.18	25.63

*, ** Significant at 5% and 1% levels when tested against error mean square

++ Significant at 5% and 1% levels when tested against line x tester interaction mean square, respectively

Table-2 : Estimation of per cent heterobeltiosis (HB) and standard heterosis (SH) in bread wheat.

S. No.	Hybrids	Days to heading		No. of effective tillers per plant		Days to maturity		Plant height	
		HB	SH	HB	SH	HB	SH	HB	SH
1.	J-16-14 x GW496	3.85*	5.88**	21.58**	7.77**	0.67	3.04	-14.60**	-2.60
2.	J-16-14 x HD2932	3.21*	5.23**	-34.90**	-42.30**	2.29	4.70**	-18.48**	-7.03*
3.	J-16-14 x RAJ4328	-6.41**	-4.58**	-41.25**	-38.76**	2.96	5.38**	-4.92*	8.44*
4.	J-16-14 x GW499	3.85*	5.88**	-24.92**	-33.45**	0.00	3.04	-9.13**	3.63*
5.	VA2017-04 x GW496	-1.94	-0.65	-5.72	-24.87**	-0.66	1.01	-0.22	18.73**
6.	VA2017-04 x HD2932	4.76**	0.65	-53.07**	-65.85**	-0.34	0.34	-4.94*	13.11**
7.	VA2017-04 x RAJ4328	8.84**	4.58**	-34.17**	-31.38**	2.34	3.03**	-5.61*	12.31**
8.	VA2017-04 x GW499	3.90*	4.58**	-9.17	-48.30**	-1.00	2.01	-9.34**	7.48*
9.	VA2017-05 x GW496	7.10**	8.50	-14.67*	-32.00**	1.65	3.36**	-19.12**	-7.48*
10.	VA2017-05 x HD2932	10.14**	6.54**	-10.71	-35.02**	2.02	2.37**	-9.87**	3.10
11.	VA2017-05 x RAJ4328	8.78**	5.23**	-18.29**	-14.83**	-2.01	-1.68	-13.30**	-0.82
12.	VA2017-05 x GW499	2.60*	3.27*	-39.05**	-64.81**	-1.30	1.70	-12.69**	-0.12
13.	GW519 x GW496	-5.81*	-4.58**	-41.22**	-47.80**	0.67	2.36	-4.44*	5.45*
14.	GW519 x HD2932	11.04**	11.76**	-28.34**	-36.36**	1.34	1.34	2.52	11.79**
15.	GW519 x RAJ4328	12.99**	13.73**	-9.86*	-6.04	4.35*	4.36*	10.59**	10.69**
16.	GW519 x GW499	3.90*	4.58**	-42.27**	-48.73**	0.64	3.70*	-0.50	6.80*
17.	AKAW4927 x GW496	7.74**	9.15**	-29.70**	-43.98**	0.01	3.70	-1.98	8.17**
18.	AKAW4927 x HD2932	15.69**	15.69**	5.33	-19.99**	-1.62	2.03	3.35	12.70**
19.	AKAW4927 x RAJ4328	6.54*	6.54**	-58.03**	-56.25**	-1.95	1.68	2.13	10.16**
20.	AKAW4927 x GW499	3.25*	3.92*	-28.10**	-45.38**	-2.92	0.68	-1.56	6.18*
21.	DDW88 x GW496	-5.81*	-4.58**	-32.32**	-46.07**	-0.66	2.02	3.01	13.67**
22.	DDW88 x HD2932	6.12**	1.96	-22.81**	-43.82**	0.98**	3.70*	1.12	10.27**
23.	DDW88 x RAJ4328	6.12**	1.96	-48.90**	-46.74**	-0.66	2.01	8.11*	10.51**
24.	DDW88 x GW499	6.49**	7.19**	17.43*	-23.85**	0.63**	3.69*	8.26**	16.20**
25.	MP3382 x GW496	3.23*	4.58**	-44.00**	-41.86**	2.31**	4.03*	5.05*	15.92**
26.	MP3382 x HD2932	2.58	3.92*	-56.82**	-55.18**	3.04**	2.35**	-7.09*	1.32
27.	MP3382 x RAJ4328	2.58	3.92*	-58.68**	-56.93**	3.04**	2.70**	13.20**	12.61**
28.	MP3382 x GW499	-0.65	0.65	-55.99**	-54.31**	-2.30	0.67	0.12	7.47**
29.	PBW757 x GW496	-5.16**	-3.92*	17.95**	-6.00	-3.54*	0.68	-14.46**	-5.61*
30.	PBW757 x HD2932	8.78**	5.23**	-38.03**	-54.90**	-4.16*	0.03	-9.04**	-0.82
31.	PBW757 x RAJ4328	-2.03	-5.23**	-27.63**	-24.56**	-2.25	2.02	-8.05*	-0.45
32.	PBW757 x GW499	5.19**	5.88**	-2.14	-30.95**	-2.58	1.68	6.67*	15.48**
SEd+			0.98	0.98	1.03	1.03	2.04	2.04	2.36
CD at 5%			1.62	1.62	1.72	1.72	3.40	3.40	3.92

Table-3 : Estimation of per cent heterobeltiosis (HB) and standard heterosis (SH) in bread wheat.

S. No.	Hybrids	Number of spikelets per main spike		Grain filling period		Length of main spike		100-grain weight	
		HB	SH	HB	SH	HB	SH	HB	SH
1.	J-16-14 x GW496	10.86*	8.72**	-0.64	1.99	8.85*	19.67**	-29.75**	-35.16**
2.	J-16-14 x HD2932	-9.78*	-11.38**	3.22	5.96**	-21.05**	-10.87*	-8.05	-14.38**
3.	J-16-14 x RAJ4328	6.88	3.93	13.45**	17.21**	-2.76	2.62**	0.28	-4.58
4.	J-16-14 x GW499	9.26*	2.80	-3.14	1.99	-4.64	-1.01	-9.27	-16.26**
5.	VA2017-04 x GW496	-13.93**	-3.10	-0.63	4.63	22.28**	34.43**	8.49	-0.24
6.	VA2017-04 x HD2932	-8.57*	2.94	-3.14	1.99	-5.30	6.91	-4.75	-11.30*
7.	VA2017-04 x RAJ4328	-9.44*	1.96	-1.88	3.31	7.50	13.46**	9.46	4.14
8.	VA2017-04 x GW499	-18.50**	-8.24	-3.77	1.32	-6.74	-3.19	10.44	1.55
9.	VA2017-05 x GW496	0.95	-1.00	-3.82	0.00	-14.12**	-5.58	-12.55*	-15.12**
10.	VA2017-05 x HD2932	3.39	1.56	-3.82	0.00	-10.37*	1.19	-16.05**	-18.52**
11.	VA2017-05 x RAJ4328	-3.69	-6.35	-10.18**	-6.62*	-2.20	3.83	-0.91	-3.82
12.	VA2017-05 x GW499	-3.12	-9.02**	-5.03*	0.00	-6.22	-0.43	11.30*	8.03
13.	GW519 x GW496	6.06	4.02	7.14**	9.26**	-15.29**	-6.86	1.18	-9.66
14.	GW519 x HD2932	8.30	6.38	-11.60**	-9.26**	-12.55**	-1.28	2.70	-4.36
15.	GW519 x RAJ4328	8.09	5.10	-12.81**	-9.93**	0.17	5.72	-8.98	-13.40*
16.	GW519 x GW499	-2.88	-12.22**	-2.51	2.65	-2.17	1.55	8.92	-2.75
17.	AKAW4927 x GW496	-23.26**	-12.35**	-8.64**	-1.99	-14.00**	1.70	7.26	3.86
18.	AKAW4927 x HD2932	-1.15	12.91**	-12.34**	-5.96**	2.39	21.08**	4.59	1.27
19.	AKAW4927 x RAJ4328	-22.41**	-11.38*	-9.87**	-3.31	-13.83**	1.90	1.85	-1.38
20.	AKAW4927 x GW499	-19.97**	-8.59*	-9.25**	-2.65	-12.20**	3.82	10.80*	7.29
21.	DDW88 x GW496	-11.33**	9.90*	-1.20	4.3**	12.01**	23.14**	7.18	-5.96
22.	DDW88 x HD2932	-9.06*	12.72**	-4.21	5.29**	-1.21	11.53*	-13.97*	-19.88**
23.	DDW88 x RAJ4328	0.99	25.18**	-7.22**	1.99	10.22*	16.33**	5.50	0.38
24.	DDW88 x GW499	-2.12	21.32**	-9.03**	0.00	10.74*	16.87**	-5.20	-15.38**
25.	MP3382 x GW496	0.55	-1.39	1.30	3.31	0.97	11.01*	-4.40	-16.12**
26.	MP3382 x HD2932	-4.62	-6.32	-1.93	0.66	-5.37	6.84	-5.77	-12.25*
27.	MP3382 x RAJ4328	2.49	-0.34	-1.92	1.32	-3.17	2.19	6.27	1.11
28.	MP3382 x GW499	8.61	-0.80	-4.40	0.66	2.99**	6.91	23.73**	10.45*
29.	PBW757 x GW496	-4.40	1.98	-6.59**	5.29*	6.33	16.90**	-8.77	-19.95**
30.	PBW757 x HD2932	-11.99**	-6.11	-15.98**	-5.29*	-8.08**	3.77	-1.54	-8.31
31.	PBW757 x RAJ4328	-5.85	0.43	-3.06	9.26**	4.83	10.64*	3.07	-1.93
32.	PBW757 x GW499	-12.89**	-7.08	-13.63**	-2.65	3.43**	7.36	13.88*	1.66
SEd+			0.88	0.88	1.56	1.56	0.49	0.49	0.28
CD at 5%			1.47	1.47	2.59	2.59	0.82	0.82	0.47

(g), grain yield per plant (g), biological yield per plant (g) and harvest index (%). The data were analyzed for heterosis following procedure suggested by Fonseca and Patterson (1968).

Results and Discussion

Analysis of variance revealed significant differences among all the parents for all the characters studied whereas in hybrids Analysis of Variances revealed significant differences among all characters except in days to maturity. Variance due to parents vs. hybrids were found significant for all the characters except viz., plant height, number of spikelets per main spike, grain filling period and biological yield per plant. The conspicuous heterotic effects were observed for grain yield per plant and its components. A total of 5 and 12 hybrids manifested significant desirable heterobeltiosis and standard heterosis, respectively. The heterobeltiosis for

grain yield ranged from -42.75 to 27.96%, while standard heterosis ranged from -33.83 to 60.43%. The cross combinations viz., J-16-14 x RAJ4328 (27.96%), MP3382 x GW499 (24.85%) and AKAW4927 x GW496 (21.33%) exhibited the highest desirable heterosis over better parent. The cross AKAW4927 x GW496 (60.43%) exhibited highest significant heterosis towards positive direction over standard check (GW451) followed by MP3382 x GW499 (55.04%) and DDW88 x RAJ4328 (52.68%). Vanpariya *et al.* (2006a), Singh *et al.* (2007), Kamani (2009), Biliginet *et al.* (2011), These findings are in accordance with the findings of Kallimullah (2011), Fellahiet *al.*(2013)and Singh *et al.* (2013).

This suggested the existence of overall heterosis and the chance of significant differences between the parents and crosses with respect to these characters. By seeing possibility of heterosis among these selected genotypes further analysis was undertaken. The degree

Table-4 : Estimation of per cent heterobeltiosis (HB) and standard heterosis (SH) in bread wheat.

S. No.	Hybrids	Grain yield per plant		Biological yield per plant		Harvest index	
		HB	SH	HB	SH	HB	SH
1.	J-16-14 x GW496	-39.11**	-19.50**	8.87	30.96**	-44.30**	-38.03**
2.	J-16-14 x HD2932	-14.84**	-5.71	-3.07	10.40	-21.20**	-15.01
3.	J-16-14 x RAJ4328	27.96**	26.56**	43.81**	63.79**	-10.04	-21.47*
4.	J-16-14 x GW499	-12.57**	8.57	-23.51**	30.75**	-4.27	-16.92*
5.	VA2017-04 x GW496	-17.38**	9.24	2.64	23.46*	-20.98**	-12.09
6.	VA2017-04 x HD2932	6.28	17.68**	36.52**	39.21**	-21.86**	-15.72
7.	VA2017-04 x RAJ4328	-30.95**	-33.83**	-17.80*	-9.54	-14.64	-23.48**
8.	VA2017-04 x GW499	-31.08**	-14.42*	-42.20**	-1.19	-4.02	-13.95
9.	VA2017-05 x GW496	-6.13	24.11**	18.95**	79.74**	-38.40**	-31.47**
10.	VA2017-05 x HD2932	-16.79**	-7.86	6.56	61.02**	-45.23**	-40.93**
11.	VA2017-05 x RAJ4328	10.44*	12.95*	1.55	53.46**	-16.12	-26.78**
12.	VA2017-05 x GW499	-12.35**	8.84	-38.06**	5.89	41.57**	2.32
13.	GW519 x GW496	-36.46**	-15.99**	-31.46**	0.90	-23.80**	-15.22
14.	GW519 x HD2932	-6.08	11.74*	-16.54**	22.86*	-16.31*	-9.74
15.	GW519 x RAJ4328	-31.31**	-18.27**	11.80	64.58**	-43.61**	-50.77**
16.	GW519 x GW499	-42.75**	-28.91**	-43.74**	-3.83	-12.65	-25.68**
17.	AKAW4927 x GW496	21.33**	60.43**	-18.97**	53.26**	-6.51	4.01
18.	AKAW4927 x HD2932	-2.56	7.89	-4.63	80.39**	-46.47**	-42.27**
19.	AKAW4927 x RAJ4328	-26.82**	-26.01**	-12.28*	65.91**	-49.19**	-55.65**
20.	AKAW4927 x GW499	-38.89**	-24.12**	-50.54**	-6.45	12.78	-18.49
21.	DDW88 x GW496	-19.28**	6.72	7.52	29.34**	-26.06**	-17.75*
22.	DDW88 x HD2932	6.01	33.84**	5.28	24.04*	-0.70	7.10**
23.	DDW88 x RAJ4328	20.93**	52.68**	37.90**	62.46**	-12.05	-6.42
24.	DDW88 x GW499	-4.74	20.27**	-25.77**	26.89**	-10.26	-4.52
25.	MP3382 x GW496	-16.07**	10.97*	38.87**	68.74**	-41.31**	-34.71**
26.	MP3382 x HD2932	-14.42**	-3.79	-22.38*	-5.68	-5.72	1.68
27.	MP3382 x RAJ4328	1.82	14.47*	10.64	34.44**	-4.75	-7.98
28.	MP3382 x GW499	24.85**	55.04**	-6.40	60.01**	-0.57	-3.94
29.	PBW757 x GW496	-27.92**	-4.70	-7.03	11.82	-23.25**	-14.61
30.	PBW757 x HD2932	-22.05**	-13.69*	-15.34	-13.75	-7.70	-0.45
31.	PBW757 x RAJ4328	-12.14*	-15.81**	18.31*	30.20**	-25.50**	-33.55**
32.	PBW757 x GW499	-29.70**	-12.71*	-30.02**	19.63*	-18.68*	-27.47**
SEd+			0.80	0.80	3.39	3.19	4.10
CD at 5%			1.33	1.33	5.63	5.30	6.83

of heterosis varied from cross to cross for all the traits studied. Considerably high heterosis in certain hybrids and low in others revealed that nature of gene action varied with the genetic architecture of the parents involved. Such nature as well as magnitude of heterosis helps in identifying superior cross combinations for its exploitation commercially to isolate better transgressive segregants from segregating generations. The commercial usefulness of a hybrid would primarily depend on its performance in comparison with the best existing cultivars of that crop species.

The exploitation of heterosis of crosses will lead toward yield enhancement so these hybrids were compared over better parent and standard check GW451, for estimating heterobeltiosis and standard heterosis. Top three crosses, viz., J-16-14 x RAJ4328, GW519 x GW496 and DDW88 x GW496 were found significantly earlier in days to heading over better parent. Whereas

hybrids viz., PBW757 x RAJ4328, GW519 x GW496 and DDW88 x GW496 were performing better than the standard check GW451. For the number of effective tillers per plant top three crosses, viz J-16-14 x GW496, PBW757 x GW496 and DDW88 x GW499 were found significant and desired whereas cross J-16-14 x GW496 exhibited both heterobeltiosis as well as standard heterosis. For days to maturity negative and significant values of hybrids were preferred, the hybrids namely PBW757 x HD2932 and PBW757 x GW496 were executed significantly earlier over better parent and none to standard check. For plant height Hybrids VA2017-05 x GW496, J-16-14 x HD2932 and J-16-14 x GW496 exhibited highest heterobeltiosis and hybrids viz., VA2017-05 x GW496, J -16-14 x HD2932 and PBW757 x GW496 exhibited highest standard heterosis.

For number of spikelets per main spike two crosses, viz., J-16-14 x GW496, and J-16-14 x GW499 were found

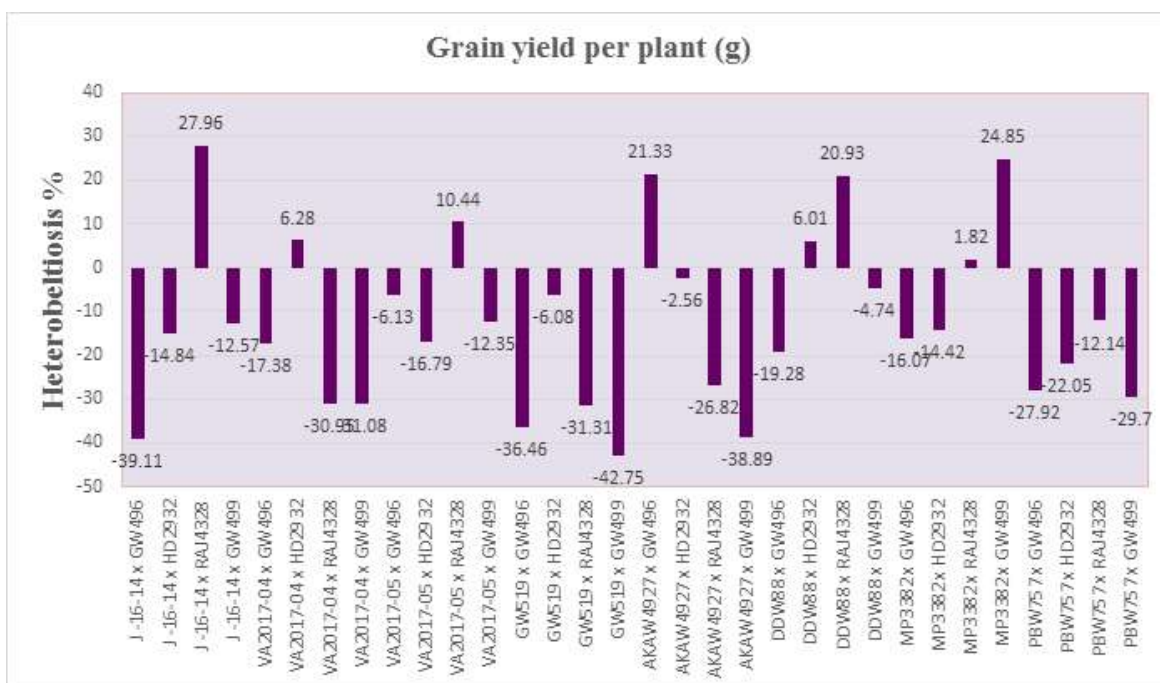


Fig-1 : Depicting graphical representation of heterobeltiosis (%) for the trait grain yield per plant.

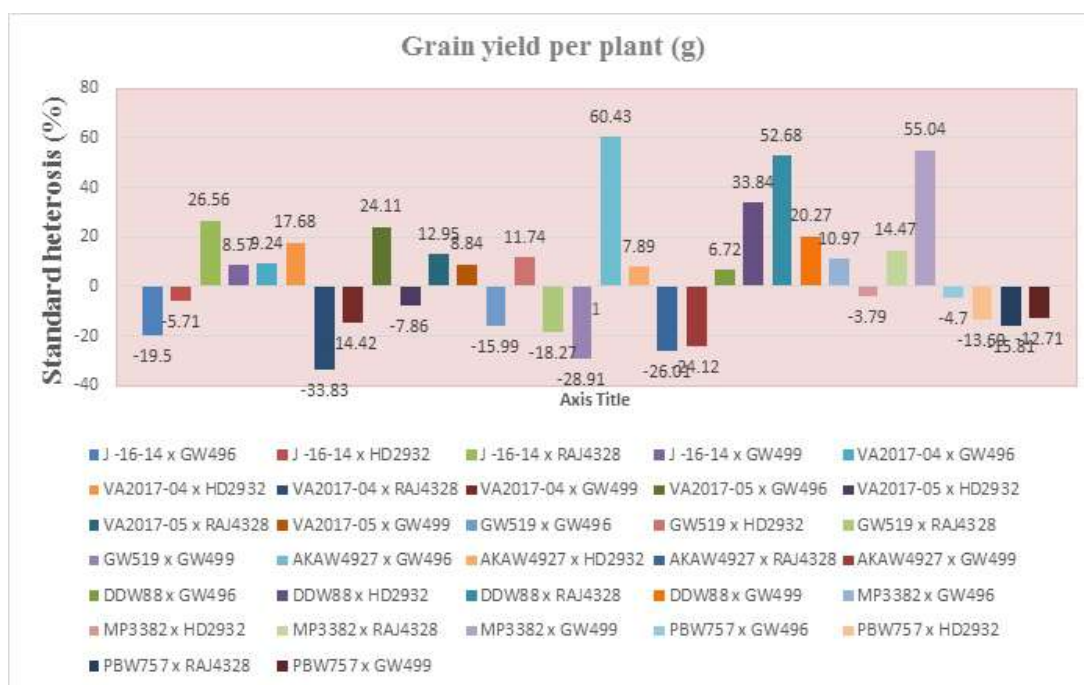


Fig-2 : Depicting graphical representation of standard heterosis (%) for the trait grain yield per plant.

significant and desired for this trait over better parent whereas top three hybrids, DDW88 x RAJ4328, DDW88 x GW499 and AKAW4927 x HD2932 registered standard heterosis. For grain filling period GW519 x RAJ4328, AKAW4927 x HD2932 and GW519 x HD2932 were negative and significant over better parent whereas hybrids which exhibited standard heterosis were GW519 x RAJ4328, GW519 x HD2932 and VA2014-05 x RAJ4328 for grain filling period. Top three crosses, viz.,

VA2017-04 x GW496, DDW88 x GW496 and DDW88 x GW499 were found positive and significant in length of main spike over better parent. Top three hybrids which registered standard heterosis were VA2017-04 x GW496, DDW88 x GW496 and AKAW4927 x HD2932.

For 100-grain weight three crosses, viz., MP3382 x GW499, PBW757 x GW499 and VA2017-05 x GW499 found significant and desired over better parent and cross namely, MP3382 x GW499 exhibited standard heterosis.

P ₁	F ₁	P ₂
		
AKAW4927 (7.4 cm)	AKAW4927 x GW496 (8.4 cm)	GW496 (7.1cm)
		
MP3382 (6.9cm)	MP3382 x GW499 (7.0cm)	GW499 (7.2cm)
		
DDW88 (6.5 cm)	DDW88 x RAJ4328 (7.4 cm)	RAJ4328 (6.8 cm)

Plate-1 : Pictorial representation of seeds of lines, hybrids and testers which exhibited highest Standard heterosis (over GW451) in bread wheat for grain yield per plant.

For Grain yield per plant heterobeltiosis was observed in crossed viz., J -16-14 x RAJ4328, MP3382 x GW499 and AKAW4927 x GW496. Three crosses, viz., AKAW4927 x GW496, MP3382 x GW499 and DDW88 x RAJ4328 were found positive and significant over standard check. For biological yield per plant Top three crosses, viz., J -16-14 x RAJ4328, MP3382 x GW496 and DDW88 x RAJ4328 over better parent, whereas crosses AKAW4927 x HD2932, VA2017-05 x GW496 and MP3382 x GW499 were found significantly and desired over standard check. For harvest index Crosses, VA2017-05 x GW499 and DDW88 x HD2932 were found significantly positive for harvest index over better parent and standard check (GW451), respectively. These findings have similarity with the findings of Singh *et al.* (2007), Bilgin *et al.* (2011), Kallimullah (2011), Desale and Mehta (2013), Devi *et al.* (2013) and Singh *et al.* (2013).

In case of line x tester, three cross combinations viz., AKAW4927 x GW496, MP3382 x GW499 and DDW88 x RAJ4328 were found to be performing better than standard check for grain yield per plant and also showed higher *per se* performance. Hence, such cross combinations may be utilized for commercial exploitation of heterosis grain yield improvement programme in bread wheat.

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Production of Quality Vermicompost Using *Eisenia fetida* from Various Bio Wastes under Different Seasons

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Abstract

A pot experiment consisted of four bio wastes (leaf litter, Ipomea, Water hyacinth and Vegetable market waste) and tested for three seasons (Rainy, Winter and Summer) was conducted for two years (2015-16 and 2016-17) at Rajala research farm of M.G.C.G.V., Chitrakoot Satna (M.P). The twelve treatment combinations were arranged in a randomized block design, replicated thrice. Result of study showed that bio wastes as well as changes of season and their interaction has significant effect on production of vermicompost during required as well as conversion rate. The higher required quantity of vermicompost (4520 g) from 8 kg of bio waste was recorded from the waste of leaf litter followed by vegetable waste (4380 g) and water hyacinth (4346 g). The lowest quantity of vermicompost (3640g) was obtained from Ipomea. In this regard it was observed that the conversion rate of 133.45g /day was under water hyacinth which was higher than other.

Introduction

Cultivated lands are deficient in almost all essential plant nutrients while the large quantity of such nutrients containing bio waste like crop residues, weeds and other bio wastes generated in the market, house and farms are wasted. These organic wastes also pose a problem for safe disposal. Among these wastes some of them are hard to decompose and emit out certain harmful gases as well as release certain substances which are toxic to living organisms. Physically and biologically these wastes have no use as they are neither used for fuel nor for feeding the animals. In the soil laboratory, number of macro and micro organisms that have an ability to convert organic wastes into valuable manures, which are critical for maintaining soil productivity (Nagavallemmu *et al.* 2004). Earthworms are biological creatures having nature to maintain nutrient flow from one system to another and also help to minimize environmental degradation.

The invertebrates like termites and earthworms both are found to be in slow motion as they move in compact environment which limits their activity to immediate micro site where they reside. The earthworm *Eisenia fetida* is highly prolific due to consistent production of cocoons with outstanding hatching rates of young which attain sexual maturity within seven weeks. The *Eisenia fetida* has proved to be an important species with respect to rate of reproduction speed in which it can compost large amount of material and possess tolerance of wide range of temperature and pH level. Thus the conversion of diverse organic wastes with respect to origin and nature is an essential vital issue not only for meeting out the

requirement of nutrients for crop production but also necessary for maintaining the soil environment as well as conserve our resources. The challenges presently being faced by researchers and environmentalists is how to develop cost effective, eco-friendly and appropriate technology that maximizes the economic value of nutrient, and minimize the adverse impact of conventional on our resources. Therefore, the vermicomposting, which is a simple biotechnology process, which could provide a win-win solution to tackle the aforesaid problem, related to the safe disposal of waste as well as the need of crops for nutrient for sustainable productivity (Wani, 2002).

Materials and Methods

A pot experiment was conducted for two years (2015-16 and 2016-17) at research farm of MGCGV, Chitrakoot. A total of twelve treatment combinations consisted of four bio wastes (Leaf litter, Ipomea, Water hyacinth and vegetable market wastes) and tested for three seasons (Rainy, Winter and Summer). These treatments were arranged in a factorial randomized block design with three replications. All the four bio wastes including the tree leaves, Ipomea & water hyacinth and vegetable market wastes were collected from road side, ponds and vegetable market whereas the during from instructional dairy farm, respectively. These bio wastes were weighted as fresh and determined the dry matter percentage. On the basis of dry matter 4 kg of each bio waste mixed with 4 kg of during in the ratio of 1:1 (bio waste and dung) were put together for partial decomposition for a period of 21 days. After partial decomposition, partially decomposed matter was put in an earthen pot for dization by

earthworms, as per treatments separately,. This process was repeated in each season of rainy, winter and summer seasons. Earthworms species *Eisenia fetida* was used and inoculated @200g in each pot. However, counts of worms were varies in different treatments. Observations with respect to production of vermicompost, duration required for completion of vermicompost process, ratio of conversion as well as quality with respect to physical chemical and biological properties were recorded.

Production of Vermicompost : Data in relation of production of vermicompost as influence by different bio-wastes as well changes of season. These analysed data are presented in Table 1 Pooled analysis of data several that bio-wastes, seasons as well as their interaction their interaction has marked effect on production of vermicompost. The production of vermicompost with the use of leaf litter produced heightened quantity (45.20g) of 45208 of vermicompost closely followed by vegetable market waste (4380g) out of 8 kg of substrata including animal dung was taken for the purpose. The significantly lowest quantity of vermicompost was obtained under Ipomea. The leaf litter degraded earlier due to microbial proliferation and there activities along with earthworms similar findings were also reported by Kaviraj and sharma (2003).

Similar, change of season changed the outcome of vermicompost and rainy season closely followed by summer produced 4465 and 4243g vermicompost respectively, while, winter season produced least quality of vermicompost.

As regards to the interaction, different bio-wastes showed different behavior to various seasons. The leaf litter during rainy season produced 4870g vermicompost which was significantly superior over rest of the treatment combinations. Thus, it is conformed that leaf litter, water hyacinth and vegetable market waste are found to produce good quantity of vermicompost under rainy season.

Table-1 : Production of vermicompost (g) as affected by difference bio waste and seasonal changes.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	mean
Leaf litter	4870	4040	4650	4520
Ipomea	3860	3450	4300	3640
Water hyacinth	4580	3450	6400	4346
Vegetable market waste	4550	3940	4420	4380
Mean	4465	3900	4243	5008
	Bio-waste	Season	Bio x Sea	
SEm±	0.170	0.210	0.390	
CD at 5%	0.520	0.650	1.200	

Duration required for completion of vermicompost process : Data pertaining to duration required for

completion of vermicomposting were computed by subtracting 28 days from total period taken for completion of process. data on this parameter as influenced by different bio-wastes and change of season are presented in Table 2. It is obvious from the data that duration from inoculation of worms to maturity of vermicompost found significantly varied due to bio-waste and seasons. Data reveal that Ipomea take maximum duration of 52 days for digestion (Conversion into vermicompost) just from inoculation of earthworms to maturity period where as only 33 days required by water hyacinth which is significantly lower to all the bio-wastes. However leaf litter and vegetable market wastes found at par to each other. Change of season also had significant effect on duration require for vermicompost maturity. Conversion of wastes into vermicompost was proved faster during rainy season. It means rainy season take the lowest duration of 37 days closely followed by 40 days in summer season. More ever, winter season required longest duration of 45 days which is significantly superior over both of rainy and summer seasons.

The different bio-wastes showed their differential response to different seasons for maturity period of vermicompost. The significantly lowest period of only 28 taken by water hyacinth during rainy season and proved superior over all the combination except leaf litter rainy and summer season, water hyacinth summer as well as vegetable market waste in rainy season which required 35,35,33 and 36 days for maturity of vermicompost, respectively.

Table-2 : Duration (days) required for completion of vermicompost process after release of earthworms.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	35	42	35	37.0
Ipomea	48	56	52	52.0
Water hyacinth	28	37	33	33.0
Vegetable market waste	36	44	40	40.0
Mean	36.8	44.8	40.0	
	Bio-waste	Season	Bio x Sea	
SEm±	1.31	1.58	2.89	
CD at 5%	3.88	4.73	8.68	

Conversion rate (g/day) : The conversion rate means change of used substrata into vermicompost. The conversion rate was computed and analyzed data are presented in Table-3 and revealed significant different among the bio-wastes, seasons as well as their interaction. The higher rate of conversion (133.45 g/day) was recorded under water hyacinth which was found significantly superior over rest of the bio-wastes. On the other hand, leaf litter proved its superiority over vegetable

market wastes and Ipomea. Significantly the lowest rate of conversion was recorded with Ipomea (70.42 g/day).

The interaction of bio-waste and season showed significantly the highest conversion rate of 163.57g /day and superiority over rest of the combination. However, W1 x S1, W1 x S3, W3 x S3, and W4 x S1 were found at par and superior over other combinations.

Table-3 : Conversion rate of bio-wastes into Vermicompost (g/day).

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	139.14	96.19	132.85	122.72
Ipomea	80.42	61.60	69.23	70.42
Water hyacinth	163.57	106.60	130.30	133.45
Vegetable market waste	126.38	94.77	110.5	110.55
Mean	127.38	89.76	110.72	
	Bio-waste	Season	Bio x Sea	
SEm±	2.76	3.04	5.87	
CD at 5%	8.28	9.12	17.61	

Quality of Vermicompost : Production of vermicompost would have no much importance, if they are of poor in quality. Thus the Quantitative production of vermicompost has no meaning without quality with respect to its physical chemical and biological properties.

Microbial diversity : In this study, vermicompost sample were drawn and analyzed for microbial diversity as well as the study of counts per g sample. vermicompost samples were taken in sterile containers before harvesting of vermicompost. In order to compare microbial diversity, sample from the decomposed organic matter ready for release of earthworms were also collected. The microbial population of bacteria, fungi and actinomycetes from various type of substrata and vermicompost were determined by using dilution plate technique with suitable media and expressed as CFU g⁻¹.

It has been well established that worms play a significant role and bring out the change in population of organisms. (Parmelee et al. 1998) In the present study, it was noted that the higher population of microbes especially the bacteria, fungi and actinomycetes were observed in partially decomposed material, prior to release of earthworms as compared to vermicompost obtained. It shows that microbial diversity is more in partially decomposed matter than the vermicompost.

Table-4 : Microbial populations of partially decomposed matter and vermicompost.

Particular	Bacteria (CFUg ⁻¹)	Fungi (CFUg ⁻¹)	Actinomycetes (CFUg ⁻¹)
Partially decomposed organic waste used for vermicompost.	60 x 10 ⁶	12 x 10 ⁴	2 x 10 ⁴
Vermicompost	51 x 10 ⁶	7 x 10 ⁴	1 x 10 ⁴

Biodiversity in vermicompost : Association of earthworms with microbes is repeated to be complex certain microbial groups found to be a part of earthworm diet and when it is passed through digesting system of worm they suppress and destruct their microbes are *Fusarium oxysporum*, *Alternaria solani* and micro fungi were digested by earthworm.

In the present study, sample of partially decomposed waste for vermicompost preparation and prepared vermicompost were collected and analyzed for microbial counts. It is clear from the data presented in Table-4 that the counts of bacteria and fungi were found to be significant differ in various types of vermicompost prepared from different substrata. the maximum number of bacteria (58*10-6CFUg⁻¹) and fungi (9*10-4 CFUg⁻¹) sampled of vermicompost prepared from vegetable market waste were recorded and proved superior over ipomea and water hyacinth for bacterial counts and fungi only. The vermicompost was founded to be non-significant for actinomycetes on the other hand change of seasons change the bacterial counts significant and lowest counts (43*10-6CFUg⁻¹) sample of vermicompost were observed during the seasons while highest counts of (54*10-6CFUg⁻¹) vermicompost. On the other hand fungi and actinomycetes did not show marked difference due to change.

Table-5 : Microbial population in vermicompost produced.

Bio wastes	Bacteria CFU g ⁻¹ (x10 ⁶)	Fungi CFU g ⁻¹ (x 10 ⁴)	Actinomycetes CFU g ⁻¹ (x 10 ⁴)
Leaf litter	46	8	1
Ipomea	49	7	1
Water hyacinth	50	6	1
Vegetable market waste	58	9	2
SEm	2	1	1
CD 5%	6	3	NS
Seasons			
Rainy	64	8	2
Winter	43	7	1
Summer	47	8	1
SEm	5	1.0	1
CD 5%	16	NS	NS

Physical property of Vermicompost : The most practical way to assess the quality of vermicompost are color, particle size, moisture content, bulk density, smell etc.

Observation recorded during the process and completion of vermicomposting are given in. It is evident from the Table-6 that all the bio wastes produced dark brown colour vermicompost except Ipomea which have brown colour. The particle size of vermicompost produced from leaf litter, water hyacinth and vegetable market waste possessed the fine granulated shape. As regards

Table-6 : Physical quality parameters of various Vermicomposts.

Bio wastes	Color	Category of particle	Moisture (%)	Smell	Bulk density (gcm ⁻³)
Leaf litter	03	03	25	No smell	0.804
Ipomea	02	02	26	No smell	0.881
Water hyacinth	03	03	32	No smell	0.784
Vegetable market waste	03	03	25	No smell	0.812

Color Category of particle

- | | |
|---------------|--------------------|
| 1. Light | 1. Fine |
| 2. Brown | 2. Granulated |
| 3. Dark brown | 3. Fine Granulated |

Table-7 : Chemical composition (N, P and K) in substrata as affected by different.

Treatment	N Content (%)		P Content (%)		K Content (%)	
	Partial decomposition	Vermi compost	Partial decomposition	Vermi compost	Partial decomposition	Vermi compost
Leaf litter	0.41 (0.23)	1.81	0.24 (0.11)	0.70	0.52 (0.21)	1.12
Ipomea	0.35 (0.15)	0.85	0.22 (0.13)	0.59	0.43 (0.23)	0.96
Water hyacinth	0.37 (0.18)	1.24	0.24 (0.15)	0.67	0.47 (0.44)	1.03
Vegetable market waste	0.39 (0.21)	1.44	0.27 (0.17)	0.64	0.48 (0.24)	1.03

Note : Data in Parentheses are Content is fresh substrata.

to the moisture content of vermicompost produced from various bio waste possessed 25 to 30% moisture. The highest moisture content of 32% was recorded under water hyacinth while the leaf litter and vegetable market waste possessed 25% moisture. None of the vermicompost had no odder smell and feel smell free. The bulk density of various vermicomposts were range from 0.784 to 0.881g cm⁻³ This shows that the more bulky spongy vermicompost produces under water hyacinth followed by leaf litter and vegetable market wastes.

Chemical composition of vermicompost : Data in relation to change in chemical composition of different substrata, partially decomposed matter and vermicompost obtained at maturity are presented in Table-7. It is evident from the table that content of nitrogen doubled in partially decomposed matter over initial fresh substrata. Further, digestion of partially decomposed matter by earthworms again increased three to five fold over partially decomposed matter. The increased content of NPK in vermicompost over partial decomposed matter may be due to the rapid digestion of substrata in muscular gizzard of the earthworm which hold the nephridia yields nitrozen (Alawdeen and Smile 1986) .The increase in phosphorus content in vermicompost might be due to the mineralization and mobilization of phosphorus by bacteria and faecal phosphate activity of earthworm . The similar findings were reported by Garg et al .(2006) moreover , potassium content increased in vermicompost over partial decomposition matter mighty to be due to the grinding action and chemical change occurred due to the activity of muscular gizzard of earthworm which played an important role in vermicompost production and

improvement potassium content (Khambata and Bhat 1975).

Nitrogen Content : Among the various substrata leaf litter secured significantly higher content of N (1.81%) which was significant superior over rest of the substrata. However, water hyacinth and vegetable market wastes found to be at par to each other and proved significantly superior over Ipomea.

The seasonal effect was non-significant but winter season possessed higher content of (1.40%) followed by (1.24%) in rainy season.

Further, interaction of substrata x season was found also non-significant with respect to content of N content in vermicompost. However the combinations of W1S1, W1S2, W1S3, W3S1, W3S2 and W4S2 seems to be the more prominent over others. The lowest content of 0.79 was noted under Ipomea x summer season. Thus looking to the quality of vermicompost leaf litter may be converted into vermicompost.

Table-8 : Content of nitrogen (%) in vermicompost as influenced by different treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	1.84	1.91	1.69	1.81
Ipomea	0.82	0.95	0.79	0.85
Water hyacinth	1.24	1.41	1.09	1.24
Vegetable market waste	1.08	1.35	1.01	1.14
Mean	1.24	1.40	1.14	
	Bio-waste	Season	Bio x Sea	
SEm±	0.31	0.34	0.66	
CD at 5%	0.96	NS	NS	

Phosphorus content : Data presented in Table-9 indicated that the content of phosphorus in partially decomposed matter and vermicompost increased over

initial stage of fresh bio wastes. It also evident from the table that partially decomposed matter content was doubled over the initial and in vermicompost it become tripled over the partially decompose matter. Hence, there is a definite increase in content of phosphorus was observed in each stage of vermicompost process.

Among the biowastes, leaf litter followed by water hyacinth and vegetable market wastes possessed significantly higher phosphorus content in vermicompost over Ipomea. The Ipomea possessed lowest P content (0.59%) in vermicompost.

In the different seasons, the significant variation with respect to P content in vermicompost was observed and significant es higher content of (0.67%) P was noted during winter followed by rainy season. The significantly lowest content of P (0.63%) was recorded during summer. The interaction was found to be non-significant.

Table-9 : Content of phosphorus in vermicompost as affected by different treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	0.69	0.75	0.67	0.70
Ipomea	0.59	0.61	0.58	0.59
Water hyacinth	0.65	0.69	0.67	0.67
Vegetable market waste	0.64	0.65	0.63	0.64
Mean	0.64	0.67	0.63	
	Bio-waste	Season	Bio x Sea	
SEm±	0.030	0.011	0.029	
CD at 5%	0.091	0.034	NS	

Potassium Content : Potassium content in vermicompost was determined as per the treatment and statically analyzed for interpretation

Data presented in Table-10 revel that the content of K increased in partial decomposed substrata and approximately doubled further, digestion by earthworm also increased the content over previous stage of partial the content over previous stage of partial decomposition. Hence it could be concluded that each stage of vermicompost add the nutrition values over fresh substrata.

The analysis of data with respect to content of potassium in vermicompost produced from various bio waste under different seasons showed make able effect on K content. However the interaction was founded to be non-significant. The significantly highest content of 1.12

closely followed by 1.03 .and 1.03 % K was hyacinth and vegetable market waste respectively.

Similarly, the significantly higher of 1.077% was recorded during winter seasons closely followed by rainy seasons but superior over summer. The interaction was found to be non-significant.

Table-10 : Potassium content in vermicompost as influenced by various treatments.

Bio-wastes	Seasons			
	Rainy	Winter	Summer	Mean
Leaf litter	0.11	1.17	1.09	1.12
Ipomea	0.96	1.01	0.91	0.96
Water hyacinth	1.04	1.08	0.98	1.03
Vegetable market waste	1.04	1.05	1.03	1.03
Mean	1.03	1.07	1.00	
	Bio-waste	Season	Bio x Sea	
SEm±	0.043	0.017	0.051	
CD at 5%	0.130	0.053	NS	

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Genetic Parameters Assessment for Various Morphological Traits in Different Bamboo Germplasm Uttarakhand Tarai Region

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Abstract

Genetic parameters play an important role in determining breeding methods and selection criteria. An experiment was conducted with the objective to analyze 10 bamboo genotypes with the aim to estimate the components of variance, heritability, and genetic advance for 10 metric traits like culm diameter, culm height, wall thickness, no. of node/ culm, internodal length base, internodal length middle, internodal length top, clump width, leaf length and leaf width. The experimental materials were planted in randomized block design at AFRC (Agroforestry Research Center), GBPUAT, Pantnagar, India during 2019-2020. The analysis of variance revealed significant differences among genotypes for most of the traits studied; indicating ample scope of selection for bamboo improvement. A wide range of mean values among genotypes for characters namely no. of node/ culm, internodal length top (cm), internodal length middle (cm) and internodal length base (cm) revealed large scope to improve these characters through selection or hybridization. A higher value of both GCV and PCV was observed for characters namely internodal length middle (cm), internodal length base (cm), internodal length top (cm), culm diameter (cm) and no. of node/ culm. culm height (86.00%) and internodal length middle (86.00%) exhibited the maximum value for heritability followed by internodal length base (85%), culm diameter (84%), leaf length (83%), and clump width (78%), wall thickness (74%) and internodal length top (65%). High heritability coupled with high genetic advance as percent of mean was recorded for characters viz. internodal length base (cm), clump width (m), culm height (m) and internodal length middle (cm), showed the presence of additive genetic effects in the expression of these characters. Hence, selection for these characters in segregating generations would likely to be more effective.

Key words : Bamboo, coefficient of variation, genetic parameters, genetic advance, heritability.

Introduction

India is the second richest country in bamboo genetic resources after China. These two countries together have more than half of the total bamboo resources worldwide [17]. Bamboo is fast growing species and it occupies a Special place in the lives of the people, especially in Asia. Bamboos are very important forest resources found in the forest as well as the non-forest area in the country. The total bamboo bearing area of India is estimated to be 15.69 million hectares according to [6]. Endemism in Indian bamboos is of a very high order. The maximum concentration of species is found in the deciduous and semi-evergreen regions of North-east and the tropical moist deciduous forests of North and South India. As per [16] over half of the bamboo species occur in Eastern India, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and West Bengal. In India bamboos show a great diversity in both their habitat and habit of growth. They found in different forest types, ranging from tropical to sub-alpine zones while some species are found only in the cultivated state in few gardens. They are fast growing, widely present, renewable and versatile resource of the country.

With the growing demand for timber, bamboo can be used as a viable substitute for timber in the country as per [14]. Bamboo is grown irrespective of latitude, altitude and climatic factors on the planet earth. Despite of its immense importance in human life from cradle to coffin, the study of distribution of bamboo and their identification is still very limited. Being clonally propagated, much of breeder's effort goes in generating genetic variability and using the already existing and freshly generated variability for developing improved cultivars. So genetic parameters could assist plant breeders in determining breeding methods and selection criteria. By keeping bamboo's usefulness and growth character variation, the present investigation was formulated with the objective of assessment of growth variation among different species of bamboo in tarai region of Uttarakhand.

Materials and Methods

10 germplasm lines of bamboo (listed in table-1) was evaluated for various quantitative traits in randomized block design at AFRC (Agroforestry Research Center), GBPUAT, Pantnagar, India during 2019-2020. The site is located at 29°N latitude, 79.58°E longitude and at an altitude of 244 m a.s.l. in the Tarai belt of Udham Singh

Table-1 : List of bamboo species used for present study.

Sr. No.	Bamboo Species	Site of collection
1.	<i>Dendrocalamus strictus</i>	AFRC bambusetum, Pantnagar
2.	<i>Bambusa balcooa</i>	AFRC bambusetum, Pantnagar
3.	<i>Bambusa bambos</i>	AFRC bambusetum, Pantnagar
4.	<i>Dendrocalamus asper</i>	AFRC bambusetum, Pantnagar
5.	<i>Bambusa nutans</i>	AFRC bambusetum, Pantnagar
6.	<i>Dendrocalamus hamiltonii</i>	AFRC bambusetum, Pantnagar
7.	<i>Bambusa vulgaris</i> var. <i>green</i>	AFRC bambusetum, Pantnagar
8.	<i>Bambusa vulgaris</i> var. <i>yellow</i>	AFRC bambusetum, Pantnagar
9.	<i>Bambusa vulgaris</i> var. <i>wamin</i>	AFRC bambusetum, Pantnagar
10.	<i>Dendrocalamus giganteus</i>	AFRC bambusetum, Pantnagar

Nagar district of Uttarakhand, India. The Tarai region is a 15 –18 km wide low-lying strip with high water table adjacent to the central Himalayan foot hills of the Shivalik range. The climate of Tarai is humid, sub-tropical with dry hot summer and cold winter. The experiment was planted in a Randomized Block Design with four replications in which each species was planted in four rows and each row containing four clumps. The plot consisted of total sixteen clumps in each treatment with row to row and clump to clump spacing of 5 m x 5 m. Four competitive culms were selected in each the four replication and were used for recording the observations on 10 characters i.e.; culm diameter (cm), culm height (m), wall thickness (cm), no. of node/ culm, internodal length base (cm), internodal length middle (cm), internodal length top (cm), clump width (m), leaf length (cm) and leaf width (cm). Average data of these four culms was calculated and data were analyzed statistically by using R software. Analysis of variance was conducted followed by computation of phenotypic and genotypic coefficients of variation (PCV and GCV) as suggested by [2]. The estimates of PCV and GCV were classified as high >20%, moderate 10-20% and low <10% according to [2]. Heritability in broad sense and genetic advance for each character was estimated following formulae by [1] for respective parameter. Heritability and genetic advance as percent of mean were further categorized into low, medium and high as per [1]. The crop was raised following the practices as per the package of practices of G.B.P.U.A. & T., Pantnagar, U.S. Nagar.

Results and Discussion

Genetic variability studies form the basis for crop improvement program in plant breeding and it aids to decipher the main components of variation in the base population. This information further indicates towards the extent of sensitivity towards environment and transfer ability to the next generation. The analysis of variance revealed a wide range of variation and significant

differences for all the ten traits undertaken for study, indicating the presence of adequate variability in the base population for further improvement under selection. The estimates of mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic advance as percent of mean (GAM) for all ten traits are furnished in Table-2

Wide range of variation was observed for culm characters like no. of node/ culm, internodal length top (cm), internodal length middle (cm) and internodal length base (cm). Overall, the estimates of PCV were higher than GCV for all the traits under study. The values for phenotypic coefficient of variation varied from 0.18 to 93.67 per cent corresponding to trait wall thickness (cm) and internodal length middle (cm) respectively. PCV estimates were low for wall thickness, clump width and leaf width, it was moderate for culm height and leaf length while high for culm diameter (cm), no. of node/ culm, internodal length base (cm), internodal length middle (cm) and internodal length top (cm). The values for genotypic coefficients of variation ranged from 0.13 for wall thickness (cm) to 80.83 percent for internodal length middle (cm). GCV estimates were categorized low for wall thickness, clump width and leaf width, it was moderate for culm height and leaf length. GCV estimates were high for culm diameter (cm), no. of node/ culm, internodal length base (cm), internodal length middle (cm) and internodal length top (cm). Overall, together PCV and GCV estimates were high for internodal length middle (cm), internodal length base (cm), internodal length top (cm), culm diameter (cm) and no. of node/ culm. Therefore, it is indicated that variability is high for internodal length middle (cm), internodal length base (cm), internodal length top (cm), culm diameter (cm) and no. of node/ culm. Similar results were obtained by [8] and [4] in *Azadirachita indica*.

Broad sense heritability estimates varied from 42.00 % to 86%. culm height (86.00%) and internodal length middle (86.00%) exhibited the maximum value for

Table-2 : Estimates of genetic parameters for quantitative traits in Bamboo germplasm.

Sr. No.	Characters	Mean	Range	CD at 5%	GCV	PCV	Heritability	Genetic advance	GAM
1.	Culm diameter (cm)	23.24	18.00-36.33	3.89	26.64	31.79	84	9.73	41.89
2.	Culm height (m)	11.12	3.13-14.17	2.17	10.08	11.68	86	6.08	54.66
3.	Wall thickness (cm)	2.69	2.10-3.50	0.37	0.13	0.18	74	0.64	23.77
4.	No. of node/ culm	45.53	36.67-55.00	9.40	22.14	52.17	42	6.32	13.87
5.	Internodal length base (cm)	18.92	5.00-29.00	5.38	55.96	65.80	85	14.21	75.12
6.	Internodal length middle (cm)	33.73	11.67-45.00	6.15	80.83	93.67	86	17.20	51.00
7.	Internodal length top (cm)	28.33	11.33- 34.67	7.31	33.70	51.86	65	9.64	34.02
8.	Clump width (m)	6.01	2.17-9.60	2.19	5.92	7.54	78	4.44	73.88
9.	Leaf length (cm)	25.75	19.17-31.33	2.54	10.73	12.92	83	6.15	23.88
10.	Leaf width (cm)	3.69	1.47-5.50	1.67	1.19	2.14	56	1.68	45.58

heritability followed by internodal length base (85%), culm diameter (84%), leaf length (83%), and clump width (78%), wall thickness (74%) and internodal length top (65%) which showed high estimates for heritability. Heritable portion of variance is a good index for transfer of characters from parents to offspring but heritability estimates are influenced by environment, thereby the information on heritability alone is not sufficient for effective selection. Meanwhile, the heritability estimates in coupled with values of the genetic advance as percent of mean could resolve the picture of genetic makeup and help to improve the efficiency of selection.

Success in selection programme depends primarily upon magnitude of heritable portion in total variation. Early generation selection should be used only if a reasonable proportion of the genotypic variance is additive or if the heritability of a trait is high [7]. Knowledge of heritability coupled with expected genetic advance of a trait is necessary for deciding scope of improvement through selection. [9] indicated that heritability values along with estimates of genetic gain were more useful than heritability alone in predicting the effect of selection.

Perusal of results revealed high estimates of heritability with high genetic advance for internodal length base (cm), clump width (m), culm height (m) and internodal length middle (cm), which indicated that these characters are controlled by additive gene action [9] and will respond effectively on phenotypic selection. The results were in agreement to earlier findings of [11], [5],[15] and [10]. High heritability accompanied with high genetic advance for several growth parameters have also been reported by [3] in *D. strictus*. The above findings of high heritability and genetic advance for the characters observed in the present study were supported by [13] in *Bambusa pallida* Roxb for culm height, culm girth and number of new culms per clump over 1.5 to 4.5 year growth period. [12] observed high heritability with high genetic gain for diameter of culms, height of culms as well as number of internodes in *Dendrocalamus strictus*.

Among various genetic parameters, co-efficient of

variation and range of means provide an idea about relative variability in a population. Wide range of means coupled with sufficient coefficient of variation for most of the characters in present study suggested presence of inherent genetic variability in species. Most of the characters studied showed high variance and coefficient of variability at genotypic level which is also supported by good heritability and genetic gain clearly indicating that the expression of these characters are under genetic control.

Conclusion

Characters like no. of node/ culm and internodal length top showed wide range in variations across the species. Internodal length middle showed maximum variation in range. This shows that internodal length is one of the most important diagnostic features for taxonomic characterization. High values for most of traits were shown by *D. giganteus*, *D. hamiltonii* and *B. nutans*. This shows the economic utility of these species for special requirement like thick culms and total culm length. Perusal of results revealed high estimates of heritability with high genetic advance for internodal length base (cm), clump width (m), culm height (m) and internodal length middle (cm), which indicated that these characters are controlled by additive gene action and will respond effectively on phenotypic selection. The general trends of results obtained for heritability in the present investigation suggest the importance of employing direct selection for the improvement of characters having high heritability. For characters like wall thickness, leaf width and clump width had low difference between PCV and GCV indicating that environment had slight effect on the expression of these characters.

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Effect of Nitrogen and Phosphorus on the Grain Yield of Late Sown Wheat (*Triticum aestivum* L.)

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Abstract

The field experiment was carried out at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during the *rabi* season of 2019-20 to study the effect of nitrogen and phosphorus on the grain yield of wheat (*Triticum aestivum* L.). The treatments consisted of three nitrogen levels viz. 75, 100, 125 kg N ha⁻¹ and three phosphorus levels viz. 30, 60, 90 kg P₂O₅ ha⁻¹. The experiment was laid out in randomized complete block design (RCBD) with three replications. The maximum grain yield of 47.1 q ha⁻¹ was obtained with 125 kg N ha⁻¹. The higher yield was might be due to more tillers/m row length, growth parameters, 1000 grain weight and ear length which was significantly higher over 75 and 100 kg N ha⁻¹. In case of phosphorus, the highest grain yield of 44.4 q ha⁻¹ recorded with the application of 90 kg P₂O₅ ha⁻¹ which was significantly higher over the 30 kg and 60 kg P₂O₅ ha⁻¹. The interaction between nitrogen and phosphorus levels was non-significant in all growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important winter cereal crop in India after rice. It contributes substantially to the national food security by providing more than 50 percent calories to the people who mainly depend it (Kaur *et al.* 2015). Wheat is grown in India over an area of about 30.55 million hectare with production 107 MT. (Anonymous, 2020). In Punjab, it is grown on an area of 35.20 lakh tonnes with production of 176.2 lakh tonnes and average yield of 50.04 quintals per hectare (Anonymous, 2021). Wheat is a major cereal crop of Punjab but the grain of wheat is much low than other developed countries. Sowing time, Seed rate,

Nitrogen is one of the most important mineral nutrients for poaceae plants influencing growth, development, yield and protein content of grains. Nitrogen plays an undeniable role in all living tissues of plant. No other element has such an effect on promoting vigorous plant growth. Abundant protein tends to increase number of leaves and to increases the carbohydrate synthesis. Nitrogen plays a major role in increasing the yield of the crop. Application of proper amount of nitrogen is considered key to obtain bumper crop of wheat. Bungard *et al.* (1999)

Phosphorous is the most essential plant nutrient next to nitrogen which plays a major role for achieving the maximum crop production. It plays a vital role in several physiological processes viz. photosynthesis, respiration, energy storage, transfer and cell division. It is also important structural components of many biochemicals viz. nucleic acid (DNA and RNA enzymes and co-enzymes) and also stimulates root growth and associated with early maturity of

crops (Bairwa *et al.* 2018). Keeping this in view, the present study was conducted.

Materials and Methods

The experiment was carried out during *rabi* season 2019-20 at the Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental site was located at 30.6642° N latitude and 76.2914° E longitude at an altitude of + 268 meters above mean sea level. The site was low in organic carbon (0.38%) and soil available nitrogen (144.6 kg N ha⁻¹), medium in soil available phosphorus (17.3 P₂O₅ ha⁻¹) and medium in soil available potassium (138 kg K₂O ha⁻¹). The treatments comprised of three nitrogen levels viz. 75, 100, 125 kg N ha⁻¹ and three phosphorus levels viz. 30, 60, 90 kg P₂O₅ ha⁻¹. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The 112.5 kg seed ha⁻¹ was used for sowing and crop was sowing on December 30, 2019 at a spacing of 20 × 15 cm. The phosphorus in the form of single superphosphate (16 % P₂O₅) was applied as per the treatments. The gross plot size was 4.5 m × 3.5 m and net plot size was 4.5 m × 2.5 m The crop was harvested on May 10, 2020. All the other cultural practices were applied uniformly to all the treatment

Results and Discussion

Growth Parameters : The plant height of the late sown wheat was influenced significantly higher with nitrogen and phosphorus levels (Table-1). The nitrogen levels 125 kg N ha⁻¹ recorded higher plant height (82.5 cm) over 75 kg N ha⁻¹ (74.8 cm) but was at par with 100 kg N ha⁻¹ (79.1 cm). Significantly higher with rest at all stages of growth. Tallest plant height were observed 125 kg N ha⁻¹ higher nitrogen levels was might be the reason that due to nitrogen plays a

Table-1: Effect of Nitrogen and Phosphorus levels on the growth parameters, yield attributes and yield of late sown wheat.

Treatments	Plant height (cm)	Number of tillers (m/row length)	Ear length (cm)	Numbers of grains/ear	1000-grains weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Nitrogen levels kg ha⁻¹								
75 kg ha ⁻¹	74.8	68.7	9.2	30.5	28.4	38.2	63.1	35.4
100 kg ha ⁻¹	79.1	74.7	10.3	33.1	32.5	43.5	72	38.0
125 kg ha ⁻¹	82.5	76	11.4	41.6	32.7	47.1	64	42.3
CD at 5%	4.8	5.3	0.79	2.3	2.2	1.7	6.2	2.4
Phosphorus levels kg ha⁻¹								
30 kg P ₂ O ₅ ha ⁻¹	73.2	68.6	8.3	32.7	28.8	40.8	70.2	34.6
60 kg P ₂ O ₅ ha ⁻¹	79.4	74.3	10.3	35.0	32.2	42.6	66.6	39.5
90 kg P ₂ O ₅ ha ⁻¹	83.8	76.5	12.3	37.5	32.6	44.4	62.2	41.6
CD at 5%	4.8	5.3	0.79	2.3	2.2	1.7	NS	2.4
Interaction	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.0	7.2	7.6	6.6	7.2	6.1	10.5	6.2

key role in cell division and cell elongation. These results are supported by the findings of Patel *et al.* (2012). Phosphorus levels, recorded significantly higher plant height was noticed with the application of 90 kg P₂O₅ ha⁻¹ (83.8 cm) over the rest of the treatments at all stages of growth. It may be due to the rapid by maintenance good established of the root and various metabolic process which performed higher nutrient mobilization. These results are also supported by the findings of Singh *et al.* (2018). Interaction effect due to nitrogen and phosphorus levels was non-significant.

The Number of tillers m/row length of late sown wheat was significantly influenced by nitrogen and phosphorus levels (Table-1). Among different N levels, the highest number of tillers m/row length (76.0) were observed with 125 kg N ha⁻¹ which was significantly higher than 75 kg N ha⁻¹ but was at par with 100 kg N ha⁻¹. Hussain *et al.* (2006) also reported similar results. In case of phosphorus levels, number of tillers of late sown wheat was recorded significantly by P levels. Result indicated that the highest number of tillers m/row length (76.5) were observed with 90 kg P₂O₅ ha⁻¹ which were significantly higher than 30 kg N ha⁻¹ but was at par with 60 kg P₂O₅ ha⁻¹. These findings are similar by Rahim *et al.* (2010) and Singh *et al.* (2001) also observed the same results. This may be due to the enhancement in tiller number with increase in fertilizer dose was attributed to the rapid conversion of synthesized carbohydrates into protein and consequent to increase in the number and size of growing cells, resulting ultimately in increased number of tillers.

Yield Attributes : The ear length of wheat was influenced significantly by nitrogen and phosphorus levels (Table-1). The significantly higher ear length (11.4 cm) was recorded with application of 125 kg N ha⁻¹ over 75 kg N ha⁻¹ and 100 kg N ha⁻¹. Pandey *et al.* (2014) also reported that increase in grain yield at higher nitrogen levels. In case of phosphorus levels, maximum ear length (12.3 cm) was recorded with 90

kg P₂O₅ ha⁻¹ which was significantly higher over rest of the P levels. This could be attributed to the fact that phosphorous played a key role in root development energy transformation and metabolic process in plant. These results are in conformity with those of Mumtaz *et al.* (2014) and Noonari *et al.* (2016).

The grains ear⁻¹ of late sown wheat were also influenced significantly by nitrogen and phosphorus levels (Table 1). Higher numbers of grain ear⁻¹ was observed with application of 125 kg N ha⁻¹ (41.6) over 75 kg N ha⁻¹ and 100 kg N ha⁻¹. Chaturvedi *et al.* (2006) observed similar results this was might be due to the role of nitrogen in crop maturation, flowering and fruiting. The highest number of grains per spike (37.5) were recorded for 90 kg P₂O₅ ha⁻¹ over 30 kg P₂O₅ ha⁻¹ but was at par with 60 kg P₂O₅ ha⁻¹. Razdan *et al.* (2006) and Dugassa *et al.* (2019) also reported the similar results.

Test weight of wheat was influenced significantly by nitrogen and phosphorus levels (Table 1). Among the different nitrogen levels, the highest test weight was observed (32.7 g) with 125 kg N ha⁻¹ which was significantly higher than the rest of the treatments. Higher application rate of nitrogen levels increased in grain size which ultimate increased the number of grains per ear and grain weight. Similar result were reported by Jakhar *et al.* (2014). In case of phosphorus, the highest test weight observed (32.6 g) with 90 kg P₂O₅ ha⁻¹ which was significantly higher over 30, 60 kg P₂O₅ ha⁻¹. The interaction between nitrogen and phosphorus levels was non-significant.

Yield Parameters : Grain yield of late sown wheat was influenced significantly by nitrogen and phosphorus levels (Table-1). The application of 125 kg N ha⁻¹ recorded significantly higher grain yield (47.1 q ha⁻¹) over 75 kg N ha⁻¹ and 100 kg N ha⁻¹. Corroborative findings have been reported by Rautaray *et al.* (2010). The higher yield was might be due to more tillers/m row length, growth parameters, 1000 grain

weight and ear length. The significantly higher grain yield of 44.5 q ha^{-1} was observed with the application of $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ which was significantly superior to 30 and $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. Increase in grain yield of wheat with successive increases in P levels probably might be due to adequate nutrient availability to increase dry matter accumulation. Singh *et al.* (2018) also reported similar results.

The straw yield of late sown wheat was significantly higher with 125 kg N ha^{-1} but the application of phosphorus did not influence the straw yield of late sown wheat significantly.

Conclusion

It may be concluded from the present study that higher grain yield was observed with the application of 125 kg N ha^{-1} and $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$.

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Response of Wheat (*Triticum aestivum* L.) Varieties to Nitrogen Levels Under Late Sown Conditions

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Abstract

The field experiment was carried out at Agriculture Research Farm of School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh (Punjab) during the *rabi* season of 2019-20 to study the response of wheat (*Triticum aestivum* L.) varieties to nitrogen levels. The treatments consisted of two varieties viz. PBW 550 and PBW 725 and four nitrogen levels viz. 0, 75, 100, 125 kg N ha⁻¹. The experiment was laid out in randomized complete block design (RCBD) with three replications. The variety PBW 550 recorded significantly higher grain yield (50.6 q ha⁻¹) over variety PBW 725 (47.5 q/ha⁻¹). The higher grain yield in PBW 550 was might be due to highest number of tillers, long spike, more grains spike⁻¹ and more 1000-grains weight. Similarly, the highest grain yield was observed with 125 kg N ha⁻¹ which was significantly higher than control and 75 kg N ha⁻¹ but was a par with 100 kg N ha⁻¹. The higher grain yield with the application of 125 kg N ha⁻¹ was might be due to adequate nutrient availability to increase dry matter accumulation and higher yield attribute. The interaction between varieties and nitrogen levels was nonsignificant in all growth parameters, yield attributes and yield.

Introduction

Wheat (*Triticum aestivum* L.) is the second most important winter cereal crop in India after rice. It contributes substantially to the national food security by providing more than 50 percent calories to the people who mainly depend it (Kaur *et al.* 2015). Wheat is grown in India over an area of about 30.55 million hectare with production 107 MT. (Anonymous, 2020). In Punjab, it is grown on an area of 35.20 lakh tonnes with production of 176.2 lakh tonnes and average yield of 50.04 quintals per hectare (Anonymous, 2021). Wheat is a major cereal crop of Punjab but the grain of wheat is much low than other developed countries. Sowing time, Seed rate, Nitrogen application and varieties are major factor which influence the grain yield of wheat. Nitrogen is one of the most important mineral nutrients for poaceae plants influencing growth, development, yield and protein content of grains (Sharifabad *et al.* 2012). Nitrogen plays an undeniable role in all living tissues of plant. No other element has such an effect on promoting vigorous plant growth. Abundant protein tends to increase number of leaves and to increases the carbohydrate synthesis. Nitrogen plays a major role in increasing the yield of the crop. Application of proper amount of nitrogen is considered key to obtain bumper crop of wheat. Nitrogen comprises of 7% of the total dry matter of plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes and photosynthetic pigments (Bungard *et al.* 1999). Generally, nitrogen (N) fertilization at sowing increases wheat grain yield and late fertilization enhances grain protein concentration. The fertilizer N

requirement of wheat may be related to residual N in soil, varying climatic conditions etc. Hence, present investigation was undertaken to find out the suitable rate of nitrogen for getting better yield under late sown conditions.

Materials and Methods

The experiment was carried out during rabi season 2019-21 at the Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental located at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level. The site was low in organic carbon (0.38%) and available nitrogen (144.6 kg N ha⁻¹), medium in phosphorus (17.3 P₂O₅ ha⁻¹) and potassium (168 kg K₂O ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments comprised of two varieties sowing viz. PBW 550 and PBW 725 and four phosphorus levels viz. 0, 30, 60, 90. The 120 kg seed ha⁻¹ was used for sowing and crop was sowing on December 29, 2019 at a spacing of 20 × 15 cm. The phosphorus in the form of single superphosphate (16 % P₂O₅) was applied as per the treatments. The gross plot size 5 m × 1.95 m and net plot size was 4.5 m × 1.45 m. The crop was harvested on May 8, 2020. All the other cultural practices were applied uniformly to the treatments.

Results and Discussion

Growth Parameters : The plant height was influenced significantly by varieties and nitrogen levels (Table1). Among different varieties, the significantly higher plant height was observed in PBW 725 (90.7 cm) than PBW 550

Table-1 : Effect of varieties and Nitrogen levels on the growth parameters, yield attributes and yield of late sown wheat.

Treatments	Plant height (cm)	Number of tillers (m/row length)	Ear length (cm)	Numbers of grains/ear	1000 grains weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Varieties								
PBW 550	76.5	83.5	9.8	34.3	32.6	50.6	65	42.0
PBW 725	90.7	77.0	8.1	32.2	30.0	47.5	79.7	39.5
CD at 5%	4.7	4.2	0.55	1.9	1.9	2.7	NS	2.1
Nitrogen levels (kg N ha⁻¹)								
Control	72.3	70.5	7.2	31.1	27.3	42.9	75.1	36.6
75	80.5	77.6	8.3	32.5	30.2	47.5	73.6	39.7
100	87.5	83.8	9.7	34.3	33.2	52.1	70.5	42.3
125	93.9	89.0	10.6	35.1	34.6	55.2	71.7	44.1
CD at 5%	6.7	6.0	0.78	2.7	2.7	3.9	NS	3.0
CD interaction at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.4	6.0	6.9	6.5	7.1	6.5	9.3	6.1

(76.5 cm). The magnitude of increase in plant height was 15.6 percent. Variation in plant height among varieties was might also be probably due to their genetic characters. The application of 125 kg N ha⁻¹ recorded significantly higher in comparison to rest levels at all stages of growth It may be due to the fact that nitrogen plays a key role in cell division and cell elongation and thus growth in terms of height of the plant. These results are similar to Patel *et al.* (2012) and Kaur *et al.* (2015). Interaction effect due to varieties and nitrogen levels was non-significant.

Number of tillers were also improved significantly by varieties and nitrogen levels (Table1). Among different varieties, the variety PBW 550 (83.5) recorded significantly higher tillers per m/row length of late sown wheat over variety PBW 725 (77.0). The magnitude of increase was 7.7 percent. The nitrogen results indicated that highest number of tillers m/row length (89) were observed with 125 kg N which was significantly higher than control and 75 kg N ha⁻¹ but was at par with 100 kg N ha⁻¹. These findings are supported by Hussain *et al.* (2006). Interaction effect due to varieties and nitrogen levels was non-significant.

Yield Attributes : The ear length of wheat was influenced significantly by varieties and nitrogen levels (Table1). The variety PBW 550 recorded significantly higher ear length (9.8cm) over variety PBW 725. In case of nitrogen levels, maximum ear length (10.6 cm) was recorded with 125 kg N ha⁻¹. Increased yield attributes due to increasing the level of N leads to better growth parameters. These findings substantiate the results Pandey *et al.* (2014).

The grains ear⁻¹ of late sown wheat were also influenced significantly by varieties and nitrogen levels (Table-1). Among different varieties, grains ear⁻¹ increased significantly in variety PBW 550 (34.3) over the variety PBW 725 (32.2) by a margin 6.1 percent higher

respectively. The more grains/ear in PBW 550 were might be due to genetic variability. The highest number of grains per spike (35.1) were recorded for 125 kg N ha⁻¹. It could may be due to higher rate of nitrogen. Kachroo and Razdan *et al.* (2006) also reported the similar result.

Test weight of wheat was influenced significantly by varieties and nitrogen levels (Table1). Among different varieties, the significantly higher test weight was observed in variety PBW 550 (32.6 g) over variety PBW 725 (30.0 g). The test weight observed (34.6 g) with 125 kg N ha⁻¹ was significantly higher than rest of all stages. Higher nitrogen application rate which causes increased in grain size which ultimate increased the number of grains per ear and grain weight. Similar result was reported by Jakhar *et al.* (2014). The interaction between varieties and nitrogen levels were non-significant.

Yield Parameters : Grain yield of late sown wheat was influenced significantly by varieties and nitrogen levels (Table-1). The variety PBW 550 recorded significantly higher grain yield (50.6 q ha⁻¹) over variety PBW 725 (47.5 q ha⁻¹). The higher yield in varieties were might be due to highest number of tillers, long spike and more grains spike⁻¹ with more test weight. Nitrogen recorded, significantly higher grain yield of 55.2 q ha⁻¹ with the application of 125 kg N ha⁻¹ which was significantly superior to control and 75 kg N ha⁻¹ but was at par with 100 kg N ha⁻¹. Increase in grain yield of wheat with successive increases in N levels probably came through favourable influence on growth parameters in terms of plant height, number of tillers and dry matter accumulation. Corroborative findings have been reported by Beheraa and Rautaray *et al.* (2010), Narolia *et al.* (2016) and Nishant *et al.* (2016) in wheat crop.

The straw yield of late sown wheat was not affected significantly with the wheat varieties (Table-1). Similarly, application of nitrogen levels also did not influence the straw yield of late sown wheat significantly.

Conclusion

On the basis of one year study. It can be concluded that in late sown wheat all the growth parameters, yield attributes and grain yield has been increased significantly with increasing nitrogen levels up to 125 kg N ha⁻¹. Thus we can use up to 125 kg N ha⁻¹ under late sown condition to improve yield.

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Estimation of Character Association and Path Coefficient for Grain Yield in Rice (*Oryza sativa* L.) under Sodic Soil

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Abstract

The present study was conducted with 103 germplasm lines including three checks to in Kharif 2016 to evaluate the extent of association among characters and path coefficient in augmented block design for the sixteen characters of rice (*Oryza sativa* L.) at the Agriculture Research Farm of Genetics and Plant Breeding, ANDUAT, Kumarganj, Ayodhya (U.P.) under sodic soil conditions. The observations were recorded for sixteen quantitative characters viz., days to 50% flowering, plant height, flag leaf area, panicle bearing tillers /plant, panicle length, spikelets/panicles, grains/panicle, spikelet fertility%, biological yield/plant, Harvest index, 1000 grain weight, L:B ratio, chlorophyll content, leaf nitrogen, leaf temperature and grain yield / plant. The most of the traits viz., flag leaf area (0.686), Panicle bearing tillers/plant (0.748), Spikelets/panicle (0.744), grains/panicle (0.665), spikelet fertility % (0.535), biological yield per plant (0.701), harvest index (0.660), 1000-grains weight (0.266), chlorophyll content (0.518) and leaf nitrogen (0.526) exhibited highly significant and positive correlation with grain yield per plant while panicle length (-0.208) possessed negative and significant correlation with grain yield per plant. The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (0.6857) followed by harvest-index (0.6440). The highest positive indirect effect on grain yield per plant was exerted by days to 50% flowering, flag leaf area, panicle bearing tillers per plant, spikelets per panicle, grains per panicle, spikelets fertility %, harvest index, 1000-grains weight, chlorophyll content and leaf nitrogen via biological yield per plant and harvest index.

Key words : rice, *oryza sativa*, grain yield, correlation coefficient, path coefficient.

Introduction

Rice (*Oryza sativa* L.) is the monocarpic annual plant belonging to genus *Oryza* of Poaceae family. The genus *Oryza* has 24 species of which, 22 are wild and two species viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. All the varieties found in Asia, America and Europe belong to *Oryza sativa* and those found in West Africa belongs to *Oryza glaberrima*. Further, *Oryza sativa* rice varieties of the world are commonly grouped into three sub species viz., *Indica* (India), *Japonica* (Japan) and *Javanica* (Indonesia). The largest rice cultivars are available at International Rice Research Institute (IRRI), Philippines, with over 100000 rice accessions held in International Rice Gene Bank. "Rice is life" this slogan of the International year of rice (2004) outlined the importance of rice. Rice is a most important staple food crop in the world as well as in India. India is the second largest rice producing country in the world next to China; as it is grown in almost all the state of India. India's rice production is estimated at record 102.36 million tons in the kharif season of 2020-21 crop year on the reverse of appropriate thunderstorm rains and acreage, the kharif season of the 2019-20 crop time. The Union Agriculture Ministry released the first strengthen estimates of made of

important kharif crops for 2020-21. As in line with the facts, the entire food grains affair inside the kharif season of 2020-21 crop time is anticipated at record 144.52 million tones as against 143.38 million tones within the former time. The affair of nutri-cereals is predicted to decline to 32.84 million tones as against 33.69 million tones within the former time. Though India ranks first in area under rice, its productivity is not even half of China.

Yield being a complex character is a function of several component characters and their interaction with environment (Khan and Naqvi, 2012). In this regard, genotypic and phenotypic correlation reveals the degree of association between different characters and thus, aid in selection to improve the yield and yield attributing characters simultaneously. Further, path coefficient analysis helps in partitioning of correlation coefficients into direct and indirect effects and in the assessment of relative contribution of each component character to the yield.

The objectives of this study were to estimate the correlations between grain yield and other traits and determine the direct and indirect effects of traits on grain yield in rice grown under salt affected soil conditions in order to find out suitable traits that could be used for grain yield improvement under both conditions.

Materials and Methods

The experiment of present investigation was conducted to evaluate the one hundred three rice germplasm lines along with three checks in Augmented Block Design during *Kharif* 2016 at Main Experiment Station ANDUAT, Kumarganj, Ayodhya. Three rows of each test genotype were present only once in each block with 3 checks in randomized manner along with the distance of 20 cm between the rows and 15 cm between the plants were sown in the season *Kharif* 2016. The recommended cultural practices were followed to raise a good normal crop. The observation on 16 quantitative characters viz., days to 50% flowering, plant height, flag leaf area, panicle bearing tillers /plant, panicle length, spikelets/panicles, grains/panicle, spikelet fertility%, biological yield/plant, Harvest index, 1000 grain weight, L:B ratio, chlorophyll content, leaf nitrogen, leaf temperature and grain yield / plant were recorded to estimate correlation and path coefficient parameters. The observations were recorded on 5 randomly selected plants from each plot except days to 50% flowering and days to maturity where data will be recorded on plot basis.

The Simple Correlation coefficients (r) between different characters were estimated according to Searle, (1961) and Path coefficient analysis was carried out according to Dewey and Lu (1959). Grain yield was assumed to be dependent variable (effect) which is influenced by all other characters, the independent variables (causes), directly as well as indirectly through other.

Results and Discussion

Correlation coefficient : The estimates of simple correlation coefficients computed between sixteen characters of rice under sodic soil conditions are presented in Table-1. The most of the traits viz., flag leaf area (0.686), Panicle bearing tillers/plant (0.748), Spikelets/panicle (0.744), grains/panicle (0.665), spikelet fertility % (0.535), biological yield per plant (0.701), harvest index (0.660), 1000-grains weight (0.266), chlorophyll content (0.518) and leaf nitrogen (0.526) exhibited highly significant and positive correlation with grain yield per plant while panicle length (-0.208) possessed negative and significant correlation with grain yield per plant. Remaining traits exhibited non-significant associations. Plant height (0.231) exhibited significant positive correlation with panicle length and flag leaf area possessed significant positive correlation with the characters panicle bearing tillers per plant (0.654), spikelets/panicle (0.640), grains/panicle (0.504), spikelets/

Table-1 : Estimates of simple correlation coefficients between 16 characters in rice in 2016.

Characters	Days to 50% Flowering	Plant Height	Flag leaf area	Panicle bearing tillers/plant	Panicle length	Spikelets / panicle	Grains/ panicle	Spikelet fertility %	Biological yield/plant	Harvest index	1000-grain weight	L : B ratio	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Grain yield/plant
Days to 50% Flowering	1.000	0.040	-0.001	0.149	-0.019	0.107	0.001	0.003	0.158	-0.075	0.109	-0.022	0.122	-0.004	-0.026	0.060
Plant Height		1.000	-0.020	0.135	0.231*	0.073	0.019	-0.002	0.101	-0.114	0.160	0.149	-0.004	0.111	-0.128	-0.004
Flag leaf area			1.000	0.654**	-0.167	0.640**	0.504**	0.365**	0.397**	0.526**	0.171	-0.047	0.478**	0.563**	-0.119	0.686**
Panicle bearing tillers/plant				1.000	-0.105	0.680**	0.585**	0.451**	0.506**	0.470**	0.154	-0.035	0.380**	0.612**	-0.099	0.748**
Panicle length					1.000	-0.056	-0.142	-0.104	-0.218*	-0.078	-0.079	-0.062	-0.182	-0.150	-0.091	-0.208*
Spikelets/panicle						1.000	0.586**	0.371**	0.527**	0.461**	0.195*	-0.088	0.527**	0.494**	-0.136	0.744**
Grains/panicle							1.000	0.559**	0.527**	0.367**	0.278**	-0.043	0.546**	0.368**	-0.073	0.665**
Spikelet fertility %								1.000	0.426**	0.297**	0.222*	-0.084	0.291**	0.188	0.061	0.535**
Biological yield/plant									1.000	-0.058	0.176	0.064	0.445**	0.310**	-0.055	0.701**
Harvest-index										1.000	0.205*	-0.018	0.278**	0.368**	-0.159	0.660**
1000-grain weight											1.000	-0.037	0.277**	0.211*	-0.204*	0.266**
L:B ratio												1.000	0.098	0.040	0.026	0.024
Chlorophyll content													1.000	0.386**	-0.162	0.518**
Leaf Nitrogen														1.000	-0.140	0.526**
Leaf temperature															1.000	-0.131
Grain yield/plant																1.000

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

Table-2 : Direct and indirect effects of 16 characters on grain yield per plant in rice in 2016.

Characters	Days to 50% Flowering	Plant Height	Flag leaf area	Penicle bearing tillers/plant	Penicle length	Spikelets/penicle	Grains/penicle	Spikelet fertility %	Biological yield/plant	Harvest index	1000-grain weight	L:B ratio	Chlorophyll content	Leaf Nitrogen	Leaf temperature	R with Grain yield/plant
Days to 50% Flowering	-0.0080	-0.0005	0.0002	0.0063	-0.0002	0.0044	0.0000	0.0000	0.1081	-0.0483	-0.0001	-0.00001	-0.0029	-0.0001	-0.0005	0.060
Plant Height	-0.0003	-0.0130	-0.0001	0.0075	0.0017	0.0030	0.0002	0.0000	0.0690	-0.0734	-0.0001	0.00005	0.0001	0.0033	-0.0025	-0.004
Flag leaf area	0.0000	0.0003	0.0037	0.0365	-0.0013	0.0260	0.0053	0.0021	0.2723	0.3385	-0.0001	-0.00001	-0.0115	0.0169	-0.0023	0.686**
Penicle bearing tillers/plant	-0.0012	-0.0018	0.0024	0.0558	-0.0008	0.0277	0.0061	0.0026	0.3472	0.3028	-0.0001	-0.00001	-0.0091	0.0183	-0.0019	0.748**
Penicle length	0.0002	-0.0030	-0.0006	-0.0059	0.0076	-0.0023	-0.0015	-0.0006	-0.1494	-0.0501	0.0001	-0.00002	0.0044	-0.0045	-0.0018	-0.208*
Spikelets/penicle	-0.0009	-0.0009	0.0024	0.0380	-0.0004	0.0407	0.0061	0.0021	0.3610	0.2970	-0.0001	-0.00003	-0.0126	0.0148	-0.0027	0.744**
Grains/penicle	0.0000	-0.0002	0.0019	0.0327	-0.0011	0.0239	0.0105	0.0032	0.3611	0.2365	-0.0002	-0.00001	-0.0131	0.0110	-0.0014	0.665**
Spikelet fertility %	0.0000	0.0000	0.0014	0.0252	-0.0008	0.0151	0.0059	0.0058	0.2919	0.1914	-0.0002	-0.00003	-0.0070	0.0056	0.0012	0.535**
Biological yield/plant	-0.0013	-0.0013	0.0015	0.0283	-0.0017	0.0214	0.0055	0.0025	0.6857	-0.0370	-0.0001	0.00002	-0.0107	0.0093	-0.0011	0.701**
Harvest-index	0.0006	0.0015	0.0020	0.0263	-0.0006	0.0188	0.0038	0.0017	-0.0394	0.6440	-0.0001	-0.00001	-0.0067	0.0110	-0.0031	0.660**
1000-grain weight	-0.0009	-0.0021	0.0006	0.0086	-0.0006	0.0079	0.0029	0.0013	0.1209	0.1322	-0.0007	-0.00001	-0.0066	0.0063	-0.0040	0.266**
L:B ratio	0.0002	-0.0019	-0.0002	-0.0020	-0.0005	-0.0036	-0.0005	-0.0005	0.0442	-0.0115	0.0000	0.00031	-0.0023	0.0012	0.0005	0.024
Chlorophyll content	-0.0010	0.0001	0.0018	0.0212	-0.0014	0.0214	0.0057	0.0017	0.3054	0.1788	-0.0002	0.00003	-0.0240	0.0115	-0.0032	0.518**
Leaf Nitrogen	0.0000	-0.0014	0.0021	0.0342	-0.0011	0.0201	0.0039	0.0011	0.2123	0.2372	-0.0002	0.00001	-0.0092	0.0299	-0.0028	0.526**
Leaf temperature	0.0002	0.0017	-0.0004	-0.0055	-0.0007	-0.0056	-0.0008	0.0004	-0.0377	-0.1024	0.0001	0.00001	0.0039	-0.0042	0.0197	-0.131

Resi = 0.00114; *, ** significant at 5% and 1% level, respectively; Bold figures indicate direct effects.

fertility % (0.365), biological yield per plant (0.397), harvest index (0.526), chlorophyll content (0.478) and leaf nitrogen (0.563).

Panicle bearing tillers per plant possessed significant positive correlation with the characters spikelets/panicle (0.680), grains/panicle (0.585), spikelets/fertility % (0.451), biological yield per plant (0.506), harvest index (0.470), chlorophyll content (0.380) and leaf nitrogen (0.612).

Panicle length showed significant and negative correlation with only one trait i.e., biological yield per plant (-0.208). Spikelets/panicle exhibited significant positive correlation with the characters grains/panicle (0.586), spikelets/fertility % (0.371), biological yield per plant (0.527), harvest index (0.461), 1000-grains weight (0.195), chlorophyll content (0.527) and leaf nitrogen (0.494).

Grains per panicle exhibited significant positive correlation with the characters spikelets/fertility % (0.559), biological yield per plant (0.527), harvest index (0.367), 1000-grains weight (0.278), chlorophyll content (0.546) and leaf nitrogen (0.368).

Spikelets/fertility % possessed significant positive correlation with the traits biological yield per plant (0.426), harvest index (0.297), 1000-grains weight (0.222) and chlorophyll content (0.291); while biological yield per plant showed strong positive association with chlorophyll content (0.445) and leaf nitrogen (0.310).

Harvest index (%) showed strong positive association with 1000-grains weight (0.205), chlorophyll content (0.278) and leaf nitrogen (0.368); while 1000-grains weight exhibited significant positive correlation with the characters chlorophyll content (0.227) and leaf nitrogen (0.211) and also possessed negative and significant correlation with leaf temperature (-0.204). Chlorophyll content showed strong positive association with leaf nitrogen (0.386)

The overall results revealed that most of these traits were positively correlated with grain yield per plant, biological yield,

harvest index and leaf nitrogen. Hence these traits can be focussed for improvement in breeding programmes. The strong positive association of grain yield with one or more of the above traits has also been observed by previous workers Kumar (2015), Kumari *et al.*, (2017), Sumithra, *et al.* (2019), Saha *et al.* (2019), Sreedhar and Reddy (2019) respectively.

Path coefficient : The direct and indirect effects of 16 characters on grain yield per plant estimated by path coefficient analysis using simple correlations are given in Table-2. The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (0.6857) followed by harvest-index (0.6440). The highest positive indirect effect on grain yield per plant was exerted by days to 50% flowering, flag leaf area, panicle bearing tillers per plant, spikelets per panicle, grains per panicle, spikelets fertility %, harvest index, 1000-grains weight, chlorophyll content and leaf nitrogen *via* biological yield per plant *i.e.*, 0.1081, 0.2723, 0.3472, 0.3610, 0.3611, 0.2919, 0.1209, 0.3054 and 0.2123 respectively.

The highest positive indirect effect on grain yield per plant was exerted by flag leaf area, panicle bearing tillers per plant, spikelets per panicle, grains per panicle, spikelets fertility %, harvest index, 1000-grains weight, chlorophyll content and leaf nitrogen *via* harvest index with the values 0.3385, 0.3028, 0.2970, 0.2365, 0.1914, 0.1322, 0.1788 and 0.2372 respectively.

The very low estimates of direct and indirect effects recorded in case of remaining characters indicated that their direct and indirect contribution to grain yield was too low to be considered of any consequence. The estimate of residual factors (0.00114) was also low. Dwivedi *et al.* (2012), Dwivedi *et al.* (2015), Rai *et al.* (2014) and Sumithra, *et al.* (2019) have also identified biological yield per plant as a character making substantial direct positive contribution towards manifestation of grain yield in rice.

Present study illustrates, characters *viz.*, biological yield per plant, harvest spike and tillers per plant possesses positive correlation with grain yield. Also, these characters have reported positive and direct effect on grain yield and also found to have positive indirect effect on grain yield through each other. Therefore, the four traits mentioned can be capitalized further for improvement in breeding programmes in rice.

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Assessment of Genetic Variability and Heritability for Grain Yield and its Attributing Traits in Rice (*Oryza sativa* L.) under Sodic Soil

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Abstract

The present study was conducted with 103 germplasm lines including three checks to in Kharif 2016 to evaluate the extent of genetic variability, heritability and genetic advance in augmented block design for the sixteen characters of rice (*Oryza sativa* L.) at the Agriculture Research Farm of Genetics and Plant Breeding, ANDUAT, Kumarganj, Ayodhya (U.P.) under sodic soil conditions. The analysis of variance revealed that variance due to blocks and treatment were highly significant for all the traits except L:B ratio; the variance due to checks was significant for the traits days to 50% flowering, plant height, flag leaf area, spikelets per panicle, L:B ratio, chlorophyll content, leaf nitrogen, leaf temperature and grain yield per plant. Further, variance due to treatment/entry and Check V tester were significant for all the trait under study except L:B ratio. The High estimates of broad sense heritability (>75%) was observed for the character plant height (86.72%), while spikelets/panicle (73.10), flag leaf area (70.60), days to 50% flowering (62.71) and grain yield/plant (56.41) showed moderate level of heritability (50-75%). Further, high estimates of genetic advance in percent over mean at 5% and 1% was found for flag leaf area (13.87 and 17.78 respectively), grain yield per plant (11.94 and 15.30 respectively), panicle bearing tiller per plant (11.52 and 14.77 respectively) and plant height (9.10 and 11.66 respectively).

Key words : *oryza sativa*, heritability, genetic advance, grain yield, genotypic coefficient of variation.

Introduction

Rice (*Oryza sativa* L.) is the monocarpic annual plant belonging to genus *Oryza* of Poaceae family. The genus *Oryza* has 24 species of which, 22 are wild and two species viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. All the varieties found in Asia, America and Europe belong to *Oryza sativa* and those found in West Africa belongs to *Oryza glaberrima*. Further, *Oryza sativa* rice varieties of the world are commonly grouped into three sub species viz., Indica (India), Japonica (Japan) and Javanica (Indonesia). The largest rice cultivars are available at International Rice Research Institute (IRRI), Philippines, with over 100000 rice accessions held in International Rice Gene Bank. "Rice is life" this slogan of the International year of rice (2004) outlined the importance of rice. Rice is a most important staple food crop in the world as well as in India.

Improving the productivity of rice systems would contribute to hunger eradication, poverty alleviation, national food security and economic development. According to FAO estimates, there are about 840 million undernourished people, including more than 200 million children in developing countries.

Yield enhancement is the major breeding objective

in rice breeding programmes and knowledge on the nature and magnitude of the genetic and molecular variation governing the inheritance of quantitative characters like yield and its components is essential for effective genetic improvement. A critical analysis of the genetic variability parameters, viz. genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability (h^2) and genetic advance (GA) for different traits of economic importance is a major pre-requisite for any plant breeder to work with crop improvement programs. Further, information on correlation coefficients between grain yield and its component characters is essential for yield improvement, since grain yield in rice is a complex entity and highly influenced by several component characters. Studies on path co-efficient also provide useful information regarding the direct and indirect effects of different yield component characters on grain yield and thus aid in the identification of effective selection criteria for effective yield improvement.

Keeping this in view, the present study was carried out to reveal the genetic variability, heritability and genetic advance in rice under sodic soil conditions in year 2016.

Materials and Methods

The experimental material of rice germplasm was

Table-1 : Analysis of variance of augmented design for 16 characters of rice germplasm in year 2016.

Source of variation	d.f.	Days to 50% Flowering	Plant Height	Flag leaf area	Penicle bearing tillers/plant	Penicle length	Spikelets/ panicle	Grains/ panicle	Spikelet fertility %
Block	9	34.45**	324.28**	82.26**	15.30**	36.81**	534.96**	405.04**	34.53**
Treatment	102	81.60**	214.23**	38.74**	3.72**	4.08**	160.57**	111.89**	12.98
Checks	2	680.63**	683.19**	5.24*	0.36	0.33	36.22**	2.61	14.63
Treatment/entry	99	64.43**	199.81**	44.02**	4.58**	6.78**	210.53**	135.31**	15.46*
Check V Tester	1	583.85**	703.63**	-416.66**	-75.50**	-256.22**	-4536.35**	-1988.41**	-235.94**
Error	18	4.58	3.23	1.55	0.36	1.64	5.70	17.39	8.94
Total	129	67.56	192.46	36.59	4.06	6.02	165.08	119.16	14.34

Source of variation	d.f.	Biological yield/plant	Harvest-index	1000-grain weight	L:B ratio	Chlorophyll I content	Leaf Nitrogen	Leaf temperature	Grain yield/plant
Block	9	184.79**	46.55**	1.94**	0.06	11.19**	0.02613**	8.43**	28.99**
Treatment	102	40.12**	35.67**	1.87**	0.08	3.12**	0.00646**	2.30**	10.09**
Checks	2	3.68	8.99	1.10	0.13**	3.81**	0.04235**	3.02**	2.46*
Treatment/entry	99	51.73**	33.85**	2.04**	0.08	3.94**	0.00778**	2.20**	9.42**
Check V Tester	1	-1036.68**	269.33**	-14.31**	-0.12**	-79.85**	-0.19590**	10.04**	91.62**
Error	18	5.36	6.03	0.62	0.05	0.49	0.00065	0.44	0.72
Total	129	45.36	32.29	1.70	0.07	3.32	0.00702	2.47	10.10

comprised of 103 germplasm lines including three checks, taken from genetic stock available in Department of Genetics and Plant Breeding, ANDUAT, Ayodhya (U.P.). Three rows of each test genotype were present only once in each block with 3 checks in randomized manner along with the distance of 20 cm between the rows and 15 cm between the plants were sown in the season *Kharif* 2016. The observation on 16 quantitative characters *viz.*, days to 50% flowering, plant height, flag leaf area, panicle bearing tillers/plant, panicle length, spikelets/panicles, grains/panicle, spikelet fertility%, biological yield/plant, Harvest index, 1000 grain weight, L:B ratio, chlorophyll content, leaf nitrogen, leaf temperature and grain yield / plant were recorded to estimate genetic variability, heritability and genetic advance parameters.

The mean values were calculated and subjected to statistical analyses as: Analysis of variance, Heritability (Broad sense), Genetic advance and Genetic advance in percent over mean, Correlation coefficient and Path coefficient; suggested by Federer (1956), Hanson (1963), Johnson *et al.*, (1955) respectively.

Results and Discussion

The results of analysis of variance revealed that the variance due to blocks was highly significant for the characters days to days to 50% flowering (34.45), plant height (324.28), flag leaf area (82.26), panicle bearing tillers/plant (15.30), panicle length (36.81), spikelets/panicles (534.96), grains/panicle (405.04), spikelet fertility % (34.53), biological yield/plant (184.79), Harvest index (46.55), 1000 grain weight (1.94), chlorophyll content (11.19), leaf nitrogen (0.02613), leaf temperature

(8.43) and grain yield / plant (28.99). The analysis of variance revealed that variance treatment were highly significant for all the traits except L:B ratio; the variance due to checks was significant for the traits days to 50% flowering, plant height, flag leaf area, spikelets per panicle, L:B ratio, chlorophyll content, leaf nitrogen, leaf temperature and grain yield per plant. Further, variance due to treatment/entry and Check V tester were significant for all the trait under study except L:B ratio. This indicates presence of substantial amount of genetic variability for these traits among the genotypes under study (Table-1). Same type results were also observed by Seyoum *et al.* (2012) and Singh *et al.* (2014) grain yield per plant.

The character plant height (56.64-163.86) showed highest range, while the minimum range was observed in case of leaf nitrogen (0.32-0.71). The other parameters with high range of variation were days to 50% flowering (66-115.48), grains/panicle (73.22-129.65) and grains/panicle (92.86-159.34). Hence, a breeder can focus more on these traits which can provide him plenty scope for selection (Table-2).

Hight estimates of var (g) along with var (p) were recorded for plant height (21.10 and 24.33), spikelets per panicle (15.49 and 21.19), grains per panicle (9.45 and 26.84) and days to 50% flowering (7.70 and 12.28 respectively). High values of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed for panicle bearing tillers pr plant (8.05 and 11.59), flag leaf area (8.02 and 9.54) and grain yield per plant (7.72 and 10.28 respectively) as mentioned in Table 2. These results are in agreement with the earlier reports of Rai *et al.* (2014).

Table-2 : Range, mean, heritability and genetic advance in percent over mean for 16 characters of rice genotypes in year 2016.

Characters	Mean	Min	Max	var (g)	var (p)	Heritability (%)	GA	GA% mean	GA 1%	GA mean 1%	GCV (%)	PCV (%)
Days to 50% Flowering	92.68	66.00	115.48	7.70	12.28	62.71	4.53	4.89	5.80	6.26	2.99	3.78
Plant Height	96.82	56.64	163.86	21.10	24.33	86.72	8.81	9.10	11.29	11.66	4.74	5.09
Flag leaf area	24.06	12.43	42.75	3.72	5.27	70.60	3.34	13.87	4.28	17.78	8.02	9.54
Penicle bearing tillers/ plant	7.20	4.05	13.44	0.34	0.70	48.28	0.83	11.52	1.06	14.77	8.05	11.59
Penicle length	22.00	16.92	28.32	0.24	1.89	12.89	0.36	1.66	0.47	2.13	2.24	6.24
Spikelets/panicle	129.67	92.86	159.34	15.49	21.19	73.10	6.93	5.35	8.88	6.85	3.03	3.55
Grains/panicle	101.08	73.22	129.65	9.45	26.84	35.22	3.76	3.72	4.82	4.76	3.04	5.13
Spikelet fertility %	77.31	67.65	93.28	0.40	9.34	4.33	0.27	0.35	0.35	0.45	0.82	3.95
Biological yield/plant	37.46	22.27	55.97	3.48	8.83	39.35	2.41	6.43	3.09	8.24	4.98	7.93
Harvest-index	33.54	20.61	47.28	2.96	8.99	32.95	2.04	6.07	2.61	7.78	5.13	8.94
1000-grain weight	19.86	15.92	22.34	0.12	0.75	16.58	0.30	1.49	0.38	1.91	1.77	4.36
L:B ratio	2.346	1.837	2.83	0.00	0.05	5.92	0.03	1.19	0.04	1.53	2.38	9.77
Chlorophyll content	11.726	6.94	15.56	0.26	0.76	34.69	0.62	5.30	0.80	6.79	4.37	7.42
Leaf Nitrogen	0.543	0.32	0.71	0.00	0.00	47.20	0.03	6.29	0.04	8.06	4.44	6.47
Leaf temperature	33.695	29.26	36.97	0.19	0.62	29.76	0.48	1.44	0.62	1.84	1.28	2.35
Grain yield/plant	12.540	5.71	19.53	0.94	1.66	56.41	1.50	11.94	1.92	15.30	7.72	10.28

High estimates of broad sense heritability (>75%) were observed for the character plant height (86.72%), while spikelets/panicle (73.10), flag leaf area (70.60), days to 50% flowering (62.71) and grain yield/plant (56.41) showed moderate level of heritability (50-75%) (Table-2). Koli et al., (2013) also recorded high estimates to broad sense heritability for the trait plant height. Rest of the traits showed low level of heritability. Kumari *et al.* (2018) observed low heritability for panicle bearing tillers per plant.

High estimates of genetic advance in per cent over mean at 5% and 1% was found for flag leaf area (13.87 and 17.78 respectively), grain yield per plant (11.94 and 15.30 respectively), panicle bearing tiller per plant (11.52 and 14.77 respectively) and plant height (9.10 and 11.66 respectively). Rest of the traits possessed moderate to low genetic advance in percent over mean (Table-2). Sahu *et al.*, (2019) also reported high genetic advance in percent over mean for biological yield per plant. High heritability along with high genetic advance specifies that the heritability is due to additive genetic effect and selection may be effective, while high heritability associated with low genetic advance indicates the predominance of non-additive gene action, while low heritability is exhibited due to influence of environmental interactions rather than genotypic selection for such characters may not be rewarding.

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Study of Fresh Seed Dormancy in Sesame (*Sesamum indicum* L.) Varieties

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Abstract

The present investigation was conducted to study the presence of fresh seed dormancy in sesame varieties. The laboratory experiment was carried out at Seed Testing Laboratory, Department of Seed Science and Technology, Junagadh Agricultural University, Junagadh, during *summer* and *kharif* season of year 2019. In the experiment four variety V₁: GT-2, V₂: GT-3, V₃: GT-5 and V₄: GT-6 were tested in CRD design with four replication. The seeds used for experiment were produced on Instructional farm, 'krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *summer* and *kharif* season of year 2019. Fresh harvested seeds were brought at department and used for study of fresh seed dormancy. Germination trial was carried out at every ten days interval up to getting 80 percent germination. The results revealed that variety V₄ (GT-6) reached to the optimum germination (more than 80 %) at 90 DAH, V₃ (GT-5) at 100 DAH. Variety V₁ (GT-2) @ 120 DAH and variety V₂ (GT-3) @ 130 DAH in seed harvested from *summer*-2019. In case of seed harvested from *kharif*-2019 variety V₃ (GT-5) released its dormancy after 100 DAH. Variety V₂ (GT-3) at 110 DAH. At variety V₄ (GT-6) @ 120 DAH and variety V₁ (GT-2) released its dormancy at 130 DAH.

Key words : Dormancy, seed, sesame, varieties, season.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest spices and oilseed crops in the world and it was domesticated well over 3000 years ago. An India rank first in area (29%), production (26%) and export (40%) of sesame in the world. Sesame seed provides excellent food, nutrition, health care, edible oil and biomedicine. The production of oilseed crops in our country including sesame is not enough to meet the domestic demand of the large population. In general, average productivity of sesame continues to be lower (144 to 234 kg ha⁻¹) than expected from agricultural technology for the last 20 years, mainly due to its cultivation during rainy season on marginal lands, under poor management practices. The average yield in summer season is remarkably higher than the yield of *kharif* season because *kharif* sesamum is often caught in rains at maturity resulting in discolored grains due to mould incidence, failure of crop and fails to attract export market maximized (Shah *et al.*, 2020).

Dormancy is the state in which the viable seed cannot germinate even under the favorable condition for germination. There is several causes for seed dormancy such as physical, biological and genetical. In sesame, germination problem observed when summer produce is

utilized for *kharif* sowing; one of the reasons would be the existence of dormancy.

Dormancy is observed In sesame, when summer produce is utilized for *kharif* sowing: one of the because there was some germination problem. Some reports are available on seed dormancy in sesame as reported by Ashri and Palevitch (1979) in Mexican cultivar Cola de Burrego and Tanesaka *et al.* (2012) in *S. mulayanum* and F1 hybrid of *S. mulayanum* and *S. indicum*. Particular research on seed dormancy in sesame varieties of Gujarat has not been carried out. Therefore, whether dormancy is present in Gujarat sesame varieties or not, an experiment was carried out in the laboratory of Department of Seed Science and Technology, College of Agriculture, JAU, Junagadh. The study was carried out up to 100 to 130 days after harvesting and the results showed that dormancy in sesame seed is there. Based on this preliminary observation and the issue of summer sesame produce to use it for *kharif* sowing, the experiment is framed out to know the extent of fresh seed dormancy present in sesame both in *kharif* and summer seed production.

Materials and Methods

The present investigation was conducted in laboratory of Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh-

Table-1 : Germination (%) of seed harvested from *summer*-2019 for seed dormancy.

Variety (V)	Germination (%) of seed produced from seed of summer-2019												
	Period after harvesting (DAH) (D)												
	10	20	30	40	50	60	70	80	90	100	110	120	130
V ₁	21.19	24.57	35.98	45.21	50.61	55.79	64.23	68.11	71.87	75.68	79.20	82.33	85.51
V ₂	17.51	21.55	22.09	32.94	48.78	51.59	59.73	63.24	69.63	75.75	76.47	79.93	84.02
V ₃	27.20	31.40	41.83	47.21	56.73	61.24	68.32	71.29	76.50	80.10	85.50	88.44	91.49
V ₄	20.33	24.15	29.48	42.84	59.50	65.57	71.02	73.65	80.21	85.06	88.66	91.56	95.02
	(V)	(D)	V×D										
SEm ±	0.41	0.37	0.72	CV%	2.93								
C.D.	1.23	1.09	2.37										

Table-2 : Germination (%) of seed harvested from *kharif*-2019 for seed dormancy.

Variety (V)	Germination (%) of seed produced from seed of kharif-2019												
	Period after harvesting (DAH) (D)												
	10	20	30	40	50	60	70	80	90	100	110	120	130
V ₁	7.99	15.84	25.03	36.80	39.00	43.00	55.53	60.87	67.64	72.57	76.23	78.33	82.54
V ₂	10.26	21.26	30.21	37.19	41.55	46.08	51.45	65.21	71.82	79.21	84.21	88.12	91.06
V ₃	21.17	27.77	31.30	41.25	51.27	57.00	61.81	70.87	77.90	82.91	87.27	91.47	95.00
V ₄	18.13	21.03	33.32	46.84	55.38	60.10	65.20	71.87	74.67	74.21	78.25	83.23	85.46
	(V)	(D)	V×D										
SEm ±	0.31	0.62	1.20	CV%	4.11								
C.D.	0.99	1.76	3.80										

362001 with Completely Randomized Design (CRD) to study the presence of seed dormancy in sesame. The genetically pure seeds of all four varieties (V₁: GT-2, V₂: GT-3, V₃: GT-5 and V₄: GT-6) of sesame were obtained from Agricultural Research Station, Amreli. The seeds were used for sowing in *summer* and *kharif* 2019 at Instructional farm 'Krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. All agronomical practices were followed for successful cultivation of crop. According to treatment, crop was sown in field and all aftercare operation were carried out according to the crop requirements. The recommended dose of 25:25:00 kg NPK per ha was supplied.

The freshly harvested seeds of each season were used for study of presence of seed dormancy in laboratory. First germination trial was carried out after five days after harvesting of crop after both season of field cultivation. Germination percent of sesame seeds of all four varieties were recorded at 10 days interval up to getting minimum seed germination percent required for seed certification recommended by ISTA (International Seed Testing Association) i.e., 80 percent. The seeds obtained from different varieties were tested for germination by adopting top paper towel method kept at optimum conditions of temperature (25+ 10° C) and relative humidity (95+ 1% RH) in four replication of fifty seeds each as given by ISTA rules (Anonyms, 1996). Fifty seeds of each variety were used for conducting the

germination test. The number of normal seedlings were counted at the end of 7 days and the germination percentage were calculated. The collected data for various parameters were statistically analyzed using Fishers analysis of variance (ANOVA) technique and the treatments were compared at 5% levels of significance (Cochran and Cox, 1965).

Results and Discussion

Summer-2019 : The results of seed harvested after *summer*-2019 revealed the presence of seed dormancy in sesame (Table 1). Among all the varieties used for study of germination variety V₄ (GT-6) reached to the optimum germination (more than 80 %) at 90 DAH, while variety V₃ (GT-5) reached to the optimum germination percent at 100 DAH. Variety V₁ (GT-2) get the optimum germination percent necessary for seed certification @ 120 DAH and variety V₂ (GT-3) released its dormancy after 130 DAH. This was might be due to presence of seed dormancy in sesame. Similar kind of results were supported by Jyoti *et al.* (2021) in sesame,

However at the 130 DAH all the four varieties (V₁, V₂, V₃ and V₄) get 85.81, 84.02, 91.49 and 95.02 % germination respectively in the seed harvested from the *summer*-2019 season of experimentation.

Kharif-2019 : The data presented in Table-2 showed that dormancy present in all four varieties used for study on the seed harvested from *kharif*-2019 season of

experimentation. Among all four varieties variety V_3 (GT-5) released its dormancy after 100 DAH. Variety V_2 (GT-3) reached to the optimum germination percent at 110 DAH. At 120 DAH variety V_4 (GT-6) got the germination percent which are suitable for seed certification of sesame (above 80 %). Variety V_1 (GT-2) released its dormancy at 130 DAH in the seed harvested from *kharif*-2019 season of experiment. At the end of the dormancy test all four varieties (V_1, V_2, V_3 and V_4) get 82.54, 91.06, 95.00 and 85.46 % germination respectively in seed produced from second season. This was might be due to presence of seed dormancy in sesame. Similar kind of results were supported by Jyoti *et al.* (2021) in sesame.

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Effect of Nipping on Seed Yield and Component Characters on Sesame (*Sesamum indicum* L.) Varieties

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Abstract

The present investigation was conducted to study the effect of nipping on seed yield and component characters of varieties of sesame. The field experiment was carried out at Instructional farm, 'krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer and kharif season of year 2019. The experiment consist of four nipping treatments (N₁: no nipping, N₂: nipping at 25 DAS, N₃: nipping at 35 DAS and N₄: spray CCC 100 ppm at 30 DAS) and four variety treatments (V₁: GT-2, V₂: GT-3, V₃: GT-5 and V₄: GT-6) were tested in RBD (Factorial) design with three replication. The results revealed that days to flower bud initiation, days to flowering and days to maturity were significantly lower in nipping treatment N₁ and number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, biological yield per plant and harvest index (%) were significantly higher when crop was nipped with 35 DAS (N₃). Effect of varieties was found significant in case of number of days to flower bud initiation, days to flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, biological yield, harvest index and germination percent.

Key words : Nipping, varieties, yield, sesame, CCC.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest spices and oilseed crops in the world and it was domesticated well over 3000 years ago. An India rank first in area (29%), production (26%) and export (40%) of sesame in the world. Sesame seed provides excellent food, nutrition, health care, edible oil and biomedicine. The production of oilseed crops in our country including sesame is not enough to meet the domestic demand of the large population. In general, average productivity of sesame continues to be lower (144 to 234 kg ha⁻¹) than expected from agricultural technology for the last 20 years, mainly due to its cultivation during rainy season on marginal lands, under poor management practices. The average yield in summer season is remarkably higher than the yield of *kharif* season because *kharif* sesamum is often caught in rains at maturity resulting in discolored grains due to mould incidence, failure of crop and fails to attract export market maximized (Shah *et al.*, 2020).

Managing the crop geometry for manipulating the seed yield in crops like sesame with indeterminate growth habit is a challenging task. The growing sequence of sesame is indeterminate on which leaves, flowers and seeds are being produced as long as the favourable weather persists. This favours many late formed capsules

which are usually immature at harvest and stage of capsule maturity at harvest highly influences seed yield, dormancy and germination. Apical bud cutting is known to alter the source-sink relationship by arresting the vegetative growth and hastening the reproductive phase. Hence, arresting late formed flowers by nipping of main stem and side branches not only avoid the late formed capsules but also promote the efficient source sink relations and thus seed yield and quality will be maximized (Vasanthan *et al.*, 2019).

Hence, the present study was undertaken to study the performance of sesame varieties under different time of nipping practices on seed yield and quality.

Materials and Methods

The present investigation was conducted in two seasons and two phases, 1. Field and 2. Laboratory. The field experiment was conducted at the Instructional farm 'Krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, during *summer* 2019 and *kharif* 2019 to study the effect of nipping on yield and component characters on sesame (*Sesamum indicum* L.) with Randomized Block Design (RBD) (Factorial). While the study of seed quality parameters of sesame was carried out in the laboratory of Department of Seed Science and Technology, College of

Table-1 : Effect of nipping and variety on yield and component characters of sesame (Pooled of Two year).

Table 1: Effect of nipping and variety on yield and component characters of sesame (Pooled of two years).								
Characters	Days to flower bud initiation	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capsule per plant	Number of seeds per capsule	Seed yield per plant (g)
Variety								
Treatment	Pooled							
V ₁	24.93	36.14	84.55	79.51	2.20	49.86	61.71	9.74
V ₂	30.75	44.22	79.88	69.11	2.02	52.81	54.08	7.90
V ₃	29.93	41.54	89.81	64.15	2.10	60.08	70.87	12.35
V ₄	31.31	41.58	86.55	86.27	1.42	57.43	63.50	10.18
S.Em ±	0.39	0.47	1.01	4.48	0.11	0.82	0.95	0.18
C.D. at 5%	1.08	1.30	2.81	NS	0.50	2.30	2.66	0.51
Nipping								
Treatment	Pooled							
N ₁	26.94	38.54	81.66	80.70	1.67	52.06	58.89	8.63
N ₂	29.63	41.59	85.27	70.16	2.03	55.74	62.35	10.15
N ₃	31.73	44.07	88.62	74.70	2.18	58.93	67.29	12.03
N ₄	28.62	39.28	85.23	73.48	1.86	53.47	61.63	9.36
S.Em ±	0.39	0.47	1.01	1.04	0.08	0.82	0.95	0.18
C.D. at 5%	1.08	1.30	2.81	2.89	NS	2.30	2.66	0.51
Interactions								
V×N								
S.Em ±	0.78	0.93	2.01	2.07	0.06	1.65	1.91	0.37
C.D.@5%	NS	NS	NS	NS	0.16	NS	NS	1.03
E×V								
S.Em ±	0.55	0.66	1.42	1.46	0.04	1.16	1.35	0.26
C.D.@5%	NS	NS	NS	4.08	0.11	NS	NS	NS
E×N								
S.Em ±	0.55	0.66	1.42	1.46	0.04	1.16	1.35	0.26
C.D.@5%	NS	NS	NS	NS	0.11	NS	NS	NS
E xV×N								
S.Em ±	1.10	1.14	2.85	2.93	0.08	2.33	2.70	0.52
C.D.@5%	NS	NS	NS	NS	NS	NS	NS	NS
Contd....								
Characters	Biological yield per plant (g)	1000 seed weight (g)	Harvest index (%)	Germination (%)	seedling vigor index-I	seedling vigor index-II	Moisture content (%)	
Variety								
Treatment	Pooled							
V ₁	32.24	3.38	32.36	84.02	419.95	2384.82	8.53	
V ₂	29.05	2.95	26.69	87.54	432.75	2027.39	8.96	
V ₃	37.75	3.58	28.62	93.24	476.66	2391.82	9.20	
V ₄	34.20	3.09	30.62	90.24	495.17	1582.88	8.67	
S.Em ±	0.45	0.02	0.56	3.66	21.59	76.32	0.08	
C.D. at 5%	1.26	0.05	1.55	NS	NS	343.51	0.35	
Nipping								
Treatment	Pooled							
N ₁	30.64	3.23	27.92	88.21	456.26	2116.92	8.83	
N ₂	33.64	3.26	29.85	88.78	455.89	2095.02	8.80	
N ₃	37.01	3.28	31.90	89.06	456.19	2086.33	8.89	
N ₄	31.95	3.25	28.63	89.01	456.19	2088.64	8.83	
S.Em ±	0.45	0.02	0.56	0.32	2.13	10.57	0.04	
C.D. at 5%	1.26	NS	1.55	NS	NS	NS	NS	
Interactions								
V×N								
S.Em ±	0.90	0.04	1.11	0.65	4.26	21.14	0.08	
C.D.@5%	NS	0.11	NS	NS	NS	NS	NS	
E×V								
S.Em ±	0.64	0.03	0.79	0.46	3.01	14.95	0.05	
C.D.@5%	NS	NS	NS	1.28	8.38	41.61	0.15	
E×N								
S.Em ±	0.64	0.03	0.79	0.17	4.21	1.63	0.08	
C.D.@5%	NS	NS	NS	NS	NS	NS	NS	
E xV×N								
S.Em ±	1.28	0.06	1.57	0.92	6.02	29.89	0.11	
C.D.@5%	NS	NS	NS	NS	NS	NS	NS	

Agriculture, Junagadh Agricultural University, Junagadh in Completely Randomized Design (CRD) (Factorial).

There were total sixteen treatment combinations, containing four levels of sesame varieties V_1 : GT-2, V_2 : GT-3, V_3 : GT-5 and V_4 : GT-6. Four levels of nipping N_1 : no nipping, N_2 : nipping at 25 DAS, N_3 : nipping at 35 DAS and N_4 : spray CCC 100 ppm at 30 DAS.

The genetically pure seeds of all four varieties of sesame were obtained from Agricultural Research Station, Junagadh Agricultural University, Amreli. All agronomical practices were followed for successful cultivation of crop. According to treatment, crop was sown in field and nipping was done according to the treatments. The recommended dose of 25:25:00 kg NPK per ha was supplied. Five plants were randomly selected in each treatment and in each replication and labelled. Observations on plant character were recorded on these plants at different stages of crop growth.

The seeds obtained from different treatments were tested for germination by adopting between paper towel method kept at optimum conditions of temperature ($25 \pm 10^\circ \text{C}$) and relative humidity ($95 \pm 1\% \text{RH}$) in four replication of fifty seeds each as given by ISTA rules (Anonyms, 1996). The number of normal seedlings were counted at the end of 7 days and the germination percentage and other seed quality parameters were calculated. The collected data for various parameters were statistically analysed using Fishers analysis of variance (ANOVA) technique and the treatments were compared at 5% levels of significance (Cochran and Cox, 1965).

Results and Discussion

Effect of varieties : Pooled data presented in table-1 indicated that significant difference was observed among different varietal treatments in yield and yield component characters like, days to flower bud initiation, days to flowering, days to maturity, number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant (g), biological yield (g), 1000 seed weight (g), harvest index (%), seedling vigor index II and moisture content (%).

Significantly lower number of days to flower bud initiation was recorded under V_1 (24.93 days) as compared to other varieties. This might be due to genetic characteristics of cultivar and effect of environmental condition. Similar reports also supported by Tiwari *et al.* (1994) in sesame. variety GT-2 (V_1) recorded significantly minimum number of days (36.14 days) required to flowering in pooled results. These findings were in

agreement with those of Vasanthan *et al.* (2019) in sesame. Among different varieties sesame variety V_2 (GT-3) recorded significantly less days to maturity (79.88 days) than other varieties (GT-2, GT-5 and GT-6). Maximum number of days to maturity was reported in variety GT-5 (V_3) (83.58, 96.04 and 89.81 days) on pooled basis. The results were accordance with those reported by Tan (2011) in sesame.

Variety GT-2 (V_1) showed maximum number of branches per plant (2.20) in pooled results. This might be due to varietal performance to *summer* and *kharif* growing period in prevailing environmental condition. These results were in accordance with Tiwari *et al.* (1994) in sesame. Variety GT-3 (V_3) recorded maximum number of capsules per plant (60.08) in pooled basis. This was might be due to less flower drop and more fruit setting. Similar results have been found by Tembhurne and Dharai (2007) in sesame. The maximum number of seed per capsule (70.87) was recorded in V_3 (GT-5) on pooled basis. This might be due to varietal genetic characters. These results obtained in present investigation were in line with the findings of Kathiresan and Gnanamoorthy (2001) in sesame.

Significantly higher seed yield per plant (12.35 g/plant) was recorded in the variety GT-5 (V_3). This found might be due to varietal characters like plant height, number of branches per plant, number of capsules per plant and number of seeds per capsules are ultimately lead to produce more seed yield per plant in sesame. Similar kind of results were also reported by Tembhurne and Dharai (2007) and Tan (2011) in sesame. Significantly higher biological yield (g) was recorded in variety GT-5 (V_3) *i.e.* 37.75 (g). This was due to more number of branches plant⁻¹, number of capsules per plant, plant height and other biological characters of plant that helped in production of more biological weight of plant. Similar findings was supported by Vasanthan *et al.* (2019) in sesame. Variety V_3 (GT-3) recorded higher (3.58 g) 1000 seed weight among all varieties. This was might be due to varietal genetical characters and prevailing environmental condition. Similar kind of results was also reported by Tan (2011) in sesame. Among all the varieties variety V_1 (GT-2) recorded significantly higher harvest index (32.36 %). This was due to maximum seed yield and straw yield. The results are in conformity with the work of Vasanthan *et al.* (2019).

Germination (%) and seedling vigor index-I were found non significant in on the pooled basis but in case of individual season base it was found significant. This might be due to presence of seed dormancy and varietal genetic characteristics. Variety V_3 (2391.82) was higher in SVI-II.

Variety V₃ (GT-5) was found higher moisture content (9.20 %). The reason behind this might be that varietal genetic characters, presence of dormancy and seed health status of seed in given environmental condition. The same findings were supported by Vasanthan *et. al* (2019) in sesame.

Effect of nipping : Significantly lower number of days (26.94) to flower bud initiation was recorded in N₁ (no nipping). The significantly higher number of days to flowering was recorded in nipping treatment N₃ (nipping at 35 DAS) that is 38.54. This was find might be due to in nipped plants removal of apical bud promote the lateral branches and divert the photosynthates towards the branches, promote the vegetative growth in early stage as compare to nipped plants and take more days to flowering. Similar kind of results were also reported by Shinde (2015) in sesame. The nipping treatment N₁ (no nipping) showed lowest days to maturity (81.66 days). It might be due to nipped plants produce more branches and capsules per plant then non nipped plant which ultimately take more days to maturity. These findings were in accordance with reported by Vasanthan *et. al* (2019) in sesame.

Significantly higher plant height was recorded N₁ (no nipping) *i.e.* 80.70 cm as compared to other nipping treatments. This might be due to apical dominance as more auxins are continuously supplied to no topping treated plants they achieved higher plant height. The lesser plant height in topping at 25 and 35 DAS might be due to the removal of apical bud from plant which reduced the vertical growth of plant. After topping the apical dominance is declined which resulted in less height in nipped plants. Similar results were reported by Vinoth (2020) and Siro *et al.* (2020) in sesame.

Nipping treatments imparted their non significant influence on the number of branches per plant on pooled basis. The increase in number of branches with nipping might be due to nipping also activated the dormant lateral buds to produce more number of secondary branches. If the source of auxin is removed by removing the apical meristem, the lateral branching gets activated and accelerated and resulted in more branches per plant. These results were in accordance with the findings Vasanthan *et. al* (2019) and Siro *et al.* (2020) in sesame.

Among different nipping treatment nipping at 35 DAS (N₃) recorded significantly higher number of capsules per plant (58.93) over the other nipping treatments. This might be due to more number of branches resulted in higher number of flowers and

capsules which ultimately increased the number of capsules plant. Similar results were reported by Vinoth (2020) in sesame.

Significantly higher number of seeds per capsule (67.29 seeds/capsule) was noted in nipping at 35 DAS (N₃) noted over other nipping treatments. Nipping at 35 DAS (N₃) noted significantly higher seed yield (12.03 g/plant). The increase in seed yield might be due higher growth and yield attributing characters which was caused by enhanced branching and dispersion of carbohydrate towards auxiliary buds below nipped portion which helped in production of more number of branches per plant and number of capsule per plant. Seed yield itself is a complex genetic trait and several other parameters like branches per plant, days to flowering, number of capsule per plant, number of seeds per capsule *etc.* have significant role on final yield. These findings were in accordance with reported by Siddagangamma *et. al* (2018), Vasanthan *et. al* (2019) and Vinoth (2020) in sesame.

Significantly highest biological yield (37.01 g/plant) was found in nipping treatment 35 DAS (N₃). Nipping can effect positive increment in crop growth in terms of number of branches and dry matter accumulation increased the strover yield and further increase in biological yield was the cumulative effect of improved growth parameters due to nipping treatments as compared to non-nipping. Further, higher nutrient uptake and better use of radiant energy led to higher vegetative and reproductive growth, thus enhancing biological yield. These results were in the line of results Vasanthan *et. al* (2019) in sesame.

Nipping at 35 DAS (N₃) noted significantly higher harvest index (31.90 %) over other nipping treatment. Harvest index is the ratio of seed yield and total plant biomass on above ground. It shows physiological efficacy of plants to convert the total dry matter into seed yield. These results were in conformity with the findings of Vasanthan *et. al* (2019) in sesame.

Non significant effect of nipping was observed on 1000 seed weight, seed germination (%), seedling vigor index I, seedling vigor index II and seed moisture content (%) in both the season as well as on pooled basis. These results were in conformity with the findings of Siddagangamma *et. al* (2018) in sesame.

Interaction effect : In the interaction between variety and nipping significantly highest number of branches (2.38 branches/plant) were recorded in interaction V₁ x N₃ (GT-2 x nipping at 35 DAS) over rest of the treatment combinations except V₃N₃, V₂N₃, V₃N₂ and V₁N₄ (Table-2).

Table-2 : Interaction effect of variety and nipping (V×N) on number of branches per plant.

Treatments Nipping	V x N interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
N ₁	1.99	1.68	1.79	1.24	1.67
N ₂	2.20	2.16	2.31	1.46	2.03
N ₃	2.38	2.34	2.35	1.67	2.18
N ₄	2.22	1.91	1.97	1.32	1.86
Mean	2.20	2.02	2.10	1.42	
SEm ±			0.06		
CD (P = 0.05)			0.16		

In the interaction of season and variety (Table-3) the treatment combination *Kharif*-2019 (E₂) and V₁ (GT-2) variety recorded the significantly higher number of branches per plant (2.80 branches/plant) over rest of the treatment combinations except E₂V₃ (2.71 branches/plant). In interaction of season and nipping (Table-4) the combination *Kharif*-2019 (E₂) season with nipping at 35 DAS (N₃) recorded significantly higher number of branches per plant (2.81 branches/plant). This might be due to cumulative and positive effect of both interaction on vegetative growth of plants. The results were in conformity with the work of Siro *et al.* (2020) in sesame.

Table-3 : Interaction effect of season and variety (E×V) on number of branches per plant.

Treatments Variety	E x V interaction		
	Season		Mean
	Summer-2019	Kharif-2019	
V ₁	1.60	2.80	2.20
V ₂	1.46	2.58	2.02
V ₃	1.50	2.71	2.10
V ₄	1.05	1.79	1.42
Mean	1.40	2.47	
SEm ±		0.04	
CD (P = 0.05)		0.11	

Table-4 : Interaction effect of season and nipping (E×N) on number of branches per plant.

Treatments Nipping	E x N interaction		
	Season		Mean
	Summer-2019	Kharif-2019	
N ₁	1.20	2.15	1.67
N ₂	1.46	2.60	2.03
N ₃	1.55	2.81	2.18
N ₄	1.40	2.31	1.86
Mean	1.40	2.47	
SEm ±		0.04	
CD (P = 0.05)		0.11	

Significantly the higher seed yield (13.72 g) was obtained in treatment combination V₃N₃ (GT-5 and 60 x 15 cm²) over all other treatment combinations of variety and nipping (Table-5).

Table-5 : Interaction effect of variety and nipping (V x N) seed yield per plant (g).

Treatments Nipping	V x N interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
N ₁	8.16	6.64	11.40	8.33	8.63
N ₂	9.64	7.65	11.95	11.35	10.15
N ₃	11.72	10.07	13.72	12.63	12.03
N ₄	9.46	7.22	12.33	8.42	9.36
Mean	9.74	7.90	12.35	10.18	
SEm ±			0.37		
CD (P = 0.05)			1.03		

In case of interaction combination of variety and nipping (Table-6) significantly the higher 1000 seed weight (3.65 g) was obtained in treatment combination V₃N₃ (GT-5 and nipping at 35 DAS) over other treatment combinations except treatment combination V₃N₁ and V₃N₂ were found at par with V₃N₃. Significantly higher germination and SVI I (95.02 % and 522.52) was found in interaction of first season (E₁) with variety V₄ (GT-6) among all varietal and seasonal treatment combinations except E₂V₃ was found at par with E₁V₄ with respect to germination (Table-7 and 8).

Table-6 : Interaction effect of variety and nipping (V x N) 1000 seed weight (g).

Treatments Nipping	V x N interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
N ₁	3.34	2.93	3.62	3.04	3.23
N ₂	3.36	2.92	3.54	3.20	3.26
N ₃	3.40	3.01	3.65	3.15	3.30
N ₄	3.42	2.95	3.53	2.99	3.22
Mean	3.38	2.95	3.58	3.09	
SEm ±			0.04		
CD (P = 0.05)			0.11		

Table-7 : Interaction effect of season and variety (E×V) on germination (%).

Treatments Variety	E x V interaction		
	Season		Mean
	Summer-2019	Kharif-2019	
V ₁	85.51	82.54	84.02
V ₂	84.02	91.06	87.54
V ₃	91.49	95.00	93.24
V ₄	95.02	85.46	90.24
Mean	89.01	88.51	
SEm ±		0.46	
CD (P = 0.05)		1.28	

Table-8 : Interaction effect of season and variety (E×V) on seedling vigor index-I.

Treatments	E x V interaction		
	Season		
Variety	Summer-2019	Kharif-2019	Mean
V ₁	455.35	384.54	419.95
V ₂	418.88	446.62	432.75
V ₃	493.88	459.43	476.66
V ₄	522.52	467.82	495.17
Mean	472.66	439.60	
SEm ±		3.01	
CD (P = 0.05)		8.38	

Significantly higher seedling vigor index-II (Table-9) was found in interaction of first season (E₁) with variety V₁ (GT-2) among all varietal and seasonal treatment combinations (2425.99). Significantly higher moisture content (10.67 %) was found in interaction of second season (E₂) with variety V₃ (GT-5) among all varietal and seasonal treatment combinations (Table-9 and 10).

Table-9 : Interaction effect of season and variety (E×V) on seedling vigor index-II.

Treatments	E x V interaction		
	Season		
Variety	Summer-2019	Kharif-2019	Mean
V ₁	2425.99	2343.65	2384.82
V ₂	1943.74	2111.04	2027.39
V ₃	2345.73	2437.91	2391.82
V ₄	1664.56	1501.20	1582.88
Mean	2095.01	2098.45	
SEm ±		14.95	
CD (P = 0.05)		41.61	

Table-10 : Interaction effect of season and variety (E×V) on moisture content (%).

Treatments	E x V interaction		
	Season		
Variety	Summer-2019	Kharif-2019	Mean
V ₁	7.08	9.98	8.53
V ₂	7.56	10.36	8.96
V ₃	7.73	10.67	9.20
V ₄	7.09	10.25	8.67
Mean	7.36	10.32	
SEm ±		0.05	
CD (P = 0.05)		0.15	

Conclusion

From the results of two season experimentation it can be concluded that the GT-5 variety of sesame along with one nipping at 35 days after sowing were found effective in

improving the seed yield and yield component characters of sesame.

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Effect of Spacing on Seed Yield and Component Characters on Sesame (*Sesamum indicum* L.) Varieties

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Abstract

The present investigation was conducted to study the effect of spacing on seed yield and component characters of varieties of sesame. The field experiment was carried out at Instructional farm, 'krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer and kharif season of year 2019. The experiment consist of three spacing treatments (S_1 : 45 x 15 cm², S_2 : 30 x 15 cm² and S_3 : 60 x 15 cm²) and four variety treatments (V_1 : GT-2, V_2 : GT-3, V_3 : GT-5 and V_4 : GT-6) were tested in RBD (Factorial) design with three replication. The results revealed that days to flower bud initiation, days to flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant (g), biological yield (g) and harvest index (%) were significantly higher when crop was sown with 60 x 15 cm² spacing treatment (S_3) and non significant difference was observed in 1000 seed weight (g), germination (%), seedling vigor index I, seedling vigor index II and moisture content (%). Effect of varieties was found significant in case of number of days to flower bud initiation, days to flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant, biological yield, harvest index and germination percent.

Key words : Spacing, varieties, yield, sesame, interaction.

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest spices and oilseed crops in the world and it was domesticated well over 3000 years ago. An India rank first in area (29%), production (26%) and export (40%) of sesame in the world. Sesame seed provides excellent food, nutrition, health care, edible oil and biomedicine. The production of oilseed crops in our country including sesame is not enough to meet the domestic demand of the large population. In general, average productivity of sesame continues to be lower (144 to 234 kg ha⁻¹) than expected from agricultural technology for the last 20 years, mainly due to its cultivation during rainy season on marginal lands, under poor management practices. The average yield in summer season is remarkably higher than the yield of *kharif* season because *kharif* sesamum is often caught in rains at maturity resulting in discolored grains due to mould incidence, failure of crop and fails to attract export market maximized (Shah *et al.*, 2020).

Yield response to plant population and row spacing need to be known for the practical purposes, as planting density is a major management variable used in matching crop requirements to the environmental offer of resources. As plant density increase, competition between plants becomes more intense, affecting the growth, development and production of each plant.

Optimum plant density and row spacing are also

important for improving a grain yield for a particular environment. Maximum yield of sesame is achieved from the best spatial arrangement of plant for effective canopy development, water and nutrient utilization and pest and disease control. These relationships are also important for optimal physiological function of the crop.

Use of appropriate cultivar has a great impact on productivity of sesame. Sesame cultivars are highly sensitive to seasonal variations in terms of day length and temperature. Summer cultivation of sesame revealed high yielding potentiality of the crop (Basavaraj *et al.* 2000). Therefore, cultivars recommended for commercial cultivation need to be evaluated under this agro climatic conditions.

Hence, the present study was undertaken to study the performance of sesame varieties under different levels of spacing practices on seed yield and quality.

Materials and Methods

The present investigation was conducted in two seasons and two phases, 1. Field and 2. Laboratory. The field experiment was conducted at the Instructional farm 'Krishigardh', Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, during *summer* 2019 and *kharif* 2019 to study the effect of spacing on yield and component characters on sesame (*Sesamum indicum* L.) with Randomized Block Design (RBD) (Factorial). While the study of seed quality parameters of sesame was carried out in the laboratory of

Table-1 : Effect of nipping and variety on yield and component characters of sesame (Pooled of Two year).

Characters	Days to flower bud initiation	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capsule per plant	Number of seeds per capsule	Seed yield per plant (g)
Variety								
Treatment					Pooled			
V ₁	24.93	36.14	84.55	79.51	2.20	49.86	61.71	9.74
V ₂	30.75	44.22	79.88	69.11	2.02	52.81	54.08	7.90
V ₃	29.93	41.54	89.81	64.15	2.10	60.08	70.87	12.35
V ₄	31.31	41.58	86.55	86.27	1.42	57.43	63.50	10.18
S.Em ±	0.39	0.47	1.01	4.48	0.11	0.82	0.95	0.18
C.D. at 5%	1.08	1.30	2.81	NS	0.50	2.30	2.66	0.51
Spacing								
Treatment					Pooled			
S ₁	29.26	41.42	84.55	74.64	1.94	54.91	62.76	9.96
S ₂	28.38	38.54	82.49	72.47	1.87	51.17	60.47	8.70
S ₃	30.05	42.65	87.40	77.17	2.02	59.07	64.39	11.47
S.Em ±	0.34	0.40	0.80	0.90	0.03	0.71	0.83	0.16
C.D. at 5 %	0.94	1.13	2.22	2.50	0.07	1.99	2.31	0.44
Interactions								
					VxS			
S.Em ±	0.67	0.81	1.74	3.91	0.05	1.43	1.65	0.32
C.D.@5%	1.87	2.26	4.86	13.53	NS	3.98	4.61	0.89
					ExV			
S.Em ±	0.55	0.66	1.42	1.46	0.04	1.16	1.35	0.26
C.D.@5%	NS	NS	NS	4.08	0.11	NS	NS	NS
					ExS			
S.Em ±	0.47	0.57	1.23	1.27	0.04	1.01	1.17	0.23
C.D.@5%	NS	NS	NS	NS	0.10	2.81	NS	0.63
					E xVxS			
S.Em ±	0.55	1.14	2.47	2.54	0.07	2.02	2.34	0.45
C.D.@5%	NS	NS	NS	7.07	NS	NS	NS	NS
Contd....								
Characters	Biological yield per plant (g)	1000 seed weight (g)	Harvest index (%)	Germination (%)	seedling vigor index-I	seedling vigor index-II	Moisture content (%)	
Variety								
Treatment					Pooled			
V ₁	32.24	3.38	32.36	84.02	419.95	2384.82	8.53	
V ₂	29.05	2.95	26.69	87.54	432.75	2027.39	8.96	
V ₃	37.75	3.58	28.62	93.24	476.66	2391.82	9.20	
V ₄	34.20	3.09	30.62	90.24	495.17	1582.88	8.67	
S.Em ±	0.45	0.02	0.56	3.66	21.59	76.32	0.08	
C.D. at 5%	1.26	0.05	1.55	NS	NS	343.51	0.35	
Nipping								
Treatment					Pooled			
S1	33.49	3.25	29.56	88.42	0.79	2097.20	8.84	
S2	31.01	3.22	28.05	88.91	NS	2096.52	8.82	
S3	35.43	3.26	31.10	88.96	0.79	2096.47	8.86	
S.Em ±	1.88	0.02	0.48	0.28	0.79	9.15	0.03	
C.D. at 5%	5.54	NS	1.34	NS	NS	NS	NS	
Interactions								
					VxS			
S.Em ±	1.88	0.03	0.96	0.56	3.69	18.31	0.07	
C.D.@5%	5.54	0.09	2.68	0.56	NS	NS	NS	
					ExV			
S.Em ±	0.64	0.03	0.79	0.46	3.01	14.95	0.05	
C.D.@5%	NS	NS	NS	1.28	8.38	41.61	0.15	
					ExS			
S.Em ±	0.55	0.02	0.68	0.40	2.61	12.94	0.05	
C.D.@5%	NS	NS	1.90	NS	NS	NS	NS	
					ExVxS			
S.Em ±	1.11	0.05	1.36	0.79	5.21	25.89	0.09	
C.D.@5%	3.09	NS	NS	NS	NS	NS	NS	

Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh with Completely Randomized Design (CRD) (Factorial).

The soil of the experimental site was clayey in texture, medium in organic carbon (0.66 and 0.62%), medium in available nitrogen (253.20 and 258.13 kg/ha), phosphorus (37.12 and 35.47 kg/ha), potassium (269.10 and 275.30 kg/ha) and slightly alkaline in nature (PH 8.16 and 7.92) during 2019. Soil was uniform in depth and suitable for growing of sesame crop during *summer* and *kharif* season. There were total sixteen treatment combinations, containing four levels of sesame varieties V₁: GT-2, V₂: GT-3, V₃: GT-5 and V₄: GT-6. Three levels of spacing S₁: 45 x 15 cm², S₂: 30 x 15 cm² and S₃: 60 x 15 cm².

The genetically pure seeds of all four varieties of sesame were obtained from Agricultural Research Station, Junagadh Agricultural University, Amreli. All agronomical practices were followed for successful cultivation of crop. According to treatment, crop was sown in field and nipping was done according to the treatments. The recommended dose of 25:25:00 kg NPK per ha was supplied. Five plants were randomly selected in each treatment and in each replication and labeled. Observations on plant character were recorded on these plants at different stages of crop growth.

The seeds obtained from different treatments were tested for germination by adopting between paper towel method kept at optimum conditions of temperature (25+10° C) and relative humidity (95+ 1% RH) in four replication of fifty seeds each as given by ISTA rules (Anonyms, 1996). The number of normal seedlings were counted at the end of 7 days and the germination percentage and other seed quality parameters were calculated. The collected data for various parameters were statistically analyzed using Fishers analysis of variance (ANOVA) technique and the treatments were compared at 5% levels of significance (Cochran and Cox, 1965).

Results and Discussion

Effect of varieties : Pooled data presented in table-1 indicated that significant difference was observed among different varietal treatments in yield and yield component characters like, days to flower bud initiation, days to flowering, days to maturity, number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant (g), biological yield (g), 1000 seed weight (g), harvest index (%), seedling vigor index II and moisture content (%).

Significantly lower number of days to flower bud

initiation was recorded under V₁ (24.93 days) as compared to other varieties. This might be due to genetic characteristics of cultivar and effect of environmental condition. Similar reports also supported by Pawar (1991) in sesame. variety GT-2 (V₁) recorded significantly minimum number of days (36.14 days) required to flowering in pooled results. These findings were in agreement with those of Kanabur (1998) and Baswaraj (2019) in sesame. Among different varieties sesame variety V₂ (GT-3) recorded significantly less days to maturity (79.88 days) than other varieties (GT-2, GT-5 and GT-6). Maximum number of days to maturity was reported in variety GT-5 (V₃) (83.58, 96.04 and 89.81 days) on pooled basis. The results were accordance with those reported by Singh *et al.* (1994) and Tan (2011) in sesame.

Variety GT-2 (V₁) showed maximum number of branches per plant (2.20) in pooled results. This might be due to varietal performance to *summer* and *kharif* growing period in prevailing environmental condition. These results were in accordance with Tiwari *et al.* (1994) in sesame. Variety GT-3 (V₃) recorded maximum number of capsules per plant (60.08) in pooled basis. This was might be due to less flower drop and more fruit setting. Similar results have been found by Tembhurne and Dharai (2007) in sesame. The maximum number of seed per capsule (70.87) was recorded in V₃ (GT-5) on pooled basis. This might be due to varietal genetical characters. These results obtained in present investigation were in line with the findings of Narayan and Narayanan (1987) and Kathiresan and Gnanamoorthy (2001) in sesame.

Significantly higher seed yield per plant (12.35 g/plant) was recorded in the variety GT-5 (V₃). This found might be due to varietal characters like plant height, number of branches per plant, number of capsules per plant and number of seeds per capsules are ultimately lead to produce more seed yield per plant in sesame. Similar kind of results were also reported by Narayan and Narayanan (1987), Singh *et al.* (1994), Tembhurne and Dharai (2007), Tan (2011) and Baswaraj (2019) in sesame. Significantly higher biological yield (g) was recorded in variety GT-5 (V₃) *i.e.* 37.75 (g). This was due to more number of branches plant⁻¹, number of capsules per plant, plant height and other biological characters of plant that helped in production of more biological weight of plant. Similar findings was supported by Baswaraj (2019) in sesame. Variety V₃ (GT-3) recorded higher (3.58 g) 1000 seed weight among all varieties. This was might be due to varietal genetical characters and prevailing environmental condition. Similar kind of results was also reported by Tan (2011) in sesame. Among all the varieties variety V₁ (GT-2) recorded significantly higher harvest index (32.36 %). This was due to

maximum seed yield and straw yield. The results are in conformity with the work of Kanabur (1998) and Baswaraj (2019).

Germination (%) and seedling vigor index-I were found non significant in on the pooled basis but in case of individual season base it was found significant. This might be due to presence of seed dormancy and varietal genetic characteristics. Variety V₃ (2391.82) was higher in SVI-II. Variety V₃ (GT-5) was found higher moisture content (9.20 %). The reason behind this might be that varietal genetic characters, presence of dormancy and seed health status of seed in given environmental condition. The same findings were supported by Suhasini (2006) and Ajala *et al.* (2007) in sesame.

Effect of spacing : Significant difference (Table-1) was recorded with respect to different spacing treatment several characters like, days to flower bud initiation, days to flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, number of seeds per capsule, seed yield per plant (g), biological yield (g) and harvest index (%). Non significant difference was observed in 1000 seed weight (g), germination (%), seedling vigor index I, seedling vigor index II and moisture content (%).

Significantly lower days to flower bud initiation was recorded in S₂ (28.28 days) and spacing treatment S₁ (29.26 days) was found at par with S₂. The lower number of days to flowering was noted in spacing S₂ (30 x 15 cm²) on pooled basis (38.54 days). Significantly lowest number of days to maturity (82.49 days) was recorded in spacing treatment S₂ on pooled results. This was found might be due to narrow spacing, more spaced plants get more sunlight and nutrients were available for plants as compared to narrow spaced plants, so it get longer period for vegetative and reproduction period and hence less days to flower bud initiation, days to flowering and days to maturity was seen as compared to narrow spacing. The results were in harmony with Elobied (2010), Monpara and Vaghasia (2016) and Shah *et al.* (2020) in sesame.

Significantly maximum plant height (77.17 cm) was observed in spacing 60 x 15 cm². The plant height increased with increase in spacing between rows. This might be due to relatively competition free environments prevail, hence more availability of nutrients, greater light interception, efficient utilization of soil moisture and space under lower degree of inter-plant competition in wider space. In narrow row spacing more competition among the plants for sunlight, other nutrients and diversion of energy. Similar results were also obtained by Sivagamy and Rammohan (2013), Valiki *et al.* (2015) and Kithan and Singh (2017) in sesame.

Significantly more number of branches (2.02) were recorded with the spacing of 60 x 15 cm². Enhanced mean number of branches over remaining spacing owing to better geometric arrangement resulting in better absorption of moisture and nutrient due to less competition exerted for light, moisture and nutrients. Sufficient interception of sunlight promotes efficient photosynthesis activities and ultimately greater accumulation of photosynthates under wider spacing. Narrow spacing with dense plant population resulted in the lower values of yield attributes and also agreement with the resulting of Rajpurohit *et al.* (2017), Unde *et al.* (2018) and Shah *et al.* (2020) in sesame.

Significantly higher number of capsules per plant (59.07) was observed in spacing treatment 60 x 15 cm² then other spacing treatments. The reason behind this might be that wider spacing registered more plant height and branches per plant which enhanced the number of capsules per plant. High plant population reduced both the number of capsules and the number of seeds per capsule. These findings were in close agreement with the results of Narayan and Narayanan (1987), Elobied (2010), Sivagamy and Rammohan (2013) and Modu and Mustapha (2021) in sesame.

Significantly higher number of seeds per capsule registered with spacing treatment S₃ (60 x 15 cm²) *i.e.* 64.39 seeds/capsule. This was might be due to reduction in row spacing increased intra-specific competition which finally caused a decrease in the number of seeds per capsules compared with wider spacing. These findings were in close agreement with the results of Jan *et al.* (2014), Valiki *et al.* (2015) and Ali *et al.* (2020) in sesame. 1000 seed weight revealed that there was no significant difference between different spacing treatments. Such non significant effect of spacing on 1000 seed weight was observed by several workers like, Jan *et al.* (2014) and Valiki *et al.* (2015) in sesame.

Spacing treatment S₃ (60 x 15 cm²) recorded higher seed yield per plant (11.47 g/plant) then other spacing treatment. This might be attributed to more number of branches, more number of capsules, and higher plant height under wider spacing which might have helped in better translocation of nutrients towards yield attributes. Crop geometry of wider spacing of was found to enhance more yield which may be due to wider inter-row spacing thus, giving a better chance for the plant to grow with lesser competition for space and better absorption of light and nutrients thus, sufficient interception of sunlight resulting in efficient photosynthesis activities and ultimately greater accumulation of photosynthates of the plant and thereby, resulting in better manifestation of yield attributes under wider spacing. This finding was in

accordance with the recommendation of Elobied (2010), Sivagamy and Rammohan (2013). Jan *et al.* (2014), Patel *et al.* (2014), Valiki *et al.* (2015), Monpara and Vaghasia (2016), Patel (2016), Kithan and Singh (2017), Rajpurohit *et al.* (2017), Ali *et al.* (2020), Shah *et al.* (2020) and Modu and Mustapha (2021) in sesame.

Maximum biological yield (35.43 g/plant) was recorded with the spacing (60 x 15 cm² S₃) which was significantly higher over other spacing treatments in both the season. This could be explained in light of increased plant height under wider spacing which provided more space for plant height, number of branches per plant, setting more number of capsules and also increased biological yield. These finding corroborate the reports of Jan *et al.* (2014), Patel (2016), and Shah *et al.* (2020) in sesame.

Significantly higher (31.10 %) harvest index was pointed in spacing S₃ (60 x 15 cm²). This was finding might be due to harvest index is correlated with grain yield and biological yield therefore increase in grain yield increase harvest index. Optimum plant population and had more chance to get nutrients and ultimately get more branches, capsules, seeds per capsules and more yield per plant which directly increase harvest index of sesame. Similar findings were supported by Jan *et al.* (2014) and Badshah *et al.* (2017) in sesame.

Non significant effect of spacing was noted in the seed quality characters of sesame. Germination per cent of different spacing treatment was found non significant in pooled analysis. Seedling vigor index I and seedling vigor index II failed to show the significant difference of different spacing treatments in pooled basis. The seed moisture content (%) also did not show any significant difference in different spacing treatment of sesame on pooled basis. This result indicate that the effect of different spacing treatment was uniform in all seed quality parameters.

Interaction effect

Interaction effect of variety and spacing on days to flower bud initiation : Significantly the higher number of days to flower bud initiation (32.08 days) was obtained in treatment combination V₄S₃ (GT-6 and 60 x 15 cm²) over other treatment combinations except treatment combination V₂S₃, V₂S₁, V₄S₁, V₄S₂ and V₃S₃ (Table-2).

Table-2 : Interaction effect of variety and nipping (V×S) on days to flower bud initiation.

Treatments Spacing	V x S interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	25.14	30.63	29.88	31.41	29.26
S ₂	23.96	29.96	29.17	30.45	28.38
S ₃	25.68	31.67	30.76	32.08	30.05
Mean	24.02	30.75	29.93	31.31	
SEm ±			0.67		
CD (P = 0.05)			1.87		

Interaction effect of variety and spacing on days to flowering : Significantly more number of days to flowering (46.32 days) was obtained under treatment combination V₂S₃ (variety GT-3 and spacing 60 x 15 cm²) as compared to other treatments combinations and it remained statistically at par with the treatment combination V₂S₁ on pooled basis (Table-3).

Table-3 : Interaction effect of variety and spacing on days to flowering.

Treatments Spacing	V x S interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	36.89	44.70	41.97	42.14	41.42
S ₂	33.50	41.64	39.25	39.75	38.54
S ₃	38.05	46.32	43.39	42.84	42.65
Mean	36.14	44.22	41.54	41.58	
SEm ±			0.81		
CD (P = 0.05)			2.26		

Interaction effect of variety and spacing on days to maturity : The treatment combination V₃S₃ (variety GT-5 and spacing 60 x 15 cm²) was recorded significantly higher (92.55 days) over the other treatment combinations V₃S₁, V₃S₂ and V₄S₃ (Table-4).

Table-4 : Interaction effect of variety and spacing (V x S) on days to maturity.

Treatments Spacing	V x S interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	83.39	78.77	88.85	87.26	84.57
S ₂	83.49	78.57	88.04	84.69	83.70
S ₃	86.79	82.29	92.55	87.70	87.33
Mean	84.55	79.88	89.81	86.55	
SEm ±			1.74		
CD (P = 0.05)			4.86		

Interaction effect of variety and spacing on plant height (cm) : Significantly higher plant height (88.16 cm) was obtained under treatment combination V₄S₃ (GT - 6 and 60 x 15 cm²) as compared to other treatments and it remained statistically at par with the treatment combination V₄S₁, V₄S₂, V₁S₃, V₁S₁ and V₁S₂ on pooled basis in the interaction effect between variety and spacing (Table-5).

Table-5 : Interaction effect of variety and spacing (V x S) on plant height (cm)

Treatments Spacing	V x S interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	79.58	68.92	63.92	86.16	74.65
S ₂	76.91	66.58	61.71	84.49	72.47
S ₃	82.04	71.84	66.63	88.16	77.17
Mean	79.71	69.11	64.15	86.27	
SEm ±			3.91		
CD (P = 0.05)			13.53		

Interaction effect of season and variety on plant height (cm) : In the interaction between season and variety, the variety V_4 (GT - 6) was found significantly higher (102.00 cm) plant height in *kharif*-2019 over the other E x V combination (Table-6).

Table-6 : Interaction effect of season and variety (E x V) on plant height (cm).

E x V interaction			
Treatments	Season		
	Variety	Summer-2019	Kharif-2019
V_1		62.87	96.15
V_2		55.54	82.69
V_3		57.42	70.89
V_4		70.54	102.00
Mean		61.59	87.93
SEm $\pm$			1.46
CD (P = 0.05)			4.08

Interaction effect of season, variety and spacing on plant height (cm) : Significantly maximum plant height (Table-7) registered in treatment combination $E_2V_4S_3$ (104.58 cm) over rest of the variety, spacing and season combinations except $E_2V_4S_1$, $E_2V_4S_2$ and $E_2V_1S_3$.

Table-7 : Interaction effect of season, variety and spacing (E x V x S) on plant height (cm).

E x V x S interaction										
Treatments		Summer-2019					Kharif-2019			
		Variety				Mean	Variety			
Spacing		V_1	V_2	V_3	V_4		V_1	V_2	V_3	V_4
S_1		62.75	55.34	57.07	70.25	61.35	96.41	82.50	70.76	102.06
S_2		61.12	53.80	56.03	69.63	60.15	92.69	79.37	67.79	99.35
S_3		64.74	57.50	59.15	71.75	63.28	99.34	86.18	74.11	104.58
Mean		62.87	55.54	57.42	70.54		96.15	82.69	70.89	102.00
SEm $\pm$						2.57				
CD (P = 0.05)						7.07				

Interaction effect of season and variety on number of branches per plant : The treatment combination *Kharif*-2019 (E_2) and V_1 (GT-2) variety recorded the significantly higher number of branches per plant (2.80 branches/plant) over rest of the treatment combinations except E_2V_3 (2.71 branches/plant) in the interaction between season and variety on number of branches per plant in sesame (Table-8).

Table-8 : Interaction effect of season and variety (E x V) on number of branches per plant

E x V interaction			
Treatments	Season		
	Variety	Summer-2019	Kharif-2019
V_1		1.60	2.80
V_2		1.46	2.58
V_3		1.50	2.71
V_4		1.05	1.79
Mean		1.40	2.47
SEm $\pm$			0.04
CD (P = 0.05)			0.11

Interaction effect of season and spacing on number of branches per plant : Significant interaction was observed (Table-9) between season of experimentation and spacing (E x S) on number of branches per plant of sesame. The spacing S_3 (60 x 15 cm²) was found significantly higher (2.54 btanches/plant) in *kharif*-2019 (E_2) over other spacing except E_2S_1 .

Table-9 : Interaction effect of season and variety (E x V) on number of branches per plant

E x V interaction			
Treatments	Season		
	Variety	Summer-2019	Kharif-2019
S_1		1.42	2.48
S_2		1.35	2.39
S_3		1.43	2.54
Mean		1.40	2.47
SEm $\pm$			0.04
CD (P = 0.05)			0.10

Interaction effect of variety and spacing on number of capsules per plant : The treatment combination V_3S_3 (GT - 5 and 60 x 15 cm²) recorded significantly higher

number of capsules per plant (64.17) as compared to other treatment combinations in interaction effect of V x S on the number of capsules per plant in pooled basis.

Table-10 : Interaction effect of variety and spacing (V x S) on number of capsules per plant.

V x S interaction					
Treatments	Variety				
	Spacing	V_1	V_2	V_3	V_4
S_1		49.91	52.59	59.83	57.30
S_2		45.67	48.69	56.25	54.06
S_3		54.01	57.15	64.17	60.93
Mean		49.86	52.81	60.08	57.43
SEm $\pm$				1.01	
CD (P = 0.05)				2.81	

Interaction effect of variety and spacing (V x S) on number of seeds per capsules : The treatment combination V_3S_3 (variety GT-5 and spacing 60 x 15 cm²) was recorded significantly higher (72.79) while, treatment combination V_3S_1 and V_3S_2 (70.98 and 68.85) were found

at par with over other treatment combinations with V_3S_3 , respectively in the interaction of variety and spacing on number of seeds per capsules (Table-11).

Table-11 : Interaction effect of variety and spacing (V x S) on number of seeds per capsules.

Treatments Spacing	V x S interaction				
	Variety				
	V ₁	V ₂	V ₃	V ₄	Mean
S ₁	62.12	54.23	70.98	63.73	62.76
S ₂	59.33	51.77	68.85	61.94	60.47
S ₃	63.68	56.25	72.79	64.83	64.39
Mean	61.71	54.08	70.87	63.50	
SEm ±			1.65		
CD (P = 0.05)			4.61		

Interaction effect of variety and spacing on seed yield per plant (g) : Treatment combination V_3S_3 recorded significantly higher seed yield per plant (14.10 g/plant) as compared to rest of the treatment combinations in the interaction between variety and spacing (Table-12).

Table-12 : Interaction effect of variety and spacing (V x S) seed yield per plant.

Treatments Spacing	V x S interaction				
	Variety				
	V ₁	V ₂	V ₃	V ₄	Mean
S ₁	9.99	7.69	12.03	10.14	9.96
S ₂	7.87	6.29	10.91	9.74	8.70
S ₃	11.37	9.72	14.10	10.68	11.47
Mean	9.74	7.90	12.35	10.18	
SEm ±			0.32		
CD (P = 0.05)			0.89		

Interaction effect of season and spacing (ExS) on seed yield per plant (g) : The spacing S_3 (60 x 15 cm²) with season *Summer-2019* (E₁) was found significantly higher (13.22 g/plant) seed yield in the interaction between season of experimentation and spacing (Table-13).

Table-13 : Interaction effect of season and spacing (ExS) on seed yield per plant (g).

Treatments Variety	E x S interaction		
	Season		
	Summer-2019	Kharif-2019	Mean
S ₁	11.50	8.42	9.96
S ₂	10.18	7.22	8.70
S ₃	13.22	8.97	11.09
Mean	11.63	8.20	
SEm ±		0.23	
CD (P = 0.05)		0.63	

Interaction effect of variety and spacing on biological yield (g) : Treatment combination V_3S_3 (GT-5 and 60 x 15 cm²) recorded significantly higher biological yield (40.89 g/plant) as compared to rest of the treatment combinations except V_3S_1 and V_4S_3 in the interaction between variety and spacing on pooled basis.

Table-14 : Interaction effect of variety and spacing (V x S) on biological yield (g).

Treatments Spacing	V x S interaction				
	Variety				
	V ₁	V ₂	V ₃	V ₄	Mean
S ₁	32.98	28.93	37.61	34.45	33.49
S ₂	29.34	27.23	34.76	32.72	31.01
S ₃	34.39	31.00	40.89	35.42	35.43
Mean	32.24	29.05	37.75	34.20	
SEm ±			1.88		
CD (P = 0.05)			5.54		

Interaction effect of season, variety and spacing on biological yield (g) : In the interaction between season, variety and spacing, the pooled analyzed data (Table-15) of two seasons indicated that *Kharif - 2019* (E₂) season, spacing 60 x 15 cm² (S_3) with variety GT - 5 (V_3) gave significantly higher biological yield (44.18 g/plant) over rest of the treatment combinations except $E_2V_3S_1$.

Table-15 : Interaction effect of season, variety and spacing (ExVxS) on biological yield (g).

Treatments Spacing	ExVxS interaction				
	Summer-2019				
	V ₁	V ₂	V ₃	V ₄	Mean
S ₁	30.55	26.64	32.92	31.84	30.49
S ₂	27.23	25.91	31.40	30.33	28.72
S ₃	31.54	27.01	37.60	32.90	32.26
Mean	29.77	26.52	33.97	31.69	
SEm ±			1.11		
CD (P = 0.05)					

Contd...

Treatments Spacing	ExVxS interaction				
	Kharif-2019				
	V ₁	V ₂	V ₃	V ₄	Mean
S ₁	35.41	31.23	42.29	37.07	36.50
S ₂	31.45	28.55	38.13	35.11	33.31
S ₃	37.25	34.99	44.18	37.95	38.59
Mean	34.70	31.59	41.53	36.71	
SEm ±			1.11		
CD (P = 0.05)			3.09		

Interaction effect of variety and spacing on 1000 seed weight (g) : It is quite evident from the data (Table-16) that treatment combination V_3S_3 (GT-5 and 60 x 15 cm²) recorded significantly higher 1000 seed weight (3.62 g) as compared to rest of the treatment combinations except treatment combination V_3S_1 and V_3S_2 on pooled basis.

Table-16 : Interaction effect of variety and spacing (V x S) 1000 seed weight (g).

Treatments Spacing	V x S interaction on pooled basis				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	3.41	2.95	3.57	3.10	3.26
S ₂	3.30	2.89	3.56	3.14	3.22
S ₃	3.42	3.03	3.62	3.04	3.28
Mean	3.38	2.95	3.58	3.09	
SEm ±			0.03		
CD (P = 0.05)			0.09		

Interaction effect of variety and spacing on harvest index (%) : It is quite evident from the data (Table-17) that treatment combination V₁S₃ (GT-2 and 60 x 15 cm²) recorded significantly higher harvest index (34.19 %) as compared to rest of the treatment combinations except V₁S₁.

Table-17 : Interaction effect of variety and spacing (V x S) on harvest index (%).

Treatments Spacing	V x S interaction				
	Variety				Mean
	V ₁	V ₂	V ₃	V ₄	
S ₁	32.57	26.63	28.46	30.60	29.56
S ₂	30.33	23.44	28.19	30.26	28.05
S ₃	34.19	30.00	29.21	31.00	31.10
Mean	32.36	26.69	28.62	30.62	
SEm ±			0.96		
CD (P = 0.05)			2.68		

Interaction effect of season and spacing on harvest index (%) : The season E₁ (summer-2019) and spacing S₃ (60 x 15 cm²) was found significantly higher (36.20 %) harvest index among other treatment combination except E₁S₁ in the interaction between season of experimentation and spacing (Table-18).

Table-18 : Interaction effect of season and spacing (E x S) on harvest index (%).

Treatments Variety	E x S interaction		
	Season		Mean
	Summer-2019	Kharif-2019	
S ₁	34.65	24.48	29.56
S ₂	32.73	23.38	28.05
S ₃	36.20	25.09	30.65
Mean	34.53	24.32	
SEm ±		0.68	
CD (P = 0.05)		1.90	

Conclusion

From the results of two season experimentation it can be concluded that the GT-5 variety of sesame along with spacing 60 x 15 cm² were found effective in improving the seed yield and yield component characters of sesame.

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Germplasm Evaluation of Custard Apple (*Annona squamosa* L)

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Abstract

The present investigation "Germplasm evaluation of Custard apple (*Annona squamosa* L)" was carried out during the year 2017 at Fruit Preservation Laboratory, Department of Horticulture, JNKVV, Jabalpur (M.P.) The experimental material for the present investigation was comprised of sixteen germplasm of custard apple collecting from the district of Madhya Pradesh. Among 16 promising significantly the maximum fruit wt, width, volume, pulp weight, rind weight and pulp seed ratio of germplasm JCA5 (363.0g), (1.46), (330.00cc), (55.85g) (69.5g) and (23.89:1). The maximum fruit length, seed wt percent in JCA-7 (85.11cm), (4.315g), and minimum seed wt is observed (5.350) in JCA-3. The maximum TSS, ascorbic acid(mg/100g), Reducing sugar (%), non-reducing sugar (%) and Total sugar (30.90B), (21.60), (5.78%), (1.37%), (22.80%) and minimum acidity (0.125) was recorded under JCA-5.

Key words : Custard apple, TSS, acidity, sugar, Madhya Pradesh.

Introduction

Custard apple (*Annona squamosa* L.) belongs to the family *Annonaceae* and is commonly known as *Sitaphal* in India. The centre of origin of custard apple is tropical America from where it has spread to different parts of the world (Rathore, 1990). In India, custard apple is grown in an area of 53,000 ha (Shanmughavelu, 1987) in Andhra Pradesh, Tamil Nadu, Maharashtra, Orissa and other states. Andhra Pradesh tops in area and production in the country. Madhya Pradesh rank third in production 33.99 Tones (20.58%) after Chhattisgarh 36.65 Tones. (NHB 2013-14). *Annona* fruits grow well throughout the plains of India at elevations not exceeding 4,000 ft. It prefers a tropical climate, but with cool winters. The fruit tolerates a variety of conditions, from saline soils to droughts. Farmers usually cultivate the fruits on hills in barren lands. Erratic rains will, however, impede fruit quality. It is usually propagated by grafting a selected scion variety on to a rootstock and planted mostly in rainy season. In forest, it grows naturally through seeds. The species thrives well under dry conditions in marginal soil, wastelands and can tolerate light to gravelly soils.

The fruit is mostly used as a dessert for its delicious taste and nutritive values. The pulp is creamy, custard like, granular with a good blend of sweetness and acidity. The tree displays yellow trumpet shaped flowers that emit a pleasant sweet smell, with only a small number of flowers setting fruit. The fruits are variable in shape with the outer being covered in rounded knobs, with the inside containing a custard like flesh, pleasant flavor and mild aroma of the fruit have a universal liking. It is an excellent

source of carbohydrates (23.5%), protein (1.6 %), minerals (0.9 %), and vitamin C (37mg/100gm) (Gopalan, *et al*, 1987). The unripe fruits, seed, leaf and root are used to destroy insect and lice. The oven dried kernels of seeds are found to contain 30% of oil.

Custard Apple is full of vitamin C anti-oxidants, which helps to combat many diseases and also enhances the immune system. Custard apple is abundant with potassium, magnesium and contains vitamin A, calcium, copper, fiber and phosphorous. It has high calorific value, able to provide sustained energy and delicious in nature. The luscious fruit is eaten throughout the world. Eating custard apple will help you to save from many diseases and disorders. The fruit is good for heart, skin, and bone, and maintains blood pressure. Custard apple is also helpful in curing of boils, ulcers and gum related problems. The leaves of this fruits work against cancer and bark can be used in case of toothache and gum pain.

Materials and Methods

An extensive survey was undertaken across two districts (Chhindwara and Sehore) of Madhya Pradesh, during fruiting season of 2017 to identify elite types of germplasm among its population. carried out and 15 elite types were collected on the basis of morphological characters. Chemical analysis was done in the Post Harvest Laboratory, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur. Chemicals and processing equipments: Most of the chemicals used in this investigation were of analytical grade. Equipments and chemicals were obtained from Fruit Preservation Laboratory, Department of Horticulture, JNKVV, Jabalpur (M.P.)

Table-1 : Observation on physical composition of different germplasms of custard apple.

Germplasm	Average fruit Weight (g)	Length of fruit (cm)	Width of fruit (cm)	Volume of fruit (cc)	Rind Weight (g)	Seed weight/ fruit (g)	No. of seeds/ fruit	Seed weight (%)	Pulp weight (%)	Pulp seed ratio
JCA 1	263.000	70.200	78.975	215.000	105.600	19.100	41.500	7.255	53.995	7.090
JCA 2	197.500	74.670	74.615	167.500	107.500	19.300	37.500	6.560	47.625	10.950
JCA 3	187.000	63.545	77.200	103.500	88.550	5.350	14.000	2.730	41.270	8.550
JCA 4	255.000	75.705	80.345	225.000	106.000	17.750	32.500	7.029	50.540	7.285
JCA 5	363.000	77.400	91.460	330.000	69.500	23.350	57.500	10.450	55.850	23.890
JCA 6	250.000	78.465	78.515	220.000	96.300	15.850	19.000	6.385	53.780	8.480
JCA 7	296.500	85.110	82.815	230.000	153.500	16.500	30.000	4.315	55.535	11.755
JCA 8	221.500	74.705	71.350	185.000	89.350	25.400	64.500	12.965	41.460	3.985
JCA 9	138.000	44.000	62.500	102.500	75.350	7.650	18.500	5.245	43.720	3.860
JCA 10	221.750	63.000	73.965	165.000	89.250	13.500	40.000	5.880	41.655	7.920
JCA 11	233.000	71.100	69.000	217.500	113.000	19.500	52.000	8.395	39.205	4.625
JCA 12	227.500	66.000	67.050	190.000	95.250	16.500	38.000	7.850	48.540	6.965
JCA 13	192.750	67.500	75.000	166.500	91.000	11.000	31.500	5.730	44.755	6.325
JCA 14	170.500	55.000	74.290	159.500	83.500	7.500	22.500	4.520	43.455	9.950
JCA 15	165.000	49.550	67.710	151.000	91.500	13.500	35.500	8.255	52.950	6.895
JCA 16	186.250	55.330	76.290	172.000	84.900	14.100	39.500	7.260	46.790	6.355
CD at. 5%	79.877	18.383	12.808	92.812	31.696	8.961	21.561	3.725	N/A	7.203

Table-2 : Observation on chemical composition of different germplasm of custard apple.

Germplasm	T.S.S. (°Brix)	Acidity (%)	Ascorbic acid (mg/100 g)	Reducing sugar (%)	Nonreducing sugar (%)	Total sugar (%)
JCA 1	23.100	0.240	20.750	3.890	14.820	18.710
JCA 2	29.200	0.160	20.900	5.650	16.240	22.020
JCA 3	23.050	0.140	14.300	3.620	14.340	17.960
JCA 4	26.550	0.230	15.400	3.440	12.320	22.810
JCA 5	30.900	0.125	21.600	5.780	19.370	22.980
JCA 6	26.500	0.185	18.350	5.630	13.335	18.960
JCA 7	22.050	0.195	16.700	3.000	14.505	17.510
JCA 8	29.600	0.255	16.800	4.750	13.725	17.180
JCA 9	30.100	0.210	16.800	5.180	11.890	17.180
JCA 10	28.750	0.200	19.900	5.050	17.640	17.080
JCA 11	26.950	0.205	13.900	2.940	11.430	16.460
JCA 12	20.300	0.275	17.800	3.000	19.030	21.980
JCA 13	25.900	0.215	18.000	5.430	15.310	18.710
JCA 14	25.250	0.225	17.800	4.320	15.955	20.000
JCA 15	29.900	0.240	18.500	3.470	17.900	21.140
JCA 16	30.750	0.170	20.600	3.310	17.285	21.980
CD at. 5%	0.940	0.046	2.386	0.902	2.626	1.732

Physical characteristics of custard apple

Weight of fruit (g) : The weight of individual fruit was recorded on electronic balance and average weight of fruit calculated in grams.

Number of seeds per fruit : The seeds, which were embodied in flesh, were separated and counted from each fruit.

Weight of seed per fruit (g) : The seeds which were separated for taking its count were weighed on electronic balance in grams.

Weight of rind (g) : Rind of fruit including the stem end impregnated in fruit pulp was separated from its pulp and seeds by manual labor and weights were recorded on electronic balance.

Weight of pulp (g) : For calculating weight of pulp, sum of weight of rind and weight of seed was subtracted from weight of fruit.

Length and Width of fruit (cm) : For calculating length and Width of fruit, sum of length and Width of fruit were recorded by *Vernier Caliper*.

Chemical Properties of Custard Apple

(1) Total soluble solids (T.S.S.) : The total soluble solids of the fruit juice was determined by using a Zeis Refractometer of 0-30 percent range. The values were corrected at 20°C and expressed as percent total soluble solids of the fruit juice (A.O.A.C., 1990).

(2) Titratable Acidity : Acidity was estimated by simple acid-alkali titration method as described in A.O.A.C. in 1984. Took 20 ml of fruit juice solution by pipette and transferred into a 100ml flask, added distilled water to make up the volume up to 100ml and shaken well to dissolve 25 ml of diluted fruit juice was taken by pipette and transferred it into a 250ml beaker. Added 3 drops of phenolphthalein indicator to the solution. Filled the burette with N/10 NaOH solution and titrated the juice with alkali solution, drop by drop with constant stirring till the pink end point was reached. Each point readings (3 to 4) were recorded and the percentage acidity was calculated by the formula and expressed in terms of citric acid.

$$\text{Titrateable acidity (\%)} = 0.128 \times \text{titrate value}$$

(3) Ascorbic Acid content :

Estimation of ascorbic acid was performed following per-assay method given by AOAC (1984).

Preparation of 3% Metaphosphoric Acid

Solution of oxalic acid 3% : Sticks or pellets of oxalic acid 15 g were dissolved in 500 g distilled water.

Standard ascorbic acid : L-ascorbic acid 100 g was dissolved in 3% oxalic acid solution at the volume 100 ml. An aliquot of 1 ml was further diluted to 10 ml with 3% oxalic acid which yielded a solution as 1 ml = 0.1 mg ascorbic acid

Dye solution : Salt of 3, 6-dichloro-phenol-indophenol 52 mg was dissolved in 150 ml hot distilled water containing 42 mg sodium carbonate. After cooling it was further diluted to 200 ml with distilled water and stored in refrigerator and standardized every day before use.

Standardization of dye : In 5 ml of standard ascorbic acid solution 5 ml of oxalic acid was added. A microburette was filled with the dye solution. Standard ascorbic acid was titrated against the dye solution to the pink colour, which persisted for 15 seconds. The readings were instantly recorded. Milligram of ascorbic acid consumed per ml of dye was employed to determine the dye factor as follow :

$$\text{Dye factor} = \frac{0.5}{\text{Titrate value}}$$

Preparation of sample : Sample 10 g was blended with 3% oxalic acid and the volume was made up to 100 ml with 3% oxalic acid. Then it was filtered.

Assay of ascorbic acid : An aliquot 10 ml of the sample was taken and titrated against the standard dye to end point of pink colour, which persisted for 15 seconds. The reading was recorded instantly. Ascorbic acid content of sample was calculated by using the following formula :

$$\text{Titrate reading} \times \text{dye factor} \times \text{vol. made up}$$

$$\text{Ascorbic acid}$$

$$= \frac{\text{Titrate reading} \times \text{dye factor} \times \text{vol. made up}}{(5\text{g / guava}) \text{ Vol. of sample} \times \text{sample wt.}} \times 100$$

Results and Discussion

The data on physical parameter such as average fruit wt. (g), Length of fruit (cm), width of fruit (cm), volume of fruit (cc) Rind wt (g) Pulp wt. (%) Pulp Seed Ratio, Seed wt (%), Seed wt /Fruit (g) and No. of Seed per fruit were presented in Table 01. The germplasm JCA5 recorded maximum fruit wt. (363.0g) followed by JCA7 (26.50) and they were statistically at par with each other, while the minimum (135.0g) was recorded in JCA-9. Shukla et al (2006) was also reported the similar result. The length of fruit was noticed maximum (85.11cm) in germplasm JCA-7 and minimum in germplasm JCA-9 whereas maximum fruit width (1.46) was recorded in germplasm JCA-5 by JCA-7 (82.81cm) and JCA-4 (80.345cm) and they were statically at par with each other and significantly superior over rest of the germplasm. The results are recorded with Shukla et al (2006). And Beerh et al (183). The maximum fruit volume (330.00cc) was found in germplasm JCA-5, which was statistically superior over all the other germplasm. The similar result has been reported in wood apple by Pandey et. al. 00(02013). The maximum rind weight (153.50g) was recorded in germplasm JCA-7 while minimum rind wt. (69.50g) was recorded in germplasm JCA-5. Good quality germplasm should possess less rind weight. The average weight ranges from 5.35 to 25.40g. The maximum seed wt. (25.40g) was recorded in germplasm JCA-4, while the minimum seed wt (5.35g) was recorded in JCA-7. The maximum seed weight percentage (12.96) was recorded in JCA-4 and minimum (4.31) in JCA-7. The maximum pulp weight percentage (55.85) was observed in germplasm JCA-5 while minimum was recorded in JCA-11 (3.20). However, difference among these was found statistically insignificant. The highest pulp seed ratio (23.89:1) was recorded in JCA-5, while lowest pulp seed ratio (3.26:1) was recorded in JCA-4.

The data on chemical composition of fruit such as TSS ($^{\circ}$ Brix), Acidity (%), Ascorbic acid (mg/100g), Reducing sugar (%), Non-reducing sugar (%) and Total sugar percent in table 2.0. The TSS of fruit ranged between 20.30 to 30.90 ($^{\circ}$ Brix). The maximum TSS (30.90B) was recorded in germplasm JCA-5 followed by JCA-9 (30.10B) and they were statistically at par with each other. The minimum TSS (20.30B) was recorded in JCA-12. These finding are collaborated with Beerh et. al. (1983). The maximum acidity (0.275) was recorded under JCA-12, whereas minimum (0.125) was recorded in JCA-5. The maximum ascorbic acid (21.60mg/100g) was recorded under JCA followed by JCA-2 (20.90mg/100g) and JCA-1 (20.75mg/100g). The difference among these germplasm was insignificant. The minimum ascorbic acid (13.90mg/100g) was recorded in JCA-11. Similar result has been reported in wood apple by Pandey et. al. (2013). The reducing sugar in different germplasm ranged between 2.4 and 5.78%. The maximum reducing sugar (5.78%) was recorded under JCA-5 followed by JCA-2 (5.65%) and difference among these was found statistically insignificant. The minimum reducing sugar (2.94%) was recorded under JCA-11. The maximum non-reducing sugar (1.37%) was recorded under JCA-5 followed by JCA-12 (19.03%), JCA-15(17.90%), JCA-10 (17.64%) and JCA –15(17.28%). However, difference among these germplasm was found statistically insignificant. The minimum non-reducing sugar (11.43%) was recorded in JCA-11. The data percentage total sugar indicated that these were significant difference among the germplasm with respect to total sugar. Significantly highest total sugar as (22.80%) recorded in germplasm JCA-5 and lowest (16.46%) was recorded in JCA-11.

On the basis of overall performance it can be concluded that the custard apple germplasm JCA-5 was found out standing for most of the fruit. Now therefore, it may be recommended for most of the fruits. Now therefore, it may be recommended for commercial production to the growers.

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Response of Wheat (*Triticum aestivum* L.) to Zinc and Boron Fertilization

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Abstract

The study was carried out on Effect of Zinc and Boron in Wheat (*Triticum aestivum* L.) during *rabi* season of 2018-2019 at the agriculture farm of IFTM University, Lodhipur Rajput, and Moradabad (U.P). Ten treatments combinations were comprised in randomized block design (RBD) with the three replications. The treatments T₁₀ [(Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA))] was observed significant increase in all growth attributes viz., plant height (cm), number of tillers/plant, dry weight (g/plant) and as well as on yield and yield attributed such as number of spikes/ plant, number of grains/spike, 1000 - seed weight (g), grain yield (q/ha), straw yield (q/ ha), biological yield (q/ha), and B: C ratio respectively over rest of the treatments significantly highest plant height (107.20 cm), maximum number of tillers/plant (6.40) and highest dry matter accumulation (19.37 g) at harvesting stage was found in T₁₀ [(Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA))]. And yield attributes such as maximum number of spikes/plant (5.65), maximum number of grain/spike (60.33), maximum 1000 - seed weight (40.12g), maximum grain yield (58.23 q/ha), maximum straw yield (65.72 q/ha), maximum biological yield (123.95 q/ha) and maximum B: C Ratio (Rs/ha) (2.77) respectively was recorded from T₁₀ [(Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA))].

Key words : Wheat, zinc, boron, soil application, foliar application

Introduction

Wheat (*Triticum aestivum* L.) is number one cereal of the world and is grown on the largest area. The global area under wheat in 2009 was 226 million ha as compared to 158 million ha under rice. As regards global production, it is next only to maize; in 2009, 686 million tonnes was produced as compared to 819 million tonnes of maize and 685 on tonnes of paddy or unhulled rice. The highest per hectare yield of 7.9 tonnes/ha in 2009 was obtained in UK, followed by 7.8 tones/ha in Germany, 7.5 tonnes/ha in France and 4.7 tonnes/ha in China. In India the average yield of wheat in 2009 was only 2.9 tonnes/ha; it was almost the same in USA (1). Wheat is known to respond to the application of several macro and micronutrients during its growing stages and results in enhanced output in terms of yield (2). Due to increased cropping intensity, higher application of NPK through inorganic sources, use of more nutrients responsive and high yielding varieties etc. the problem of micronutrients deficiency has arisen in wheat crop in almost all parts of the country. As per practical experience presently deficiency of zinc and boron in standing wheat crop is very common in soils of Central India. Zinc was one of the first micronutrients, essentiality of which for plant growth has been confirmed. Zinc is essential for the normal healthy growth and reproduction of plants and plays a key role as a structural constituent or regulatory co-factor of a wide range of enzymes in many important biochemical pathways (3).

Zinc is an important element for terrestrial life since it is required as either a structural component or reaction site in numerous proteins. Zinc deficiency in wheat resulted in sever reduction in growth, grain yield and seedling vigour, and enhances sensitivity of plants to pathogens. Decrease in grain quality is another typical consequence of zinc deficiency in wheat (4). Zinc also plays a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen, as well as in seed formation. Decrease in grain quality is another typical consequence of zinc deficiency in wheat. While in case of boron it is also an essential micronutrient for crop like wheat. It plays a vital role in the physiological process of wheat plant such as cell elongation, cell maturation, sugar translocation, development of meristematic tissues, protein synthesis and ribosome formation (5). Boron is also one of the seven essential micronutrients required for the normal growth of most of the cereal, fruit and vegetable crops. It is the only non-metal among the seven plant micronutrients and also influences cell development and elongation. Boron affects carbohydrates metabolism and plays a role in amino acid formation and synthesis of proteins. Deficiency of boron can also cause reduction in crop yield and inferior crop quality. Boron is an essential plant food element, having a specific role in growth and development of plants. The requirement of boron varies greatly between crops and cultivars and between soil and climatic conditions. Boron is unique among the essential

Table-1 : Growth parameters of wheat as influenced by zinc and boron fertilization.

Treatments	Plant height (cm)	No. of tillers/plant	Dry matter accumulation (g/plant)
T ₁ - control	88.25	4.95	9.33
T ₂ - 5 kg Zn/ha (SA)	95.15	5.55	12.52
T ₃ - 1 kg Zn/ha (FA)	91.26	5.35	10.33
T ₄ - 1 + 1 kg Zn/ha (two FA)	97.05	5.84	14.39
T ₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA)	101.50	6.10	17.50
T ₆ - 0.5 kg B/ha (SA)	96.25	5.75	13.25
T ₇ - 0.1 kg B/ha (FA)	92.78	5.60	11.25
T ₈ - 0.1 + 0.1 kg B/ha (two FA)	99.23	6.00	15.93
T ₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA)	104.15	6.25	18.14
T ₁₀ - 5 kg Zn/ha (SA) + 0.5 kg B/ha (SA)	107.20	6.40	19.37
SE(m)±	1.45	0.08	0.09
C.D. at 5%	4.35	0.22	0.25

SA – Soil Application, FA – Foliar Application

Table-2 : Yield attributes of wheat as influenced by zinc and boron fertilization.

Treatments	No. of spikes/plant	No. of grains/spike	1000 seed weight (g)
T ₁ - control	3.33	48.68	36.85
T ₂ - 5 kg Zn/ha (SA)	4.12	54.14	38.10
T ₃ - 1 kg Zn/ha (FA)	3.67	52.24	37.15
T ₄ - 1 + 1 kg Zn/ha (two FA)	4.33	54.93	38.24
T ₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA)	5.12	56.54	39.25
T ₆ - 0.5 kg B/ha (SA)	4.10	54.00	38.23
T ₇ - 0.1 kg B/ha (FA)	4.00	53.80	37.60
T ₈ - 0.1 + 0.1 kg B/ha (two FA)	4.60	56.13	39.11
T ₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA)	5.33	58.33	39.52
T ₁₀ - 5 kg Zn/ha (SA) + 0.5 kg B/ha (SA)	5.65	60.33	40.12
SE(m)±	0.07	0.83	0.49
C.D. at 5%	0.22	2.47	1.47

SA – Soil Application, FA – Foliar Application

mineral micronutrients because it is the only element that is normally present in soil solution as non-ionized molecule over the pH range suitable for plant growth. Boron is involved in the transport of sugars across cell membranes and in synthesis of cell wall material. It influences transportation through the control of sugar and starch formation. It also influences cell development and elongation (6).

Imbalanced use of chemical fertilizers by the farmers has deteriorated soil health. The widely practiced rice-wheat system in northern India is one such instance, where sustainability is under threat. However, it is the most productive and profitable system. To curb this trend of declining yield, there is a need to adopt the concept of INM. Micronutrients such as zinc, boron manganese, Molybdenum, copper, iron and chlorine are important components of INM and may help to recover the soil health in the cropping system.

Methods and Materials

A field experiment was conducted at the Agricultural Research farm of IFTM University, Moradabad (U.P.) during *rabi* 2018-19 under irrigated conditions. The

experimental farm is situated at 28°21' N latitude, 78° 4' E longitude and 193.23 m above mean sea level. The soil of the experimental site was sandy loam in texture and low in organic carbon content (0.38%). The pH of the soil was 7.4 and determined in soil water suspension in the ratio of 1:2.5 with glass electrode pH meter. The experiment comprised of ten treatments of zinc and boron [T₁ - control, T₂ - 5 kg Zn/ha (soil application), T₃ - 1 kg Zn/ha (foliar application), T₄ - 1 + 1 kg Zn/ha (two foliar application), T₅ - 5 kg Zn/ha (soil application) + 1 kg Zn/ha (foliar application), T₆ - 0.5 kg B/ha (soil application), T₇ - 0.1 kg B/ha (foliar application), T₈ - 0.1 + 0.1 kg B/ha (two foliar application), T₉ - 0.5 kg B/ha (soil application) + 0.1 kg B/ha (foliar application) and T₁₀ - 5 kg Zn/ha (soil application) + 0.5 kg B/ha (soil application)]. The experiment was laid out in Randomized Block Design (RBD) during *rabi* 2018-19 and replicated thrice. The wheat variety 'HD 2967' was taken for experiment and sowing at 22.5 cm × 5 cm spacing. Recommended dose of fertilizers (120 kg N, 60 kg P₂O₅ and 40 kg K₂O) were applied to experimental crop. Half dose of nitrogen and full dose of phosphorus and potassium was applied

Table-3 : Yield of wheat as influenced by zinc and boron fertilization.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)
T ₁ - control	35.30	45.77	81.07
T ₂ - 5 kg Zn/ha (SA)	46.00	57.02	103.02
T ₃ - 1 kg Zn/ha (FA)	43.72	47.63	91.35
T ₄ - 1 + 1 kg Zn/ha (two FA)	48.74	56.11	104.85
T ₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA)	52.28	60.47	112.74
T ₆ - 0.5 kg B/ha (SA)	48.11	54.65	102.76
T ₇ - 0.1 kg B/ha (FA)	45.58	51.67	97.26
T ₈ - 0.1 + 0.1 kg B/ha (two FA)	49.95	59.07	109.02
T ₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA)	55.35	61.86	117.21
T ₁₀ - 5 kg Zn/ha (SA) + 0.5 kg B/ha (SA)	58.23	65.72	123.95
SE(m)±	0.68	0.69	0.20
C.D. at 5%	2.03	2.06	0.59

SA – Soil Application, FA – Foliar Application

Table-4: Economics of wheat as influenced by zinc and boron fertilization.

Treatments	Gross income (Rs/ha)	Net income (Rs/ha)	B:C Ratio
T ₁ - control	66352	39400	1.46
T ₂ - 5 kg Zn/ha (SA)	86202	58750	2.14
T ₃ - 1 kg Zn/ha (FA)	81273	53721	1.95
T ₄ - 1 + 1 kg Zn/ha (two FA)	90911	62759	2.23
T ₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA)	97537	69485	2.48
T ₆ - 0.5 kg B/ha (SA)	89652	62275	2.27
T ₇ - 0.1 kg B/ha (FA)	84932	57430	2.09
T ₈ - 0.1 + 0.1 kg B/ha (two FA)	93320	65268	2.33
T ₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA)	103049	75272	2.71
T ₁₀ - 5 kg Zn/ha (SA) + 0.5 kg B/ha (SA)	108480	80853	2.93

SA – Soil Application, FA – Foliar Application

as basal dose at the time of sowing and remaining half dose of nitrogen was applied as top dressing at 40 days after sowing. Zinc and Boron fertilization treatments were applied as per treatments. The crop was grown with recommended package and practices. Need based application of pesticides and herbicides were also followed to protect the crop from diseases and weeds.

Five plants were selected randomly from each net plot, tagged permanently and used for measurement of plant height. For dry matter accumulation five plants were uprooted randomly from sample rows of each plot and after removal of root portion, the samples were first air dried for some days followed by dried in an electric oven at 65° C till constant weight. The weight was recorded and expressed as g/plant. The total number of tillers and number of spikes per plant were counted at harvest stage from five tagged plants and the average was worked out. Five spikes were randomly selected from each net plot and the length of spike was measured in centimeter and mean length was calculated. Same five spikes were used to recording number of grains/spike. The weight of the sun dried harvested produce from net area of each plot was recorded separately before threshing and expressed

as biological yield in q/ha. After proper drying of harvested produce were threshed separately. Grain yield from each net plot was recorded and expressed as grain yield q/ha. The straw yield for each plot was worked out by subtracting grain yield from total biological yield and was expressed in q/ha. The economic analysis was based on the prevailing prices of inputs and revenue generated from the marketable produce. The data related to each character were analyzed statistically by applying the techniques of 'analysis of variance' for randomized block design and the significance of treatment differences and interaction were tested by 'F' test as described by (7). Critical differences (CD) were worked out at 5 percent of probability where 'F' test reported significance difference.

Results and Discussion

Growth parameters : The plant height was found significantly highest (107.20 cm) respectively at harvesting stage with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table-1. The increase in plant height might be attributed due to the zinc is an activator of plant nutrients and plays an important role in growth and

development of plants because of its stimulatory and catalytic effect in various physiological and metabolic processes of plants and boron is involved in the transportation of photosynthates from leaves to other plant parts which ultimately increased the plant height. The findings are in conformity with those already reported by (2, 8 and 9).

The maximum number of tillers/plant of wheat (6.40) respectively, was recorded at harvesting stage with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] Followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table – 1. It is attributed due to the sufficient availability of plant nutrients as like N, P, K, Zn, and B to maize plant. This may be due to the synergistic effect of zinc and boron to each other, their contents and uptakes were increased. Same findings also reported by (2, 3 and 10).

The maximum dry matter accumulation by wheat (18.14 g) respectively, was recorded at harvesting stage with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] Followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) cf. Table - 1. It may be attributed due to the plant height, and number of tillers/plant was increased ultimately fresh and dry weight are increased because of zinc involvement in auxin metabolism which results in increase in overall biomass. Likewise, boron has the significant role in sugar and starch translocation and synthesis of amino acids and proteins. Same findings also reported by (2, 3, 8, 10 and 11).

Yield attributes : The maximum number of spikes/plant of wheat (5.65) respectively, was recorded with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table - 2. It may be due to the fact that zinc plays an important role in formation of growth hormones and auxin metabolism and boron involvement in development of new cells in meristematic tissues and it also regulates carbohydrates metabolism. Same findings also reported by (11 and 12).

Number of grains/spike is a most important yield contributing character and has a direct positive effect on the grain yield of wheat. It is obvious from the result table 2 that zinc and boron application had significant effect on number of grains/spike. The maximum number of grains/spike of wheat (60.33) respectively, were recorded with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA). This may be attributed due to the zinc plays an important role in regulating the auxin concentration in plants and is an

essential component of enzymes which promotes the growth and development of plants. Zinc also helps in initiation of primordial for reproductive parts. Boron plays a vital role in translocation of photosynthates, increased pollination and grain setting in wheat and ultimately sterility is reduced and number of grains/spike increased. These results are conformity with those already reported by (13, 14 and 15).

1000-seed weight has a direct positive effect on grain yield of wheat crop. More 1000-seed weight, greater will be the grain yield. The maximum 1000- seeds weight (40.13 g) respectively, was recorded from [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table - 2. Findings are in conformity with those already reported by (13 and 15).

Yield : Grain yield is the result of combined effect of various yield contributing components of crop. The data regarding grain yield showed significant differences among the treatments. Maximum grain yield (58.23 q/ha) respectively, was recorded with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table-3. It is attributed due to the zinc fertilization. Higher yield due to zinc fertilization is attributed to involvement of zinc in many metallic enzymes system, regulatory functions and auxin production (16), enhanced synthesis of carbohydrates and their transport to the site of grain production (17). The boron application enhanced pollen tube germination and improves the grain setting by improving the grain filling process and reducing the male sterility (18). The use of micronutrients significantly affected wheat yield. Micronutrients had significantly positive effect on most of yield contributing parameters of wheat (19). Study indicated that foliar application of Zn and B improved dry matter and grain yield due to improvement in allometric traits, chlorophyll and relative water contents, and increase in yield components (20). Same findings also reported by (11, 21 and 22).

Maximum straw yield (65.72 q/ha) respectively, was recorded with the application of [T₁₀ - Zinc – 5 kg/ha (SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table - 3. It is attributed due to the sufficient availability of plant nutrients as like N, P, K, Zn, and B to wheat plant up to harvest the of crop. Same findings also reported by (10, 22, 23, 24 and 30).

Maximum biological yield (123.95 q/ha) respectively, was recorded with the application of [T₁₀- Zinc – 5 kg/ha

(SA) + Boron 0.5 kg/ha (SA)] followed by T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA) and T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA) c.f. Table - 3. It is attributed due to the sufficient availability of plant nutrients as like N, P, K, Zn, and B to wheat plant up to harvest the crop. Findings are in conformity with those already reported by (22, 25 and 31).

Economics : The effectiveness of treatment is mainly based on its economic. Maximum gross income (Rs 108480/-), net income (Rs 80853/-) and benefit: cost ratio (2.93) was recorded under [T₁₀- 5kg Zn/ha (SA) + 0.5 kg B/ha (SA)] followed by [T₉ - 0.5 kg B/ha (SA) + 0.1 kg B/ha (FA)] and [T₅ - 5 kg Zn/ha (SA) + 1 kg Zn/ha (FA)] c.f. Table 4. It might be attributed to increased grain and straw yield with application of zinc and boron in soil. The value of increased yield was much more than the cost of zinc and boron application which increased the net income and B: C ratio. The same findings also reported by (26, 27, 28, 29 and 30).

Conclusion

Based on the findings of the present investigation, it may be concluded that in addition to supply of Zinc and Boron to the wheat crop as soil application is more beneficial to achieving the optimum yield of wheat. Application of Zn and B was found more beneficial and cost effective. Soil application of Zinc and Boron was observed more beneficial than the foliar application to increase the wheat yield as well as improving the soil health. Thus soil application of zinc and boron are suggested to be applied for better crop nutrition and increased crop growth, which will ensure higher monetary returns.

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Influence of Plant Growth Regulators on Root Vegetables : A Review

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Abstract

Plants require light, water, oxygen, minerals and other nutrients for their growth and development. Apart from these external requirements, plants also depend on certain organic compounds to signal, regulate and control the growth of plants. Most of the physiological activities and growth in plants are regulated by action and interaction of some chemical substance in them called hormones and by some naturally occurring inhibitors. These are collectively called as Plant Growth Regulators or Plant Growth Hormones. In general, plants are known to produce five classes of hormone, namely auxins, gibberellin, cytokinin, abscissic acid and ethylene. Both auxin and gibberellins cause stem elongation by different mechanism while abscissic acid and ethylene inhibits stem growth. These chemicals act on plant processes at very low concentrations. Often they are produced at one location and transported to another where they exert their influence; however, they may also act on the same tissue in which they are produced. Plant growth regulators are organic chemical substance, other than nutrients and vitamins which regulate the growth of plant when applied in small quantities. PGRs are employed in agriculture to obtain specific advantages, such as decreased susceptibility towards biotic and abiotic stress, improved morphological structure, facilitation of harvesting, quantitative and qualitative increases in yield, and modification of plant constituents. They are used to regulate the growth of plants and are important measures to ensure agricultural production. The response of for Plant Growth Regulators to various root vegetables (radish, carrot & turnip) for the cost effective technology in respect to crop production potential and the physiological activity of root vegetable crops after the application of PGRs is elaborated in this study.

Key words : Plant growth regulators, physiological activity, production potential

Introduction

Plant growth regulators are organic chemical substance, other than nutrients and vitamins which regulate the growth of plant when applied in small quantities. PGR are used in different forms like liquid, powder, paste etc. "Hormone" is Greek word derived from "hormao" which means to stimulate (Bayliss and Starling, 1902). The term phytohormones is defined as the organic substance, which are produced naturally in plants, synthesized in one part and usually translocated to other part where in every small quantity affect the growth and other physiological function of the plants. To distinguish them from the animal hormones they are termed as phytohormones. Similarly Phillip (1975) defined growth hormone as substances which are synthesized in particular cells and are transferred to other cells where in extremely small quantities influence the developmental process. However, the term hormone is quite popular and widely used. The PGRs are divided into five general groups of compounds based on their chemical structures and effects on plants. The groups are auxins, gibberellins, cytokinins, ethylene, and a group called inhibitors, which includes abscissic acid, phenolics, and alkaloids. Some new PGRs do not fit neatly into these classifications but are described as having effects that resemble those for known PGRs.

Effect of Plant growth regulators on carrot : Carrot,

botanically known as *Daucus carota* L. is a biennial plant in the Umbellifer family, Apiaceae. It originated in modern-day Iran and Afghanistan. The top producers of carrot worldwide are China, Uzbekistan, United States, Russia and Ukraine. In India, it is grown over an area of 1,08,000 ha with total production of 18,65,000 mt and productivity of 13.42 t/ha. Haryana, Andhra Pradesh, Karnataka, Punjab and Uttar Pradesh are major carrot growing states. Its roots contain high quantities of alpha- and beta-carotene, and are a good source of vitamin K and vitamin B₆. Effect of PGRs on carrot crop has been studied by many authors and a gist of their work is mentioned below :

Mohanta *et al.* (2015) studied the effect of PGRs on seed yield of carrot. Three plant growth regulators viz. NAA 100 ppm, Ethrel 100 ppm, GA₃ 50 ppm, GA₃ 100 ppm, GA₃ 150 ppm, GA₃ 200 ppm and untreated control were studied. The application of different plant growth regulators in different concentrations had significant impact on the seed yield of carrot. The highest seed yield (256.90 kg ha⁻¹), highest seed germination percentage (93.33) and seed vigor index (3.16) of carrot was found by GA₃ 200 ppm treatment. Ghoname *et al.* (2011) investigated the effect of using different gibberellic acid (GA₃) treatments on enforcing carrot plants (*Daucus carota* L.) to produce high quality seeds under Egyptian conditions and also to determine the effect of such

Class of plant growth regulators

Auxins	IAA, NAA, IBA, 2-4D, 4-CPA
Gibberellins	GA ₃
Cytokinins	Zeatin, Kinetin
Ethylene	Ethylene : Ethereal
Abscissic acid	Dormins, Phaseic Acid
Phenolic substances	Coumarin
Flowering hormones	Florigin, Anthesin, Vernalin
Natural substances	Vitamins, Phytochrome Transmittic
Synthetic substances	Synthetic Auxins, Synthetic Cytokinins
Growth inhibitors	AMO-1618, Phosphon-D, Cycocel, B-999.

Fig-1 : Class of plant growth regulators (Prajapati *et al.* 2015).

procedure on produced seed yield and quality. Seeds carrot cv. Chantenay Red Cored were sown and after 4 months, uniform and cleaned roots were selected and dipped in GA₃ at 0, 200 and 400 ppm for 5, 20 and 40 seconds and air dried for 5 minutes, then it was replanted directly for seed production. GA₃ treatment induced flowering at all concentrations but 400 ppm for 5 seconds followed by GA₃ at 200 ppm for 40 seconds were the best for seed production. Kwiatkowski (2013) found that growth stimulators: Asahi SL, Bio-algeen S 90, and Tytanit had a positive effect on the quantitative and qualitative parameters of carrot roots. Santos *et al.* (2000) studied influence of gibberellic acid on carrot growth and severity of alternaria leaf blight and found that applications of gibberellic acid (GA) to carrot foliage consistently reduced the percentage of leaf area affected by *Alternaria dauci* compared with nontreated plants. Also, two applications of GA had same degree of leaf blight reduction with was similar to that achieved with four applications of the fungicide iprodione. Abbas (2011) studied effect of foliar sprays of different concentrations of Gibberellic acid (0, 50 and 100 ppm) on growth and some physiological characterizes in Carrot plant (local white cultivar) and found that 50 ppm concentration led to increase significantly the studied characteristics particularly plant height (cm), number of branch/ plant, number of flower/ plant, shoot fresh weight (gm), fresh weight of biological weight gm/plant, shoot dry weight (gm), dry weight of biological weight gm/plant, chlorophyll content ($\mu\text{g}/\text{cm}^2$), when compared with the other concentrations levels and GA₃ significantly reduced the characteristics as root fresh weight (gm), root dry weight (gm) and soluble carbohydrate compared with the controlling plants. Hebbar *et al.* (1994) studied effect of growth regulators on growth and development of carrot cv. Nantes. GA₃ at 100 mg/l as seed soaking treatment had no influence on either growth parameters or flowering. The growth promoter cytokinin was higher in plant exposed to long days. The growth inhibitor, ABA was markedly higher under SD in plants raised from both unvernallized and vernallized seed.

Effect of plant growth regulators on radish : Radish (*Raphanus sativus* L.), which was originated in Asia, is presently cultivated all over the world. It belongs to mustard family Brassicaceae. China, Japan and South Korea are the leading producers of radish, worldwide. In India, it is grown over an area of 2,02,000 ha and total production of 31,45,000 mt. West Bengal, Haryana and Punjab are the leading producing states in India. Long and red/spring radishes that are mainly used for salad and decorative purposes have high demand for hotel industry. In addition, radish is used for pickling and other processing industries. It is a good source of vitamin C and minerals like calcium, potassium and phosphorus. Effect of PGRs on radish crop has been studied by many authors and a gist of their work is mentioned below:

Mahabir Singh *et al.*, (1989) observed that foliar spray of GA₃ (30, 35 and 45 ppm) recorded maximum plant height, number of leaves per plant, leaf length, width of leaf and fresh weight of leaf in radish. Mohamed Yassin and Anbu (1996) reported that root length, root girth and root weight were increased by foliar application of CCC at 1000 ppm in radish. Ashraf *et al.* (2018) studied effect of Plant Growth Regulators (IBA and 2,4-D) on the morphology and biochemical characteristics of radish in different concentrations (2 ppm and 4 ppm) individually. The results indicated that foliar application of Indole-3-butyric acid and 2,4-Dichlorophenoxyacetic acid led to significant increases in vegetative growth; leaf length, plant height, number of leaves per plant, fresh and dry weight of roots, root diameter and biochemical attributes like total soluble solids, titratable acidity and vitamin C contents of radish. Root width was maximum in 2,4-D with 4 ppm concentration. TSS was maximum in control and 2 ppm of 2,4-D. Maximum acidity was observed by the application of IBA @ 2 and 4 ppm concentrations. Malhotra and Chaudhry (2001) studied the effect of gibberellic acid (GA₃) doses sprayed on different stages of radish cv. Pusa Himani, seed crop. They concluded that GA₃, sprayed at 100 ppm conc. twice, at 30 days after steckling planting resulted in

Plant growth regulators and their associated functions

Plant growth regulators	Associated functions
Auxins	Apical dominance, root induction, control fruits drops, regulation of flowering, parthenocarp, phototropism, geotropism, herbicides, inhibit abscission, sex determination, xylem differentiation, nucleic acid activity.
Gibberellin	Stimulate cell division and elongation, stimulate germination of seeds, Stimulates bolting/flowering in response to long days, prevention of genetic dwarfism, increase flower and fruit size, dormancy, induces maleness in dioecious flowers, extending self life.
Cytokinin	Promotes cell division, cell enlargement and cell differentiation, stimulate bud initiation and root growth, translocation of nutrients, prolong storage life of flowers and vegetables, prevent chlorophyll degradation, morphogenesis, lateral bud development, delay of senescence.
Ethylene	Induce uniform ripening in vegetables, promotes abscission, senescence of leaf.
Abscissic acid	Act as plant stress hormone, dormancy induction of buds and seeds, induces seeds to synthesize storage proteins, dormancy, seed development and germination, stomata closing.

Fig-2 : Plant growth regulators and their associated functions (Prajaapati et al. 2015)

significantly increased flowering and seed yield of radish under mid hills of Kullu valley in Himachal Pradesh. Suge and Rappaport (1968) studied the relationship among gibberellins, CCC, vernalization, and photoperiod in the flowering response of radish cv. Miyashige-sofuto. The optimal condition for flowering was vernalization and a 16-hour photoperiod; GA₃ had no additional effect. Gibberellin A3 (60 µg total) was not able to induce flowering in nonvernalized plants grown on 8-hour days, but it did increase the percentage of nonvernalized plants that flowered under long days from 60 to 100. Shruthi *et al.* (2016) studied the effect of growth regulators on growth, flowering and seed yield of radish (*Raphanus sativus* L.) cv. Pusa Chetki. Five levels of growth regulators (GA₃ 200 ppm, GA₃ 250 ppm, NAA 200 ppm, NAA 250 ppm and control) in all possible combinations were assessed for vegetative, seed yield and quality characters. Among the five growth regulator levels, GA₃ 250 ppm recorded maximum plant height, spread of plant, number of branches, induced early flowering, number of siliqua per plant, pod weight, length of pod, seed yield per plant, seed germination per cent, seedling length, seedling dry weight, seedling vigour index and test weight. Shweta *et al.* (2018) studied the effect of different plant growth regulators (GA₃ and NAA) on growth and yield parameters of radish (*Raphanus sativus* L.) var. Pusa Reshmi. The treatments used were three different concentrations of GA₃ (5, 10, 15 ppm) and three different doses of NAA (10, 20, 30 ppm) and control to improve various growth and yield contributing parameters of Radish. Among all the treatments, it was concluded that higher dose of GA₃ at 15 ppm results in increasing maximum leaf length, plant height and it also increases the yield attributing characters such as root length, fresh weight of roots, root yield kg/plot and as well as highest over control. Çavuşoğlu *et al.* (2008) studied the effect of gibberellic acid, 2-chloroethylphosphonic acid (ethephon), triacontanol, 24-epibrassinolide and polyamine (cadaverine, putrescine, spermidine, spermine) pretreatments on the stem anatomy of radish

seedlings grown under saline conditions. They found that many of the growth regulator pretreatments more or less stimulated the stem diameter, epidermis cell width, cortex zone thickness, vascular bundle width, xylem width, trachea diameter and phloem width in comparison with the control seedlings grown on saline medium. Ashraf *et al.* (2016) studied biochemical, antioxidant and nutritional attributes of radish (*Raphanus sativus* L.) under foliar application of plant leaf aqueous extracts i.e., mulberry leaf extract (MLE), brassica leaf extract (BLE), sorghum leaf extract (SLE) and moringa leaf extract (MoLE) as natural growth regulators and found a significant impact of these treatments. Jung *et al.* (2020) studied the effect of gibberellin on bolting and flowering via the floral integrators RsFT and RsSOC1-1 under marginal vernalization in radish. They compared the effects of GA treatment on late-flowering (NH-JS1) and early-flowering (NH-JS2) radish lines. GA treatment promoted flowering in both lines, but not without vernalization and also, NH-JS2 plants displayed greater bolting and flowering pathway responses to GA treatment than NH-JS1.

Effect of plant growth regulators on turnip : Turnip, (*Brassica rapa* var. *rapa*) is a hardy biennial plant belonging to the mustard family (Brassicaceae) cultivated for its fleshy roots and tender growing tops. The turnip is thought to have originated in middle and eastern Asia and is grown throughout the temperate zone. Young turnip roots are eaten raw as salads or in pickled, and the young leaves and roots are cooked and served whole or mashed and are used in stews. China is the leading producing country in the world. In India, it is grown in Punjab, Bihar, Himachal Pradesh, Haryana and Tamil Nadu. Effect of PGRs on turnip has been studied by several authors and a gist of their work is mentioned below:

Liu *et al.* (2021) found that exogenous application of GA₃ significantly inhibits taproot formation in turnip and endogenous GA contents reduced during the early

developmental stages of taproot formation, concluding that GA plays a negative role in taproot formation. Abbasi *et al.* (2011) evaluated regeneration potential and antioxidative enzyme activities of economically important *Brassica rapa* var. *turnip* using PGRs. They induced calli from leaf explants of seed-derived plantlets on Murashige and Skoog (MS) medium incorporated with different concentrations of various plant growth regulators (PGRs). The highest leaf explant response (83%) was recorded for 2.0 mg l⁻¹ benzyladenine (BA) and 1.0 mg l⁻¹ -naphthaleneacetic acid (NAA). Meng *et al.* (2009) investigated the effect of exogenous application of plant growth regulators to mitigate phytotoxicity of cadmium in *Brassica napus* L. Four plant growth regulators viz. jasmonic acid (12.5 M), abscisic acid (10 M), gibberellin (50 M) and salicylic acid (50 M) were studied to alleviate cadmium toxicity symptoms. Jain *et al.* (1988) excised cotyledon explants of *Brassica tournefortii* L. from germinated seedlings and cultured on Murashige & Skoog's basal medium supplemented with various combinations of cytokinins and auxins. Both cytokinin and auxin were vital for induction of shoot organogenesis. Of the three cytokinins tested (in combination with a low concentration of IAA) kinetin was found to be the most effective for shoot regeneration. Kakar *et al.* (2014) studied in vitro regeneration and antioxidant potentials of *Brassica rapa* var. *turnip* from seed derived calli and using Thidiazuron TDZ (1-phenyl-3-(1, 2, 3-Thiadiazol-5-yl) as primary growth regulator and found that seed germination medium supplemented with TDZ (2mg L⁻¹) and NAA (1mgL⁻¹) yielded highest frequency of callus induction (71.3%) within 7 days of culture. The study gave better understanding of mechanism of TDZ as potential growth regulator for regeneration via seed derived callus and increased radical free scavenging activity.

Conclusion

Use of plant growth regulator in root vegetables has been found beneficial to improve yield, quality, synchronization in flowering, earliness, cold and high temperature fruit setting, increased post-harvest life, and resistance to biotic and abiotic stresses. Thus, they have a significant impact on quality of root vegetables and can be successfully used to have profitable returns. In view of future thrust, awareness and popularizing among the farmers should be done to expand the area under quality root vegetables by the application of plant growth substances.

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Agro Meteorological Requirement of Fennel (*Foeniculum vulgare* L.) Crop in Western Agro Climatic Zone of Haryana

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Abstract

A field experiment comprising 20 advance lines of fennel was carried out to access and investigate the agrometeorological indices such as thermal units, helio thermal units, photo thermal units and thermal use efficiency during the *Rabi* seasons 2015-16 and 2016-17 at CCS, Haryana Agricultural University, Hisar. The results revealed that the fennel crop required 219.57 day °C accumulated heat units for seed germination, 2109.67day°C accumulated heat units for flowering and 2458.79day°C accumulated heat units for total seed yield. Advance line HF-111 required minimum accumulated heat units (133.90day°C) for seed germination, flowering (1139.92day°C) and for seed yield (2343.00day°C), respectively. The better thermal use efficiency of HF-101 and HF-111 i.e 1.73 and 1.74 kg⁻¹D⁻¹ respectively, indicating for early and more seed yield availability. The pooled data of two seasons revealed that the lower values of HTU and PTU were observed in seed germination, flowering and seed yield by the advance line HF-111. Based on the agro meteorological indices among the advance lines of fennel it may be concluded that advance line HF-111 can be used for the genetic improvement of fennel crop for early and higher seed yield in the western agro climatic zone of Haryana.

Key words : Fennel, advance line, agro meteorological indices, thermal heat units, agroclimate zone.

Introduction

Fennel (*Foeniculum vulgare* L.) member of family Apiaceae and native to the Mediterranean region is a medicinal and an aromatic herb. It is primarily grown for its seeds and seeds are brown or green in colour when fresh, slowly turning green to dull grey and have an active substance, which is called essential oil and most important constituent is anethole that is used in pharmaceutical, food, perfumery and favoring industry (Miraldi, 1999; Sephidkon, 2001). Among seed spices fennel contributes about 17.47 % of total seed spices production. Its cultivation has spread from Gujarat onwards to the northern parts of India. Fennel produced in India is largely consumed within the country however; there is a large scope of its export to U.K., U.S.A., U.A.E, Sweden, Malaysia, Sri Lanka, France, and Kenya. By virtue of its finest quality and high vitamin content, demand of export due to its high quality seed is increasing steadily. In Haryana, fennel is grown on a limited acreage as Rabi crop both under rain fed as well as irrigated conditions and has remained commercially unexploited. It grows well under dry and cold weather conditions. Agro climate is the most important entity in agricultural production. Sustainable agricultural production is dependent to a large extent on the precise knowledge of the climate resources. Precise measurements of weather elements are required to understand the proper interpretation in relation to crop growth and development. Thus,

temperature, sunlight and other meteorological factors may individually or collectively limit the plant growth and production. Wang (1960) reported that duration of particular stage of growth was directly related to temperature and this duration for particular species could be predicted using sum of daily air temperature or cumulative thermal requirement also known as Growing Degree Days or Heat units. Growing degree days are measure of heat accumulation used to predict phenological development rates such as the date that a seed germinates and a flower will open or crop will reach maturity and further to explore the agro – climatic potential of a region (Pandey and Shekh, 1999). Thus air temperature based on agrometeorological indices like growing degree days, heliothermal units, photothermal units and thermal use efficiency can successfully be used for describing phenological behavior and growth parameters (Hundal and Kingra, 2000; Hundal *et al* ., 2003; Neog and Chakravarty, 2005; Kumar *et al* 2008). Therefore, present field experiment was conducted to determine agrometeorological requirements for attaining seed germination, flowering and higher seed yield attributes in advance lines of fennel crop.

Materials and Methods

Study Area : The study was conducted at the Research Farm of Department Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University Hisar

Table-1 : Thermal requirement (day°C) at different growth stages in fennel advance lines (Pooled data of 2015-16 and 2016-17).

Sr. No.	Seed germination		50% flowering	Seed yield
	Advance Line	Pooled mean	Pooled mean	Pooled mean
1.	HF-101	181.87	1,929.83	2,504.61
2.	HF-102	197.08	2,004.83	2,481.39
3.	HF-103	181.89	1,856.00	2,457.29
4.	HF-104	182.58	2,010.50	2,481.56
5.	HF-105	221.66	2,251.50	2,504.28
6.	HF-110	151.11	1,143.50	2,385.45
7.	HF-111	133.90	1,139.79	2,343.90
8.	HF-112	166.13	1,341.00	2,409.78
9.	HF-113	151.11	1,235.73	2,365.62
10.	HF-114	250.93	1,347.44	2,504.60
11.	HF-115	277.93	1,198.17	2,481.00
12.	HF-116	250.41	1,785.83	2,457.85
13.	HF-117	269.36	1,399.67	2,504.45
14.	HF-118	267.86	2,434.11	2,408.66
15.	HF-119	250.41	3,068.14	2,504.45
16.	HF-210	252.31	3,090.15	2,480.83
17.	HF-211	251.43	2,970.91	2,433.33
18.	HF-212	251.32	3,170.58	2,457.28
19.	HF-213	250.95	3,407.98	2,504.67
20.	HF-214	251.16	3,407.65	2,504.67
Overall Mean		219.57	2,109.67	2,458.79
CD at 5%		2.45	2.00	1.527
CV		0.65	0.05	0.037

Table-2 : Photo-thermal index (day°C) at different growth stages in fennel advance lines (Pooled data of 2015-16 and 2016-17).

Sr. No.	Seed germination		50% flowering	Seed yield
	Advance Line	Pooled mean	Pooled mean	Pooled mean
1.	HF-101	16.17	17.34	12.66
2.	HF-102	16.14	17.51	13.66
3.	HF-103	18.39	17.44	14.33
4.	HF-104	16.19	17.14	13.00
5.	HF-105	16.57	20.82	12.00
6.	HF-110	16.59	10.28	12.66
7.	HF-111	15.61	10.16	11.66
8.	HF-112	18.61	12.33	12.66
9.	HF-113	16.87	11.70	11.68
10.	HF-114	16.57	12.49	12.00
11.	HF-115	16.55	10.66	12.66
12.	HF-116	16.56	16.56	12.50
13.	HF-117	17.27	12.52	13.33
14.	HF-118	17.24	22.46	12.33
15.	HF-119	17.23	26.13	12.33
16.	HF-210	17.27	25.62	12.33
17.	HF-211	15.81	25.35	13.33
18.	HF-212	16.25	26.27	13.33
19.	HF-213	16.25	28.21	13.66
20.	HF-214	16.24	28.21	13.66
Overall Mean		16.72	18.46	12.79
CD at 5%		1.08	1.00	1.06
CV		2.12	2.13	2.11

(Lat.29°10' N, Long. 75°46' E and altitude 215.2 m amsl). This region has semi-arid climate with severe cold winter and hot dry summer. The zone is characterized by hot and dry summer (April to June) followed by a hot and humid monsoon period and cold winters during December-January. According to the meteorological records of the area, the average annual rainfall varies from 350-400 mm and the total rains as well as its distribution are subjected to great variation. About 80 to 90% of total rains are received from South-West monsoon during the months of July to September. A few showers of cyclonic rains are also a common feature in this zone during December, January or in late spring.

Experimental Details : The present experiment comprising twenty advance lines of fennel was carried out for two consecutive *Rabi* seasons of 2015-16 and 2016-17. Seeds of twenty advance lines were sown on 2nd November in both the *Rabi* seasons, respectively in Randomized Block Design with three replications. The recommended package and practices by the University were adopted for all genotypes to raise healthy crop. The observation for seed germination i.e. emergence of seedlings in the field was recorded by visual observations after sowing, till the seeds germinated. The observations for 50 % flowering were recorded as numbers of days from the date of sowing to the date at which the genotypes revealed 50 % flowering. Similarly, the observations were recorded for final seed yield/ physiological maturity (from sowing date to the seed yield per plant). The daily agrometrological data recorded at nearby Agrometrological Observatory situated in the Research Farm CCS Haryana Agricultural University, Hisar were used for calculation of thermal requirements for attaining different phenophases in fennel. Different agrometeorological indices were calculated on daily basis and summations were made for different stages separately from sowing to the final seed yield.

Calculation of Agrometeorological Indices : Thermal heat units, Photo-thermal units, Helio-thermal units (HTU), Photo-thermal units (PTU) and Thermal use efficiency were computed using daily metrological data. The base temperature of 5 °C was used for computation of growing degree days (GDD) on daily basis (Leong and Ong, 1983). Agrometeorological indices were computed for different phenophases of crop (seed germination, flowering and physiological maturity /seed yield) by adopting the procedure laid out by Rajput (1980). All thermal energy requirement parameters were recorded for three durations, viz., sowing to germination, owing to

Table-3 : Helio-Thermal Units at different growth stages in fennel advance lines (Pooled data of 2015-16 and 2016-17).

Sr. No.	Seed germination		50% flowering	Seed yield
	Advance Line	Pooled mean	Pooled mean	Pooled mean
1.	HF-101	615.66	6,443.17	17,431.00
2.	HF-102	738.16	6,505.83	17,183.50
3.	HF-103	478.33	6,202.00	16,933.17
4.	HF-104	614.833	6,081.67	17,182.67
5.	HF-105	923.50	6,006.50	17,431.00
6.	HF-110	416.83	5,932.00	16,470.33
7.	HF-111	304.83	5,789.50	16,225.17
8.	HF-112	415.83	5,789.67	15,766.50
9.	HF-113	416.16	5,851.83	16,002.50
10.	HF-114	1,005.00	6,005.83	17,431.00
11.	HF-115	1,222.00	6,082.33	17,183.17
12.	HF-116	1,004.67	6,703.67	16,931.67
13.	HF-117	1,110.83	7,025.17	17,431.10
14.	HF-118	1,111.83	6,905.50	16,470.33
15.	HF-119	1,004.50	6,903.00	17,431.00
16.	HF-210	1,004.00	7,025.50	17,182.50
17.	HF-211	1,110.83	7,023.67	15,766.67
18.	HF-212	1,005.17	6,443.17	16,932.00
19.	HF-213	1,005.00	6,505.83	17,431.00
20.	HF-214	1,004.67	6,202.00	17,431.00
Overall Mean		825.63	6,359.69	16,912.36
CD at 5%		2.95	3.44	2.57
CV		0.12	0.13	0.09

Table-4 : Photo-Thermal Units based on days to seed germination, 50% flowering, seed germination in fennel advance lines.

Sr. No.	Seed germination		50% flowering	Seed yield
	Advance Line	Pooled Mean	Pooled Mean	Pooled Mean
1.	HF-101	1,970.33	12,381.67	28,967.00
2.	HF-102	2,151.17	12,503.50	28,645.67
3.	HF-103	1,781.00	12,381.67	28,325.67
4.	HF-104	1,970.50	12,646.00	28,646.33
5.	HF-105	2,490.50	12,811.50	28,966.34
6.	HF-110	1,605.00	12,266.00	27,393.34
7.	HF-111	1,425.33	11,643.84	26,824.50
8.	HF-112	1,604.17	11,950.67	27,691.17
9.	HF-113	1,604.17	11,853.17	27,119.34
10.	HF-114	2,661.83	11,644.84	28,966.17
11.	HF-115	2,966.83	12,062.84	28,645.67
12.	HF-116	2,631.50	11,741.17	28,325.17
13.	HF-117	2,811.00	11,949.00	28,966.00
14.	HF-118	2,810.83	12,061.84	27,691.17
15.	HF-119	2,661.67	13,164.34	28,965.50
16.	HF-210	2,660.67	13,562.84	28,645.67
17.	HF-211	2,810.67	13,428.17	26,825.17
18.	HF-212	2,660.83	13,428.17	28,480.67
19.	HF-213	2,660.67	13,562.84	28,966.00
20.	HF-214	2,660.67	13,564.34	28,966.00
Overall Mean		2,329.97	12,530.42	28,301.12
CD at 5%		2.55	2.06	2.47
CV		0.06	0.01	0.05

50% flowering and sowing to physiological maturity/seed yield.

Growing degree days (GDD) were computed with 5°C as base temperature on the basis of daily mean temperature with the help of following formula:

$$\text{GDD} = (\text{Rmx} - \text{Tmn})2\text{-Tb}$$

Where, Tmx and Tmn are daily maximum and minimum temperature, Tb is the base temperature (5°C).

Photo thermal units (PTU) (degree –days hours) were calculated on the basis of GDD and day length with the formula given below :

$$\text{PTU} = \text{GDD} \times \text{Daylength}$$

Photo-thermal index (PTI) (degree-days day⁻¹) was calculated using the following equation :

$$\text{PTI} = \text{GDD}/\text{Growing days}$$

Helio-thermal units (HTU) (degree–days hours) were calculated on the basis of GDD and bright sunshine hours by the following formula :

$$\text{HTU} = \text{GDD} \times \text{Duration of bright sunshine hours}$$

Thermal/Heat use efficiency (HUE) (kg hadegree-day) was calculated with the help of seed yield (kg⁻¹ ha) per GDD with the help of following equation :

$$\text{HUE} = \text{Seed yield ((kg}^{-1} \text{ sha) / GDD}$$

The data were pooled for two seasons (rabi 2015-16 and 2016-17) and statistically analyzed for different phenological stages. Agrometeorological indices such as seed germination, flowering and physiological maturity/seed yield were analyzed with analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984). Treatments were compared by computing the F-test. The significant differences between treatments were compared pair wise by critical difference at the 5 per cent level of probability.

Results and Discussion

Thermal requirements : The thermal requirement of twenty advance lines of fennel crop for seed germination, flowering and seed yield are presented in Table1. All the genotypes take minimum eight days and maximum seventeen days to seed germination. Among all the advance lines, two lines viz, HF-115 and HF-117 used highest thermal units of 277.93 and 269.68 day°C, respectively for seed germination. HF-111 required lowest cumulative thermal unit of 133.90day°C for seed germination. Rest of the lines consumed thermal units ranging from 151.11day°C (HF-110) to 267.86 day°C (HF-118) for seed germination. The advance line HF-213

Table-5 : Thermal use efficiency ($\text{kg ha}^{-1}\text{D}^{-1}$) of fennel advance lines.

Sr. No.	Advance Line	1 st year 2015-16	2 nd year 2016-17	Mean
1.	HF-101	1.75	1.71	1.73
2.	HF-102	1.65	1.76	1.70
3.	HF-103	1.22	1.25	1.23
4.	HF-104	1.31	1.36	1.33
5.	HF-105	1.45	1.44	1.44
6.	HF-110	1.31	1.35	1.33
7.	HF-111	1.73	1.74	1.74
8.	HF-112	1.32	1.41	1.36
9.	HF-113	1.56	1.48	1.52
10.	HF-114	1.53	1.61	1.57
11.	HF-115	1.32	1.37	1.34
12.	HF-116	1.73	1.74	1.73
13.	HF-117	1.65	1.61	1.63
14.	HF-118	1.43	1.45	1.44
15.	HF-119	1.31	1.36	1.33
16.	HF-210	1.30	1.35	1.32
17.	HF-211	1.33	1.31	1.32
18.	HF-212	1.44	1.48	1.46
19.	HF-213	1.57	1.50	1.53
20.	HF-214	1.46	1.50	1.48
Overall Mean		1.47	1.49	1.48
CD at 5%		0.03	0.06	0.4
CV		1.41	2.55	1.45

utilized highest amount of accumulated thermal units ($3407.98 \text{ day}^{\circ}\text{C}$) to reach 50% flowering and was closely followed by HF-214 ($3407.65 \text{ day}^{\circ}\text{C}$). HF-111 required lowest cumulative thermal unit of $139.79 \text{ day}^{\circ}\text{C}$ to reach 50% flowering. While the rest of lines consumed thermal units ranging $1143.50 \text{ day}^{\circ}\text{C}$ (HF-110) to $3170.58 \text{ day}^{\circ}\text{C}$ (HF-212) to reach 50 % flowering. All the genotypes take minimum one hundred days and maximum one hundred sixteen days to reach 50 % flowering. While, for seed yield the range is 184 days to 191 days for final seed yield. The advance lines HF- 213 and HF-214 utilized the highest amount of accumulated thermal units of $2504.67 \text{ day}^{\circ}\text{C}$, respectively for seed yield. While advance line HF-111 required lowest cumulative thermal unit of $2343.85 \text{ day}^{\circ}\text{C}$ for seed yield. The advance line HF-111 produced maximum seed yield in similar order and also consumed lowest heat units for seed germination and flowering indicating their suitability for early and more yield in shorter period than the other advance lines. Though different advance lines exhibited variations in thermal use consumptions under experiment reason being prevailing weather conditions and its variability, but the shorter period for seed germination exhibits positive relation with seed yield. On an average fennel required accumulated thermal units of $219.57 \text{ day}^{\circ}\text{C}$ for seed germination $2109.67 \text{ day}^{\circ}\text{C}$ for flowering and 2458.79 for seed yield. The results are well corroborated by finding of Singh *et al.*, (1994).

Photo-thermal index : The photo thermal index of twenty advance lines of fennel for seed germination, flowering and seed yield are presented in Table-2. Among all the advance line HF-103 used highest the photo-thermal units of 18.39 in seed germination. HF-111 required lowest photo-thermal unit of 15.61 in seed germination. The advance lines HF-213 and HF-214 utilized highest amount of photo-thermal units (28.21) respectively, for attaining flowering whereas HF-111 utilized lowest amount of photo-thermal units (10.16) for flowering. However similar pattern was also observed in seed yield i.e HF-111 utilized lowest photo-thermal units (11.66) for seed yield and the advance line HF-103 utilized highest amount of photo-thermal units (14.33) for seed yield.

Helio-thermal units (HTU) : The helio-thermal unit of twenty advance lines of fennel for seed germination, flowering and seed yield are presented in Table-3. Among all the advance line HF-115 used highest the helio-thermal units of 1222.00 in seed germination. HF-111 required lowest helio-thermal unit of 304.83 in seed germination. Rest of the lines consumed helio-thermal units ranging from 415.83 (HF-112) to 1111.83°C day hour (HF-118) in seed germination. The advance line HF-210 utilized highest amount of helio-thermal units (7025.50) for attaining flowering whereas HF-111 utilized lowest amount of helio-thermal units (5789.50) for flowering. However similar pattern was also observed in seed yield i.e HF-111 utilized lowest helio-thermal units (16225.17) for seed yield and the advance line HF- 117 utilized highest amount of helio-thermal units (17431.10) for seed yield.

Photo-thermal units (PTU) : The photo-thermal unit of twenty advance lines of fennel for seed germination, flowering and seed yield are presented in Table-4. Among all the advance line HF-115 used highest photo-thermal units of 2966.83°C day hour in seed germination. HF- 111 required lowest photo-thermal unit of 1425.33 in seed germination. Rest of the lines consumed photo-thermal units ranging from 1604.17 (HF-112) to 2810.83 (HF-118) to in seed germination. The advance line HF-214 utilized highest amount of photo-thermal units (13564.34) for attaining flowering whereas HF-111 utilized lowest amount of photo-thermal units (11643.84) for flowering . However similar pattern was also observed in seed yield i.e HF-111 utilized lowest photo-thermal units (26824.50) for seed yield and the advance line HF- 101 utilized highest amount of photo-thermal units (28967.00) for seed yield.

Thermal use efficiency : Efficiency of thermal energy conversion for seed yield depends upon the genetic makeup of the plant, seed germination, flowering and yield of the genotype. The thermal use efficiency derived (Table-5) thereby was maximum (1.74) for advance line (HF-111). Other advance lines viz., HF-101 (1.73) and HF-116 (1.73) also closely followed thermal use efficiency for seed yield. The lowest thermal use efficiency (1.23) was expressed by the advance line HF-103. Rest of the advance line had thermal use efficiency ranging from 1.33 to 1.63. It is evident here that high yielding advance lines accumulated higher thermal energy and are more efficient users of thermal energy than the late flowering and poor yielder advance lines. The probable reason might be early germination have positive relation with flowering and higher yield. Thus the higher thermal energy give better result in advance line HF-111.

Conclusions

There were genotypic differences for heat requirement, helio-thermal, photo-thermal and their use efficiency for germination, flowering and final seed yield. The accumulated information gathered from the agrometeorological indices revealed that the advance line HF-111 consumes lowest thermal energy and give highest thermal use efficiency than the other advance lines. It may be concluded that the HF -111 advance line can be used for the genetic improvement of fennel crop for early and higher seed yield in the western agro climatic region of Haryana and also for inclusion in the cropping system of rice-wheat as diversified option to attain sustainable agricultural development in the zone.

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Genetic Components and Graphical Analysis for Yield and Some of its Associated Characters in Bread Wheat (*Triticum aestivum* L. em. Thell) Over Environments

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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 Hayman's (1954 a & b) approach. 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 programs 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.

Observations were recorded on days to heading

Table-1 : Estimates of regression coefficient 'b' their standard errors, deviation from zero and unity for yield and its contributing attribute.

Character	Env.	b-0		b-1		SE(b)	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Days to heading	E ₁	-0.55	-0.61	2.24**	3.79**	0.36	0.23
	E ₂	0.92**	-0.89**	5.04**	4.26**	0.17	0.19
	E ₃	-1.8**	-2.43**	1.18**	0.95*	0.34	0.3
Days to maturity	E ₁	-3.12**	-4.04**	7.31**	7.49**	0.96	0.09
	E ₂	-1.40**	-1.10**	5.10**	4.13**	0.15	0.19
	E ₃	0.19	0.47	4.71**	5.07**	0.22	0.22
Grain filling period	E ₁	-2.7**	-4.35**	1.28****	0.83**	0.25	0.19
	E ₂	-1.54**	-1.03*	1.65**	2.03**	0.31	0.33
	E ₃	1.16**	-2.28**	12.47**	2.3**	0.09	0.22
Plant height	E ₁	0.53	0.77*	4.13**	5.19**	0.28	0.23
	E ₂	-0.06	0.25	3.44**	3.48**	0.29	0.27
	E ₃	1.88**	2.83**	10.91**	13.93**	0.11	0.09
Flag leaf area	E ₁	-0.42	0.26	4.70**	3.01**	0.20	0.36
	E ₂	-0.46	-0.97*	2.47**	2.11**	0.34	0.32
	E ₃	0.39	-0.52	3.68**	0.95	0.30	0.68
Number of tillers per pant	E ₁	-1.72**	-1.30**	4.06**	4.05**	0.17	0.19
	E ₂	-0.89**	-2.19*	9.02**	9.65**	0.10	0.85
	E ₃	-0.20	-2.19**	4.08**	3.05**	0.19	0.19
Spike Length	E ₁	-2.17**	-0.78	0.43	2.03**	0.38	0.36
	E ₂	-3.93**	0.02	0.24	2.85**	0.24	0.35
	E ₃	-3.91**	1.36**	0.66*	13.47**	0.22	0.08
Grain yield per spike	E ₁	0.31	-0.35	5.25**	3.75**	0.20	0.24
	E ₂	-1.24**	0.07	1.79**	3.59**	0.33	0.28
	E ₃	-1.27**	-0.52	2.34**	2.52**	0.28	0.33
1000-grain weight	E ₁	-0.47**	0.50*	7.28**	6.84**	0.13	0.16
	E ₂	-1.53**	-1.67**	1.40**	1.62**	0.34	0.30
	E ₃	-1.50**	-0.14	3.76**	8.31**	0.19	0.12
Harvest Index	E ₁	-0.14	-1.51**	11.04**	6.35**	0.09	0.13
	E ₂	-0.18	-3.72**	2.96**	5.21**	0.32	0.11
	E ₃	-3.82**	-2.81**	0.75	2.87**	0.22	0.18
Grain yield per plant	E ₁	-0.74	-1.75**	1.41*	0.73	0.47	0.40
	E ₂	-2.51**	-1.00*	1.42**	1.31*	0.25	0.43
	E ₃	-3.73**	1.48**	1.32**	4.00**	0.20	0.18

(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.

Results and Discussion

Hayman's approach was pursued to obtain the components of genetic variance and graphical analysis. The occurrence of significant deviation of regression coefficient "b" from zero but non-significant deviation of "b" from unity suggested the adequacy of additive-dominance model (Hayman, 1954a). Additive-dominance model fitted for spike length in E₁F₁ and E₂F₁, harvest index in E₃F₁ and grain yield per plant in E₁F₁. (Table-1). These results revealed that the assumptions of diallel analysis were fulfilled for these traits only and the component analysis

was carried out only for these traits. Where additive dominance model was inadequate, only graphical analysis was performed, which indicated the existence of epistatic interactions. This showed the importance of testing the genetic material in more than one environment in order to obtain unbiased estimates of various components. Adequacy of additive-dominance model for grain yield was reported by Fellahi *et al.* (2015), for harvest index and grain yield by Kutlu and Olgun (2015) and for spike length by Shehzad *et al.* (2015).

The evaluation of component of genetic variation manifested that additive (D) and dominance (H₁ and H₂) components were significant for all the characters indicating that both components were operating in the expression of the above discussed trait (Table 2-6). However, the relative magnitude of dominance component was found to be higher than additive component. These consequences advocated the

Table-2 : Estimates of components of genetic variances for yield and its contributing attributes in three environments for F₁ generation.

	Days to Heading		Days to Heading		Days to Heading		Days to Heading		Days to Heading		Days to Maturity		Days to Maturity		Days to Maturity		Grain Filling Period	
	E1F1	E1F2	E2F1	E2F2	E3F1	E3F2	E1F1	E1F2	E2F1	E2F2	E3F1	E3F2	E1F1	E1F2	E2F1	E2F2	E1F1	E1F2
D (Additive Effect)	15.23**	15.68*	1.94	1.47	3.53**	3.43**	2.36	2.75	9.12	9.19	5.89	5.75	18.9**	18.9**	18.9**	18.9**	18.9**	18.9**
F (Mean Fr over arrays)	12.06	11.81	1.77	1.18	-0.72	-0.56	-4.16	-4.56	11.83	12.69	9.29	9.19	16.76	15.67	16.76	15.67	16.76	15.67
H1(Dominance Effect)	78.85**	86.57**	18.26**	19.33**	8.91**	8.67**	88.81**	104.8**	70.04**	46.40**	38.48**	32.33**	80.31**	82.85**	80.31**	82.85**	80.31**	82.85**
H ²	72.95**	81.15**	13.92**	14.55**	8.69**	8.75**	83.02**	96.49**	53.87**	35.57**	27.52**	21.89**	67.50**	71.01**	67.50**	71.01**	67.50**	71.01**
h ² (Heritability)	-0.37	-0.06	-0.11	13.68**	0.57	7.00**	35.95**	48.01**	1.87	6.88	7.89	0.32	3.09	12.3**	3.09	12.3**	3.09	12.3**
E (Environ.Comp.)	1.02	0.57	0.39	0.85	0.41	0.52	1.65	1.26	2.20	2.13	1.23	1.36	0.64	0.58	0.64	0.58	0.64	0.58
Mean Degree of Dominance	2.28	2.35	3.07	3.62	1.59	1.59	6.14	6.17	2.77	2.25	2.56	2.37	2.06	2.09	2.06	2.09	2.06	2.09
: : of Genes with +/- Effects in Parents	0.23	0.23	0.19	0.19	0.24	0.25	0.23	0.23	0.19	0.19	0.18	0.17	0.21	0.21	0.21	0.21	0.21	0.21
:: of Dominant & Recessive Genes in Parents	1.42	1.38	1.35	1.25	0.88	0.90	0.75	0.76	1.61	1.89	1.89	2.02	1.55	1.49	1.55	1.49	1.55	1.49
Va (Additive Gene Effects)	4.53	4.64	2.25	2.53	2.23	1.96	6.15	7.84	6.73	3.67	3.77	3.50	7.48	7.56	7.48	7.56	7.48	7.56
Vd (Dominance Deviations)	18.24**	20.29**	3.48**	3.64**	2.17**	2.19**	20.76**	24.12**	13.47**	8.89**	6.88**	5.47**	16.87**	17.75**	16.87**	17.75**	16.87**	17.75**
h ² H ² (No. of Gene Groups)	-0.01	0.00	-0.01	0.94	0.07	0.80	0.43	0.50	0.03	0.19	0.29	0.01	0.05	0.17	0.05	0.17	0.05	0.17
h ² (Heritability in Narrow Sense)	0.19	0.18	0.37	0.36	0.46	0.42	0.22	0.24	0.30	0.25	0.32	0.34	0.30	0.29	0.30	0.29	0.30	0.29

Table-3 : Estimates of components of genetic variances for yield and its contributing attributes in three environments for F₁ generation.

	Grain Filling Period		Grain Filling Period		Grain Filling Period		Plant Height		Plant Height		Plant Height		Flag Leaf Area		Flag Leaf Area	
	E2F1	E2F2	E3F1	E3F2	E1F1	E1F2	cm	cm	cm	cm	E3F1	E3F2	cm ²	cm ²	cm ²	cm ²
D (Additive Effect)	19.79	19.98**	8.60	8.68**	25.90**	26.53**	24.61**	24.93**	7.38	7.67	21.35	21.23**	5.96**	5.75*	5.96**	5.75*
F (Mean Fr over arrays)	37.24*	37.53*	11.22	10.91	50.95**	59.74**	29.87*	23.60	15.32	16.16	36.11	33.60**	8.03	8.40	8.03	8.40
H1(Dominance Effect)	109.16*	113.90*	129.1**	47.08**	119.39*	102.48*	75.10**	70.30**	126.97*	109.22*	191.91*	56.84**	19.56**	23.11**	19.56**	23.11**
H ²	84.55**	89.79**	107.90*	38.81**	92.73**	66.11**	54.09**	51.88**	94.35**	79.02**	172.26*	41.99**	13.19**	15.45**	13.19**	15.45**
h ² (Heritability)	4.04	7.92	362.6**	95.26**	22.26*	10.38	19.09**	3.98	0.86	0.71	37.08*	7.22	1.12	6.91	1.12	6.91
E (Environ.Comp.)	0.67	0.48	0.78	0.70	1.76	1.13	1.92	1.60	1.45	1.16	1.69	1.80	1.88	2.08**	1.88	2.08**
Mean Degree of Dominance	2.35	2.39	3.87	2.33	2.15	1.97	1.75	1.68	4.15	3.77	3.00	1.64	1.81	2.00	1.81	2.00
: : of Genes with +/- Effects in Parents	0.19	0.20	0.21	0.21	0.19	0.16	0.18	0.18	0.19	0.18	0.22	0.18	0.17	0.17	0.17	0.17
:: of Dominant & Recessive Genes in Parents	2.34	2.30	1.40	1.74	2.69	3.68	2.06	1.79	1.67	1.77	1.79	2.87	2.18	2.14	2.18	2.14
Va (Additive Gene Effects)	3.58	3.28	9.31	3.02	0.81	1.58	7.87	9.88	12.34	10.85	2.44	1.24	2.15	2.51	2.15	2.51
Vd (Dominance Deviations)	21.14**	22.45**	26.97**	9.70**	23.18**	16.53**	13.52**	12.97**	23.59**	19.76**	43.07**	10.50**	3.30**	3.86**	3.30**	3.86**
h ² H ² (No. of Gene Groups)	0.05	0.09	3.36	2.45	0.24	0.16	0.35	0.08	0.01	0.01	0.22	0.17	0.08	0.45	0.08	0.45
h ² (Heritability in Narrow Sense)	0.14	0.13	0.25	0.22	0.03	0.08	0.34	0.40	0.33	0.34	0.05	0.09	0.29	0.30	0.29	0.30

Table-4 : Estimates of components of genetic variances for yield and its contributing attributes in three environments for F₁ generation.

	Flag Leaf Area cm ² E3F1	Flag Leaf Area cm ² E3F2	Tillers/Plant E1F1	Tillers/Plant E1F2	Tillers/Plant E2F1	Tillers/Plant E2F2	Tillers/Plant E3F1	Tillers/Plant E3F2	Spike Length E1F1	Spike Length E1F2	Spike Length E2F1	Spike Length E2F2	Spike Length E3F1	Spike Length E3F2
D (Additive Effect)	7.94**	7.82**	-0.12	-0.44	-0.20	-0.11	0.10	0.12	5.00**	5.00**	3.48**	3.64**	2.74**	2.86
F (Mean Fr over arrays)	11.39**	10.14	-0.23	-0.56	-0.36	-0.27	-0.07	-0.05	7.46**	10.10**	3.09**	4.21	1.67	3.03
H1(Dominance Effect)	16.69**	11.57**	1.92**	5.28**	1.62**	2.07**	1.49**	1.61**	13.80**	24.07**	10.49**	9.93**	7.86**	12.25**
H2	11.42**	7.56*	1.95**	4.92**	1.62**	2.03**	1.46**	1.59**	10.46**	18.24**	9.28**	7.71**	7.04	9.95**
h ² (Heritability)	6.23**	9.13	3.75**	1.61**	-0.07	4.11**	1.76**	5.41**	1.14	2.13	8.91**	0.08	12.96**	2.69
E (Environ.Comp.)	0.79	0.91	0.67**	0.98**	0.40**	0.31**	0.30**	0.28**	0.52	0.52	0.59**	0.43	0.5**	0.39
Mean Degree of Dominance	1.45	1.22	4.01	3.48	2.84	4.26	3.89	3.65	1.66	2.19	1.74	1.65	1.69	2.07
: : of Genes with +/- Effects in Parents	0.17	0.16	0.25	0.23	0.25	0.25	0.25	0.25	0.19	0.19	0.22	0.19	0.22	0.20
::of Dominant & Recessive Genes in Parents	2.96	3.28	0.61	0.69	0.52	0.56	0.82	0.89	2.62	2.68	1.69	2.08	1.44	1.69
straightVa (Additive Gene Effects)	0.91	0.84	0.04	0.24	0.08	0.10	0.10	0.09	0.44	0.41	0.80	0.83	0.95	1.06
Vd (Dominance Deviations)	2.86**	1.89**	0.49**	1.23**	0.40**	0.51**	0.36**	0.40**	2.62**	4.56**	2.32**	1.93**	1.76**	2.49**
h2H2 (No.of Gene Groups)	0.55	1.21	1.92	0.33	-0.04	2.03	1.21	3.41	0.12	0.12	0.96	0.01	1.84	0.27
h ² (Heritability in Narrow Sense)	0.20	0.23	0.03	0.10	0.09	0.11	0.13	0.12	0.12	0.07	0.22	0.26	0.30	0.27

Table-5 : Estimates of components of genetic variances for yield and its contributing attributes in three environments for F₁ generation.

	Grains/ Spike E1F1	Grains/ Spike E1F2	Grains/ Spike E2F1	Grains/ Spike E2F2	Grains/ Spike E3F1	Grains/ Spike E3F2	1000-gr ain Weight (g) E1F1	1000-gr ain Weight (g) E1F2	1000-gr ain Weight (g) E2F1	1000-gr ain Weight (g) E2F2	1000-gr ain Weight (g) E3F1	1000-gr ain Weight (g) E3F2	Harvest Index (%) E1F1	Harvest Index (%) E1F2
D (Additive Effect)	20.89	19.63	20.28**	21.15	11.88	11.84	5.60	4.61	8.73**	8.44**	1.22	0.49	4.20	3.88
F (Mean Fr over arrays)	36.06	37.03	17.33	18.48	21.76	22.03	11.22	11.41	6.66	5.11	2.61	0.51	1.94	-0.76
H1(Dominance Effect)	145.28**	161.60**	113.25	126.21**	113.63**	104.02**	101.95**	89.65**	36.35**	36.52**	30.75**	24.83**	152.12**	102.83**
H2	117.22**	135.30**	101.64**	112.14**	89.46**	81.33**	88.37**	75.14**	32.71**	33.27**	27.21**	23.17**	135.27**	88.31**
h ² (Heritability)	-0.16	9.86	94.81**	75.37**	28.35**	0.44	75.03**	36.88**	5.06**	6.49**	41.74**	7.08**	10.58	0.24
E (Environ.Comp.)	0.86	2.12	2.23	1.36	1.44	1.47	0.80	1.79	1.09	1.38*	0.84	1.56*	1.54	1.85
Mean Degree of Dominance	2.64	2.87	2.36	2.44	3.09	2.96	4.27	4.41	2.04	2.08	5.03	7.10	6.02	5.15
: : of Genes with +/- Effects in Parents	0.20	0.21	0.22	0.22	0.20	0.20	0.22	0.21	0.23	0.23	0.22	0.23	0.22	0.22
::of Dominant & Recessive Genes in Parents	1.97	1.98	1.44	1.44	1.84	1.92	1.61	1.78	1.46	1.34	1.54	1.16	1.08	0.96
Va (Additive Gene Effects)	6.45	4.45	7.28	8.37	7.14	6.23	3.98	3.86	2.86	3.29	1.08	0.82	9.55	9.59
Vd (Dominance Deviations)	29.30**	33.83**	25.41**	28.03**	22.37**	20.33**	22.09**	18.79**	8.18**	8.32**	6.80**	5.79**	33.82**	22.08**
h2 / H2 (No.of Gene Groups)	-0.00	0.07	0.93	0.67	0.32	0.01	0.85	0.49	0.16	0.20	1.53	0.31	0.08	0.00
h ² (Heritability in Narrow Sense)	0.18	0.11	0.21	0.22	0.23	0.22	0.15	0.16	0.24	0.25	0.12	0.10	0.21	0.29

Table-6 : Estimates of components of genetic variances for yield and its contributing attributes in three environments for F₁ generation.

	Harvest Index (%) E2F1	Harvest Index (%) E2F2	Harvest Index (%) E3F1	Harvest Index (%) E3F2	Grain Yield/Plant (g) E1F1	Grain Yield/Plant (g) E1F2	Grain Yield/Plant (g) E2F1	Grain Yield/Plant (g) E2F2	Grain Yield/Plant (g) E3F1	Grain Yield/Plant (g) E3F2
D (Additive Effect)	9.99*	10.06*	9.20**	8.73**	24.70**	24.93**	22.13**	21.86**	3.65**	4.15**
F (Mean Fr over arrays)	10.57	9.96	5.71*	5.22	39.83**	46.24**	31.31**	33.14**	0.90	1.37
H1(Dominance Effect)	44.43**	66.85**	16.15**	30.49**	69.47**	81.40**	122.22**	38.03**	13.89**	11.40**
H2	38.87**	59.67**	12.70**	25.47**	50.13**	56.38**	99.65**	22.30**	13.38**	10.81**
h ² (Heritability)	-0.09	14.78**	0.62	35.76**	11.69	28.19**	167.25**	-0.06	24.73**	-0.31
E (Environ.Comp.)	1.45	1.34	0.76*	1.23	1.79	1.57	1.15	1.41	1.57**	1.07
Mean Degree of Dominance	2.11	2.56	1.33	1.87	1.68	1.81	2.35	1.32	1.95	1.66
: : of Genes with +/- Effects in Parents	0.22	0.22	0.12	0.21	0.18	0.17	0.20	0.15	0.24	0.24
: : of Dominant & Recessive Genes in Parents	1.67	1.48	1.61	1.38	2.85	3.11	1.86	3.70	1.14	1.22
Va (Additive Gene Effects)	2.49	3.64	3.47	4.26	2.11	1.85	6.69	2.22	1.63	1.69
ntb/Vd (Dominance Deviations)	9.72**	14.92**	3.17**	6.37**	12.53**	14.10**	24.91**	5.58**	3.35**	2.70**
h2 / H2 (No.of Gene Groups)	-0.00	0.25	0.05	1.40	0.23	0.50	1.68	0.00	1.85	-0.03
h ² (Heritability in Narrow Sense)	0.18	0.18	0.47	0.36	0.13	0.11	0.20	0.24	0.25	3.31

preponderance of dominance gene action. These findings were supported by Menon and Sharma (1997), Dhayal *et al.* (2003) and Al-Nagar (2015).

In the present investigation H₂/4H₁ ratio was less than 0.25 for the characters in both the generation which evinced unequal distributions of positive and negative alleles in the parents. Similar findings were obtained by Singh *et al.* (2003), Tammam and Abd El-Rady (2011) and Yao *et al.* (2011). The ratio of dominant and recessive alleles $[(4DH1)^{1/2} + F / (4DH1)^{1/2} - F]$ was more than unity for above characters studied which demonstrated the accumulation of recessive alleles. Innamullah *et al.* (2006) and Singh *et al.* (2007) also established the same findings. Narrow sense heritability estimates obtained in component analysis ranged from low to high for different traits. The lower value of heritability clearly indicated that it was much influenced by environment.

Graphical analysis according to Hayman (1954b) revealed partial to over dominance for different characters with the sowing dates. Such discrepancy in the results may be partly attributed to the partial failure of diallel assumptions.

For instance, in case days to heading, over dominance was exhibited in both the generations of E₃, partial dominance was exhibited in E₂F₁ while complete dominance was observed in E₁ for both the generations (Figure 1-6). In the present investigation, all three types of dominance was obtained for days to heading, days to maturity, number of tillers per plant, spike area, number of grains per spike and harvest index. Both partial and over dominance was observed for grain filling period, plant height, peduncle area and 1000-grain weight, while complete and over dominance was observed for grain yield per plant. Two characters namely flag leaf area and grain yield per spike depicted only over dominance. Zare-kohan and Heidari (2012), Adel and Ali (2013), Kaukab *et al.* (2013), Kaukab *et al.* (2014), Ljubcic *et al.* (2014), Fellahi *et al.* (2015) and Shehzad *et al.* (2015) supported the present findings.

The scattering of array points indicated the existence of genetic diversity among the parents for most of the traits. An overall appraisal revealed that among the parents, Raj 4079 and DBW 17 in E₁F₁ and E₁F₂, Raj 3765 and DBW-621-50 in E₃ for both the generations, Raj 3077 in E₂F₁, DBW-621-50 and Raj 3077 in E₂F₂ for days to heading DBW 621 50 and Raj 3077 in E₁ for both the generations and in E₂F₂, Raj 3077 and HD 2967 in E₂F₁, DBW 621 50 and Raj 4079 in E₃F₁, Raj 3765 and DBW 621 50 in E₃F₂ for days to maturity; parent Raj 3077 and DBW 17 in E₁ for both the generations, Raj 3077 in E₂ for both the generations, Raj 4238 in E₃ for grain filling

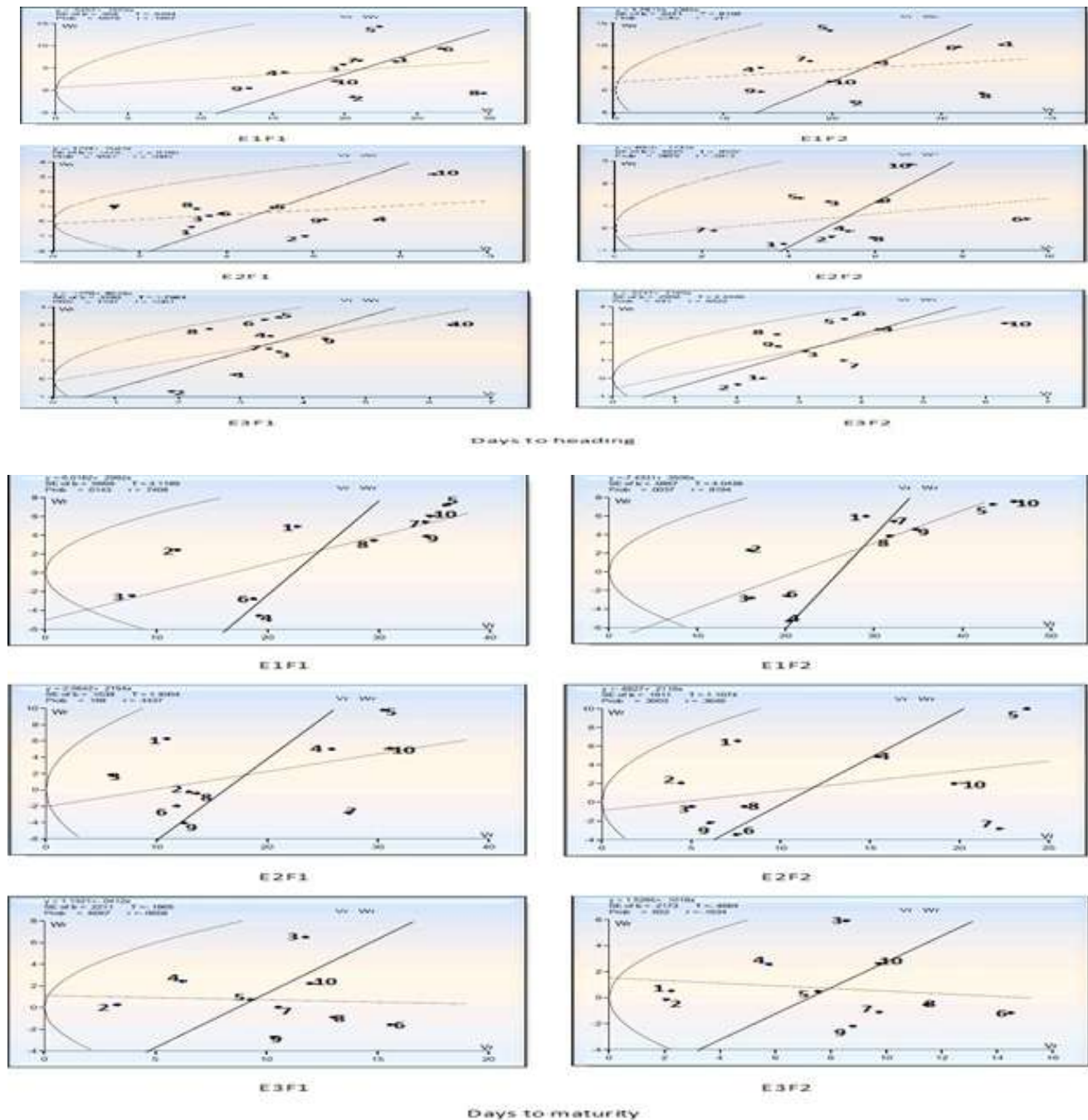


Fig-1

period; Raj 3765 and DBW 621 50 in E_1 Raj 3077 in E_2 and Raj 4079 in E_3 for plant height; parent DBW 621 50 in E_1 for both the generations, Raj 3077 in E_2F_1 , Raj 3077 and Raj 4083 in E_2F_2 , Raj 3765 and Raj 4238 in E_3F_1 and Raj 3077 and Raj 4238 in E_3F_2 for flag leaf area; Raj 3765 and Raj 4079 in E_1F_1 , Raj 4083 and DBW 88 in E_1F_2 , Raj 4238 in E_2 for both the generations, DBW 621 50 and Raj 4079 in E_3F_1 and E_3F_2 for number of tillers per plant; parent DBW 17 in E_1 and E_2 for F_1 generation, DBW 621 50 in E_1F_2 , Raj 3077 in E_2F_2 , Raj 4079 in E_3F_1 and Raj 3765 in E_3F_2 for spike length DBW 621 50 in E_1 for both

the generations, Raj 3765 in E_2 for both the generations, Raj 3765 and Raj 4079 in E_3F_1 , DBW 621 50 and Raj 4079 in E_3F_2 for number of grains per spike; DBW 621 50 in E_1 for both the generations, DBW 621 50 and DBW 17 in E_2 for both the generations, HD 2967 in E_2F_1 and DBW 88 in E_2F_2 for 1000-grain weight; DBW 88 in E_1F_1 and E_2F_2 , Raj 3077 and DBW 88 in E_1F_2 , DBW 621 50 and Raj 3077 in E_2F_1 Raj 3765 and HD 2967 in E_3 for harvest index and DBW 621 50 in E_1F_1 and E_1F_2 , DBW 17 in E_2F_1 and E_3F_1 , Raj 3077 in E_2F_2 and Raj 3765 in E_3F_2 for grain yield per plant had relatively maximum dominant genes.

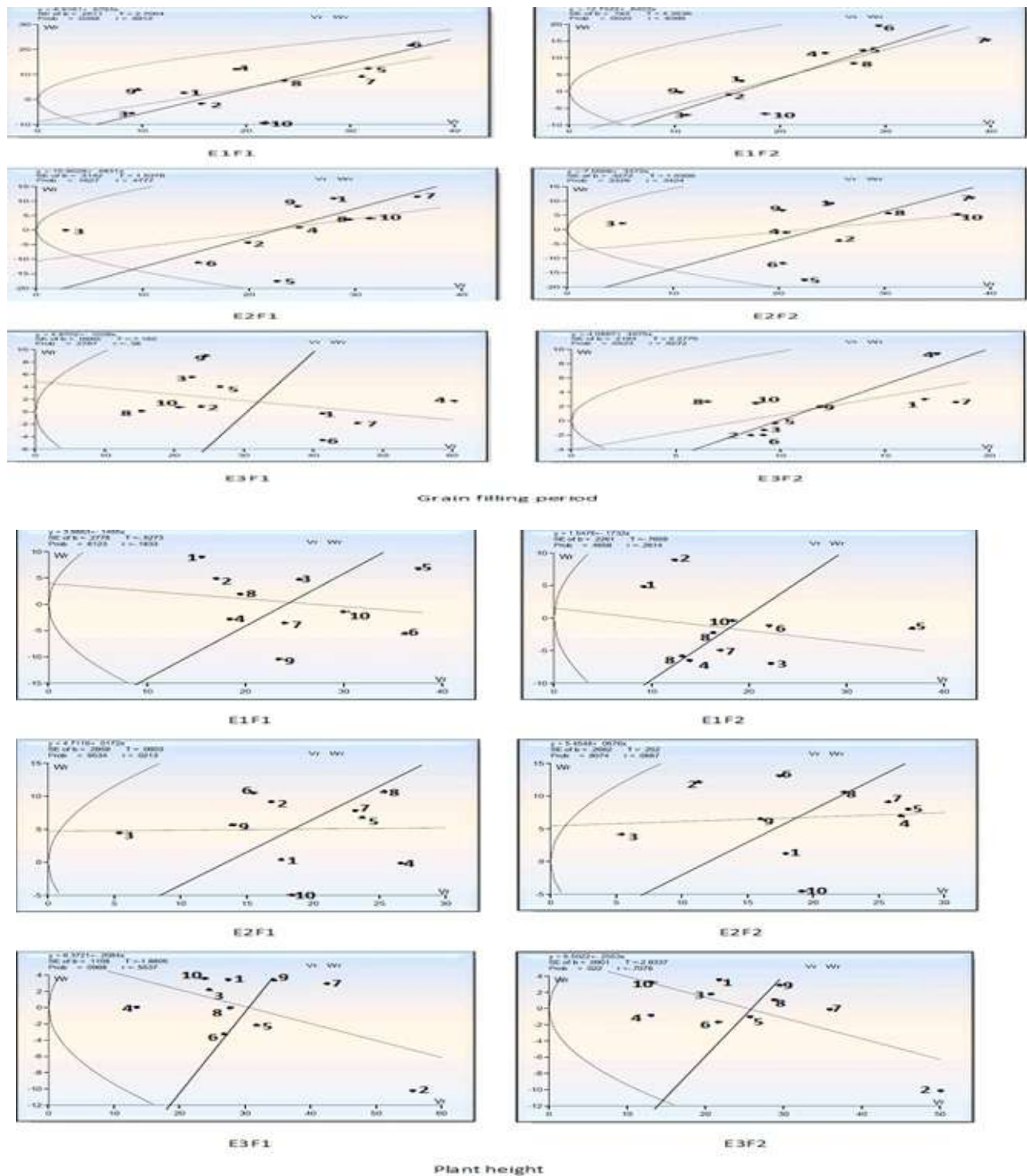


Fig-2

These parents may be used in crossing programme for the improvement of different yield components for tangible advancement of wheat. The phenotypic expression of an attribute is the sum of genotype, environment and their interaction. The genetic makeup of attributes comprises of additive, dominance and epistasis. The information of the relative degree of genetic variance

components is fundamental in the selection of appropriate breeding methodologies. The breeders of self-pollinated crop like wheat will have to lay more emphasis in the exploitation of additive gene action. Additive, additive x additive type epistasis, which can be exploited in homozygous state, is also of considerable value. A number of studies on grain yield and its contributing traits

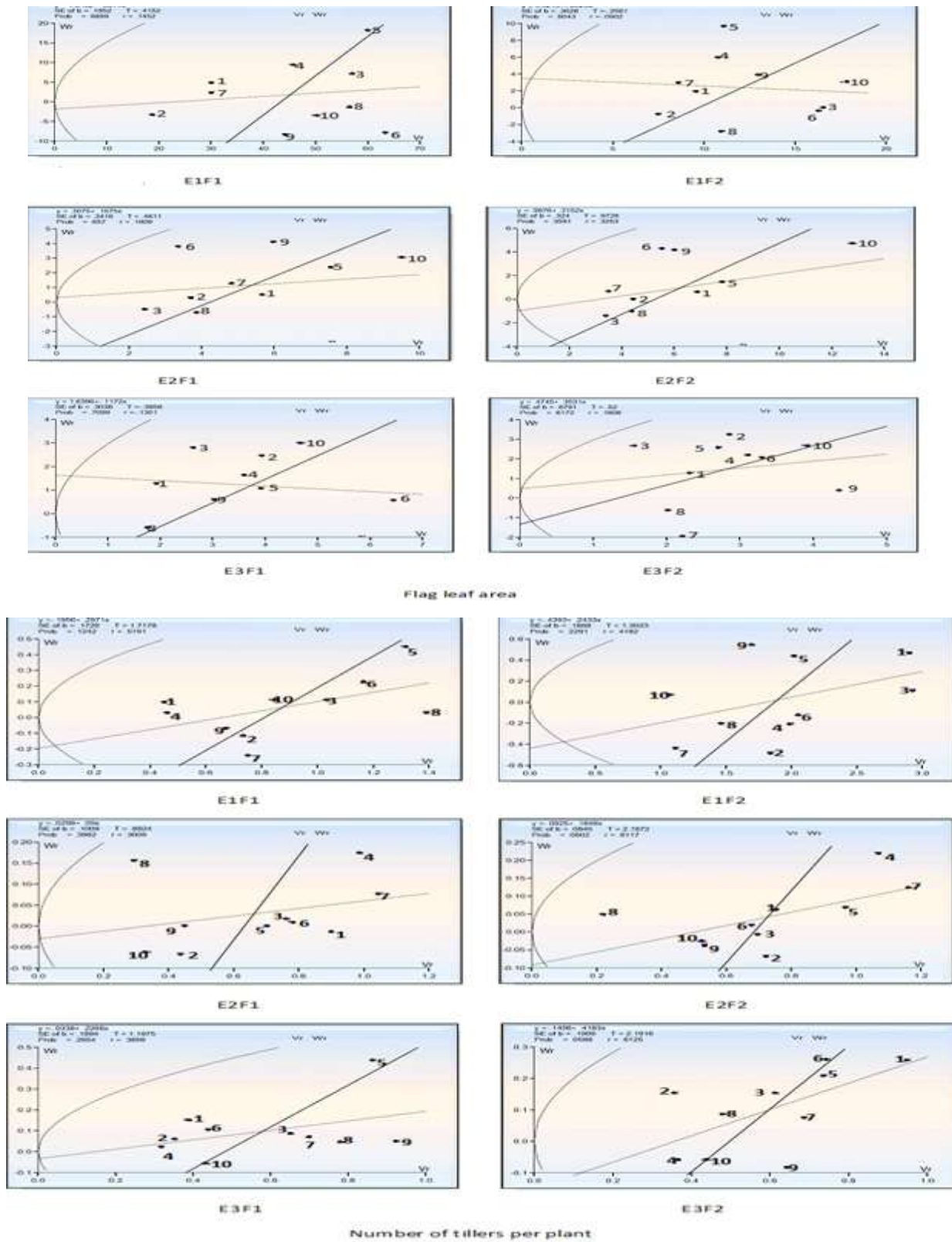


Fig-3

have shown the prevalence of different type of gene actions. Hence, the knowledge of prevalence of different type of gene actions in the present set of material is also

required for formulating effective breeding programme for the improvement of particular trait under desirable environment showing simple inheritance

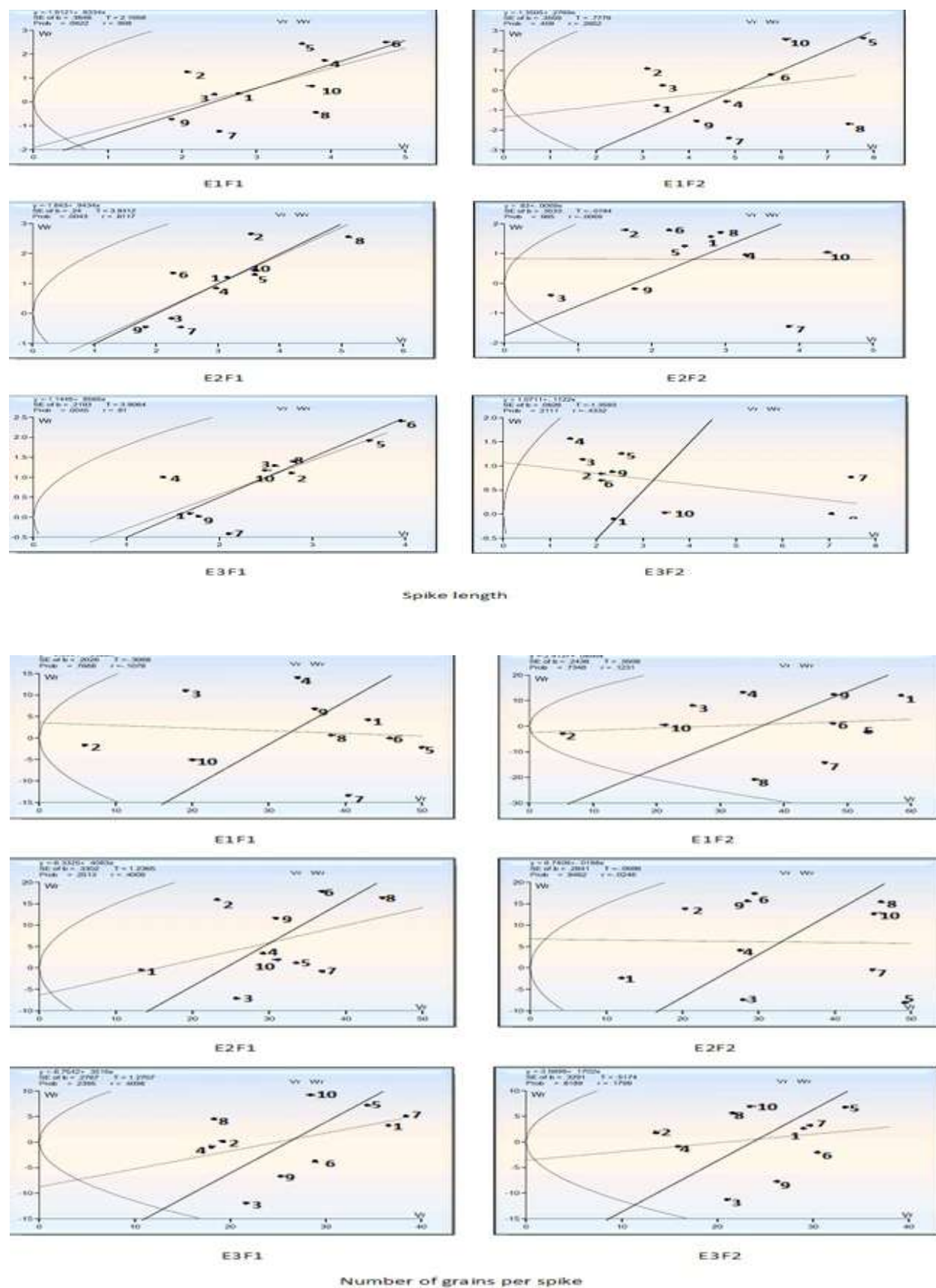


Fig-4

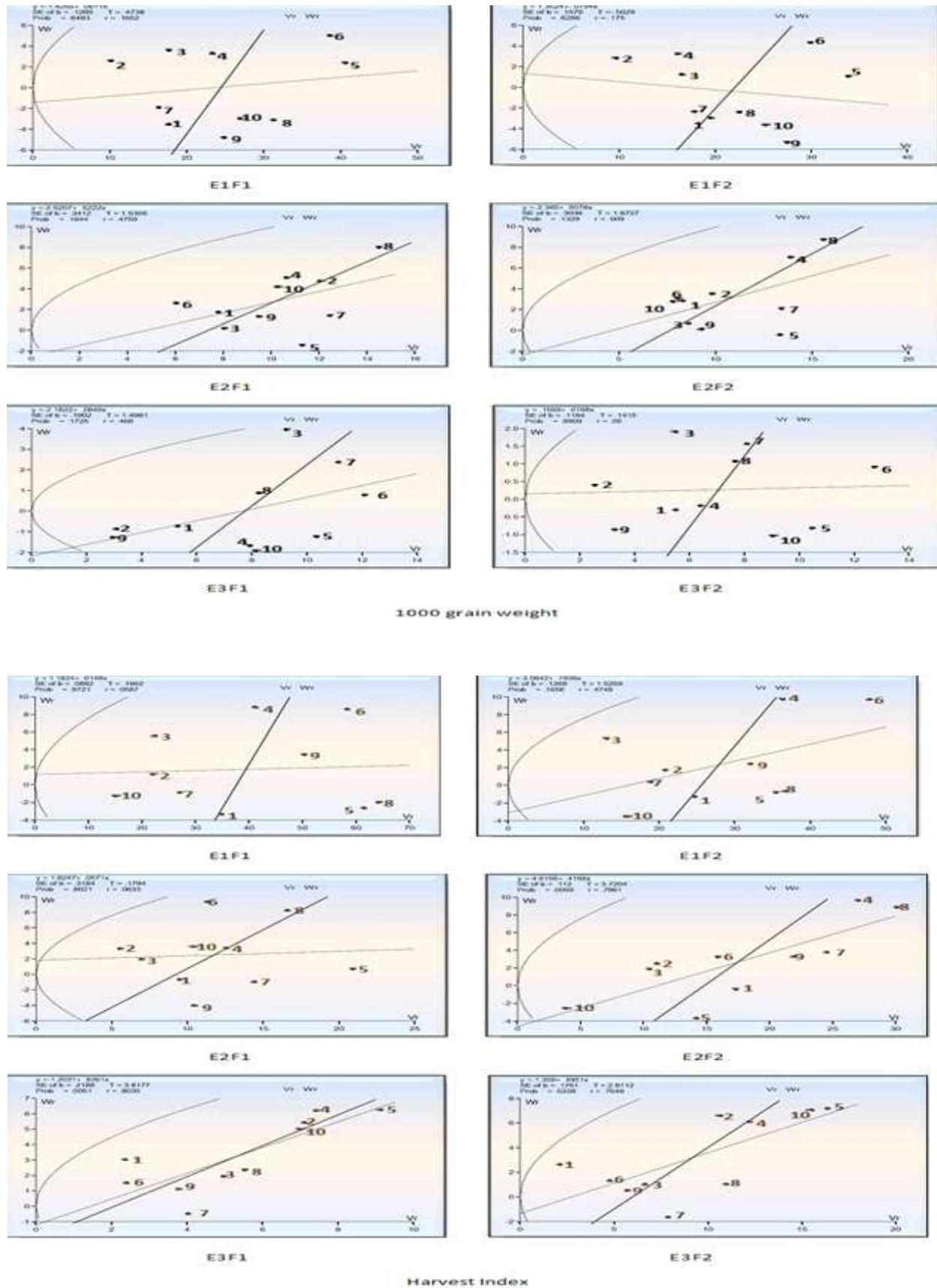


Fig-5

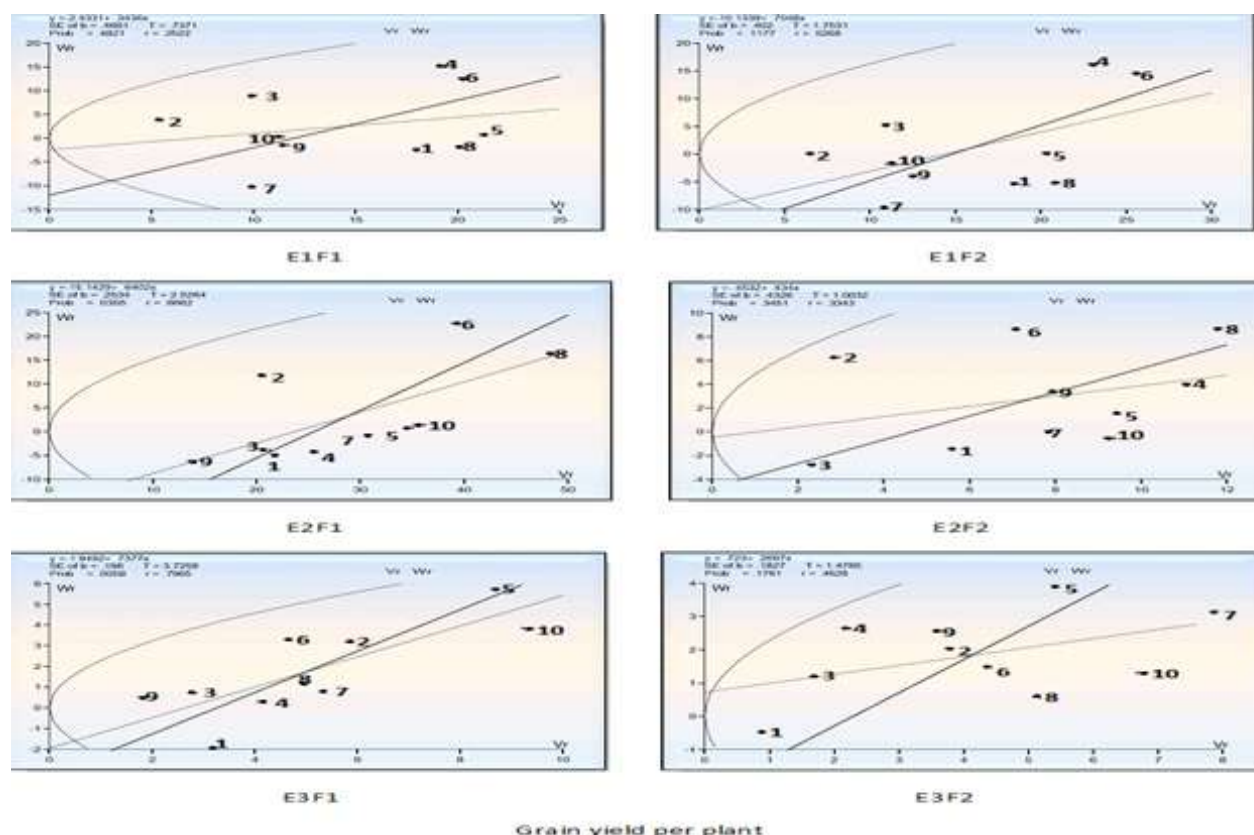


Fig-6

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Study of Heterosis and Heterobeltiosis for Yield and Some of its Associated Characters Over the Environments in Bread Wheat (*Triticum aestivum* L. em. Thell.)

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Abstract

In order to study the heterosis and heterobeltiosis for yield and some of its attributing characters in bread wheat (*Triticum aestivum* L.em. Thell) over the environments, the present experiment was carried out using diallel analysis following Griffing (1956) Method II Model I. In this study 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 in three environments viz. normal, late and very late sown created by different date of sowing during Rabi 2015-16 at Agricultural Research Farm of RARI Durgapura. Sufficient degree of heterosis and heterobeltiosis was observed for all the characters. Among top three crosses for grain yield per plant in all the environments, cross Raj 4238 X DBW 88 showed desirable heterosis and heterobeltiosis for one or more characters in all the environments.

Introduction

Wheat is one of the most important food crop and cereal crop. There is noteworthy production in the production and productivity of wheat but still it needs much improvement in the yield and quality as it is a staple food of more than one billion people and still the population is burgeoning. Increased yield of concerned crop remains the fundamental objective of most of plant breeding program by developing improved varieties through heterotic expression. The estimates of heterosis provide information about the type of gene action involved in the expression of various quantitative traits.

Materials and Methods

Ten diverse wheat varieties selected as the experimental material on the basis of their stability for different yield traits and genetic diversity. These varieties were crossed in diallel mating fashion excluding reciprocals to obtain 45 F₁s 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 at Agricultural Research Farm of RARI, Durgapura.

Observations were recorded on characters viz. days to heading, days to maturity, 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 the selected plants were used for statistical analysis.

Heterosis (%) of a cross was calculated by the following formula :

$$\text{Heterosis in per cent} = \frac{\bar{F}_1 - \bar{MP}}{\bar{MP}} \times 100$$

while heterobeltiosis (%) of a cross was calculated by the following formula as suggested by Fonseca and Patterson (1968) :

$$\text{Heterobeltiosis in per cent} = \frac{\bar{F}_1 - \bar{BP}}{\bar{BP}} \times 100$$

Results and Discussion

The commercial utilization of heterosis is regarded as magnificent implementation of genetics in the plant breeding. The economic importance of heterosis in a crop relies on its exploitation, utilization and practicability of hybrid seed production. Wheat is a self-pollinated crop in which an appropriate procedure of hybrid seed production at commercial scale is not yet available. As a consequence, the heterosis *per se* may not be of economic value in this crop at present. Nevertheless, for deciding the direction of future breeding programme and to select the promising crosses to obtain better segregants in advance generations for further amelioration of grain yield, knowledge of degree and magnitude of heterosis is imperative. In the present study, the presence of heterosis was exhibited by almost all the characters in all the three environments showed.

Mackey (1976) has described the genetic principles of expression of heterosis superior to the better parent may result from one or more of the situations i.e.

Table 1.1 : Estimates of heterosis and heterobeltiosis.

Days to heading

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMEN T3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	4.16**	-0.03	-0.80	-1.53	0.17	-3.84**
P1XP3	5.62**	1.82	-3.03**	-4.87**	-4.32**	-8.43**
P1XP4	3.41*	2.11	1.95	1.12	-2.77*	-4.00**
P1XP5	6.19**	3.45	0.12	0.00	-3.33**	-6.05**
P1XP6	1.27	-2.16	-1.70	-3.06*	-4.81**	-8.85**
P1XP7	4.14**	3.45	-3.20**	-4.45**	2.36	1.69
P1XP8	-11.96**	-13.52**	-4.46**	-4.72**	-0.68	-3.12*
P1XP9	-6.98**	-8.32**	5.09**	3.99**	3.74**	2.21
P1XP10	1.12	-1.88	1.74	1.14	3.52**	0.24
P2XP3	-4.04**	-4.48**	-5.26**	-6.38**	-5.53**	-5.83**
P2XP4	-9.67**	-12.23**	6.71**	5.06**	2.55*	-0.35
P2XP5	4.17**	-2.50	0.07	-0.55	-0.84	-2.09
P2XP6	6.88**	-0.74	-2.41*	-3.06*	-1.83	-2.08
P2XP7	-0.39	-5.01**	-2.05	-4.01**	4.07**	0.53
P2XP8	-12.34**	-14.39**	1.43	0.96	0.47	-1.17
P2XP9	-4.72**	-7.25**	-1.34	-3.09*	4.97**	2.22
P2XP10	2.62	1.47	6.50**	5.10**	0.21	-0.69
P3XP4	-0.41	-2.80	-3.69**	-6.28**	-0.65	-3.75**
P3XP5	9.28**	2.72	1.85	0.03	1.96	0.35
P3XP6	-9.50**	-15.60**	-3.52**	-4.02**	-0.58	-0.63
P3XP7	2.32	-2.00	-1.38	-4.47**	0.48	-3.23*
P3XP8	-3.37*	-5.21**	-3.35**	-4.92**	0.01	-1.93
P3XP9	-3.60*	-5.74**	2.10	-0.87	3.79**	0.76
P3XP10	1.96	1.28	1.52	-0.98	-2.57*	-3.75**
P4XP5	7.42**	3.36	6.13**	5.14**	-0.92	-2.51
P4XP6	-5.79**	-10.08**	0.40	-1.79	-1.67	-4.69**
P4XP7	-0.19	-2.10	-1.91	-2.38	-1.17	-1.78
P4XP8	5.33**	4.78**	1.72	0.61	-2.10	-3.31*
P4XP9	1.91	1.72	8.83**	8.57**	-1.44	-1.66
P4XP10	1.52	-0.26	0.61	0.37	-6.73**	-8.56**
P5XP6	-0.07	-0.91	1.89	0.59	-0.57	-2.08
P5XP7	-5.10**	-6.95**	-1.95	-3.32**	-2.24	-4.39**
P5XP8	-1.85	-6.03**	0.77	0.61	-2.96*	-3.32*
P5XP9	0.54	-3.44	0.24	-0.93	-0.86	-2.24
P5XP10	0.20	-5.21**	8.07**	7.31**	1.68	1.31
P6XP7	7.17**	4.22*	-1.31	-3.92**	-1.62	-5.21**
P6XP8	5.08**	-0.21	-1.91	-3.01*	-0.74	-2.60
P6XP9	1.94	-2.88	-4.34**	-6.65**	-2.10	-4.91**
P6XP10	9.87**	3.12	4.97**	2.91*	1.53	0.35
P7XP8	-9.68**	-11.86**	-4.89**	-6.37**	-2.84*	-4.62**
P7XP9	9.39**	7.10**	-1.21	-1.44	-0.84	-1.66
P7XP10	1.72	-1.94	-3.16**	-3.85**	-5.62**	-8.02**
P8XP9	4.30**	3.95*	0.48	-0.85	-1.03	-2.04
P8XP10	-11.74**	-12.83	-0.39	-1.25	0.87	0.12
P9XP10	-6.69**	-8.16	0.00	-0.47	-3.41**	-5.09**
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	2.413	3.140	1.533	1.995	1.539	2.002
BP	2.786	3.625	1.771	2.304	1.777	2.311
S.E.D.						
MP	1.197			0.761		0.763
BP	1.383			0.879		0.882

Table-1.2 : Estimates of heterosis and heterobeltiosis.

Days to maturity

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMEN T3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	5.87**	5.36**	-3.17	-4.18*	-0.36	-1.42
P1XP3	2.13	1.59**	-1.91	-3.20	-3.11*	-5.41**
P1XP4	6.23**	4.97**	-4.80**	-7.10**	-5.35**	-7.74**
P1XP5	3.65**	2.41	-1.47	-3.17	-0.70	-1.74
P1XP6	-0.25	-1.03	-5.74**	-6.87**	-3.74*	-4.26*
P1XP7	3.80**	3.66*	-3.76*	-4.48*	-5.82**	-6.32**
P1XP8	-4.21**	-5.36**	-4.10*	-5.67**	-1.23	-2.13
P1XP9	-0.90	-1.61	2.24	2.08	-0.18	-0.35
P1XP10	5.81**	5.63**	-0.91	-2.69	0.02	-1.42
P2XP3	5.03**	3.98**	-1.19	-3.49	-3.85**	-7.09**
P2XP4	3.00*	1.31	3.24*	-0.28	-2.66	-6.10**
P2XP5	0.33	-0.39	2.22	-0.58	-7.09**	-9.03**
P2XP6	0.75	-0.50	3.51*	3.35	-1.98	-2.51
P2XP7	3.85**	3.49*	3.55*	3.23	-5.17**	-6.67**
P2XP8	3.62**	2.86	7.67**	7.01**	-1.60	-1.76
P2XP9	5.55**	5.29**	1.81	0.60	-0.89	-2.12
P2XP10	7.79**	7.46**	8.76**	7.93**	-0.70	-1.09
P3XP4	3.03*	2.36	-6.03**	-7.10**	-5.90**	-6.06**
P3XP5	6.33**	4.51**	-0.14	-0.58	-3.08*	-4.39**
P3XP6	0.28	0.03	-1.94	-4.36*	-7.13**	-9.80**
P3XP7	7.88**	7.16**	-1.78	-3.78*	-7.06**	-8.78**
P3XP8	4.99**	3.18*	-1.20	-4.07*	-8.18**	-11.15**
P3XP9	6.36**	5.04**	1.47	0.29	-8.81**	-10.81**
P3XP10	5.52**	4.77**	2.25	-0.87	-5.94**	-9.46**
P4XP5	8.56**	6.02**	1.29	0.57	-1.20	-2.69
P4XP6	-5.90**	-6.28**	-1.91	-5.40**	0.69	-2.36
P4XP7	1.06	-0.26	-10.26**	-13.07**	-2.75	-4.71**
P4XP8	4.11**	1.66	-2.66	-6.53**	-4.51**	-7.74**
P4XP9	3.51**	1.57	-3.20*	-5.40**	-3.45*	-5.72**
P4XP10	-0.23	-1.57	3.11	-1.14	0.55	-3.37*
P5XP6	-2.02	-3.93**	0.30	-2.59	3.00*	1.39
P5XP7	-1.65	-2.69	-10.78**	-12.97**	0.87	0.35
P5XP8	1.63	1.61	-3.43*	-6.63**	2.68	0.69
P5XP9	-4.55**	-5.02**	-8.64**	-10.09**	-0.18	-1.04
P5XP10	-4.87**	-5.84**	-1.79	-5.19**	5.01**	2.43
P6XP7	5.21**	4.25**	-1.37	-1.82	3.55*	2.46
P6XP8	4.72**	2.67	2.88	2.41	6.50**	6.09**
P6XP9	4.48**	2.93*	-1.36	-2.68	6.41**	5.65**
P6XP10	6.05**	5.04**	7.69**	7.03**	5.99**	5.02**
P7XP8	-2.72*	-3.76*	-4.89**	-5.76**	1.80	0.35
P7XP9	9.51**	8.87**	3.30*	2.38	-4.93**	-5.26**
P7XP10	-3.19*	-3.23*	-7.81**	-8.79**	0.20	-1.75
P8XP9	9.89**	9.34**	0.61	-1.19	1.45	0.35
P8XP10	-1.32	-2.34	-0.15	-0.31	-4.13**	-4.65**
P9XP10	3.06*	2.50	5.31**	3.27	-1.95	-3.53*
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	3.198	4.160	3.667	4.770	2.710	3.526
BP	3.692	4.804	4.234	5.508	3.129	4.071
S.E.D						
MP		1.587		1.819		1.345
BP		1.832		2.101		1.553

Table-1.3 : Estimates of heterosis and heterobeltiosis.

Grain filling period

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMEN T3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	2.22	-7.52**	-3.16	-14.24**	-40.54**	-43.97**
P1XP3	3.84	-3.63	-7.53**	-16.57**	-6.30*	-10.71**
P1XP4	-2.60	-3.76	-17.86**	-19.15**	-44.75**	-45.21**
P1XP5	-8.76**	-9.26**	-18.58**	-25.09**	-25.47**	-33.47**
P1XP6	-3.29	-4.23	-29.38**	-36.14**	-10.93**	-18.17**
P1XP7	6.72**	3.59	5.72*	0.00	-46.90**	-47.01**
P1XP8	16.72**	6.41**	-11.76**	-22.68**	-25.23**	-30.08**
P1XP9	-13.56**	-19.52**	-14.76**	-14.82**	-19.46**	-20.93**
P1XP10	1.90	-5.87**	-3.64	-12.51**	-40.50**	-43.10**
P2XP3	14.78**	11.65**	6.47*	4.26	-40.59**	-41.29**
P2XP4	-4.01	-14.09**	-9.10**	-18.37**	-49.47**	-52.75**
P2XP5	-17.24**	-24.76**	27.02**	21.80**	-40.47**	-43.80**
P2XP6	-12.36**	-21.40**	20.58**	17.79**	-45.29**	-46.75**
P2XP7	-16.87**	-22.70**	12.22**	4.62	-33.40**	-37.37**
P2XP8	0.42	-0.43	22.76**	21.28**	-37.18**	-37.69**
P2XP9	-6.28**	-9.14**	2.96	-8.76**	-33.48**	-36.21**
P2XP10	8.49**	6.04*	32.02**	28.40**	-25.53**	-26.69**
P3XP4	-12.08**	-19.30**	-7.60**	-15.42**	-7.90**	-12.91**
P3XP5	-10.94**	-16.92**	0.91	-1.23	-7.13*	-13.31**
P3XP6	-2.26	-10.10**	6.03*	5.77	-9.67**	-13.09**
P3XP7	0.83	-3.73	0.42	-4.49	-8.35**	-12.84**
P3XP8	17.40**	15.15**	-1.01	-4.21	-16.04**	-17.70**
P3XP9	9.58**	9.21**	-10.27**	-18.98**	-24.79**	-27.03**
P3XP10	3.38	2.86	10.36**	9.59**	-25.37**	-25.64**
P4XP5	-13.94**	-15.43**	-15.26**	-20.88**	-10.20**	-20.41**
P4XP6	-0.84	-1.05	-4.14	-12.06**	-52.50**	-56.69**
P4XP7	2.16	-1.98	-26.19**	-29.12**	-48.62**	-48.93**
P4XP8	3.72	-6.46**	19.24**	5.94*	-17.52**	-23.46**
P4XP9	-3.92	-11.53**	-3.66	-5.10*	-34.69**	-36.40**
P4XP10	-16.33**	-23.55	-2.37	-10.06**	-45.37**	-48.16**
P5XP6	6.06**	4.46*	0.95	-0.94	-35.46**	-37.47**
P5XP7	4.04*	1.53	-5.93*	-8.65**	-6.42*	-16.63**
P5XP8	9.81**	0.62	15.30**	9.29**	-12.34**	-16.61**
P5XP9	2.48	-4.10	-28.49**	-34.16**	-32.27**	-38.53**
P5XP10	-17.24**	-23.16**	-4.49	-5.87*	-36.27**	-40.72**
P6XP7	-18.18**	-21.33**	-10.35**	-14.54**	-46.54**	-50.99**
P6XP8	-14.00**	-22.29**	9.01**	5.24	-9.92**	-11.62**
P6XP9	-8.02**	-15.14**	-10.62**	-19.12**	-43.63**	-47.32**
P6XP10	-21.74**	-28.35**	4.59	4.12	-37.95**	-40.52**
P7XP8	11.30**	4.32	-19.20**	-25.51**	-14.53**	-20.24**
P7XP9	-12.57**	-16.25**	-0.518	-5.82*	-27.19**	-28.67**
P7XP10	11.08**	5.55*	-23.02**	-26.30**	-32.91**	-35.97**
P8XP9	0.23	-2.01	-4.50	-16.26**	-31.06**	-34.40**
P8XP10	16.34**	14.68**	-9.92**	-13.42**	-32.61**	-34.18**
P9XP10	-3.92	-4.72	7.43**	-2.39	-28.70**	-30.58**
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	1.973	2.568	2.012	2.618	2.185	2.842
BP	2.279	2.965	2.323	3.023	2.523	3.282
S.E.D						
MP		0.979		0.998		1.084
BP		1.131		1.153		1.252

Table-1.4 : Estimates of heterosis and heterobeltiosis.
Plant height

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	-3.99*	-6.48**	-2.30	-8.55**	21.63**	19.03**
P1XP3	-2.91	-7.63**	1.60	-3.57	13.19**	12.12**
P1XP4	1.39	0.85	-10.36**	-14.50**	9.46**	3.02
P1XP5	3.89*	-2.53	0.73	-1.43	14.44**	9.37**
P1XP6	4.69*	-0.52	-3.33	-5.96*	14.27**	10.53**
P1XP7	-0.46	-2.07	-5.70*	-10.37**	18.14**	15.96**
P1XP8	1.62	0.97	-11.17**	-15.95**	12.51**	4.48
P1XP9	10.07**	9.25**	10.23**	8.24**	-1.80	-6.48*
P1XP10	1.33	1.28	3.77	0.62	-3.43	-7.39**
P2XP3	7.08**	-0.63	-3.93	-5.33*	19.85**	18.39**
P2XP4	0.48	-2.63	-13.96**	-15.65**	0.53	-3.41
P2XP5	1.09	-7.44**	-0.18	-4.62	-11.23**	-13.36**
P2XP6	-2.78	-9.87**	3.08	-5.97*	-15.63**	-16.63**
P2XP7	-5.29**	-9.20**	-2.77	-4.34	-15.77**	-16.02**
P2XP8	-1.74	-3.68	-2.36	-3.46	-16.33**	-20.70**
P2XP9	-2.93	-6.12**	-7.03**	-14.44**	-1.39	-4.09
P2XP10	-10.86**	-13.20**	-1.74	-5.25*	-1.35	-3.37
P3XP4	2.66	-1.84	-4.55*	-5.05*	-2.77	-7.68**
P3XP5	7.96**	6.40**	2.01	-1.13	-3.26	-6.70*
P3XP6	18.92**	18.79**	-1.07	-8.53**	0.18	-2.20
P3XP7	3.20	-0.26	-6.74**	-6.89**	7.63**	6.63*
P3XP8	5.13**	-0.60	-2.54	-2.87	9.34**	2.44
P3XP9	7.68**	3.16	3.57	-3.38	16.26**	11.74**
P3XP10	-1.53	-6.29**	2.11	-0.11	12.29**	8.67**
P4XP5	2.42	-3.42	4.47*	1.76	-7.59**	-9.07**
P4XP6	15.18**	10.01**	-4.87*	-11.61**	-5.40*	-8.05**
P4XP7	2.96	1.82	-14.02**	-14.33**	0.94	-3.29
P4XP8	-7.88**	-8.96**	-15.26**	-15.99**	-7.05**	-8.36**
P4XP9	-2.01	-2.21	0.37	-5.91*	6.55**	5.22
P4XP10	-3.79*	-4.26*	-0.02	-1.70	8.36**	6.25*
P5XP6	19.51**	17.91**	7.64**	2.53	-15.61**	-16.65**
P5XP7	16.07**	10.61**	-14.30**	-16.81**	11.19**	8.21**
P5XP8	8.50**	1.19	-5.37*	-8.59**	0.12	-2.85
P5XP9	17.59**	11.10**	-6.36**	-9.98**	-9.33**	-9.66**
P5XP10	2.29	-3.98	2.28	1.32	-10.33**	-10.66**
P6XP7	0.06	-3.40	-2.66	-9.86**	-12.70**	-13.99**
P6XP8	1.28	-4.33*	-5.09*	-12.51**	-7.45**	-11.27**
P6XP9	4.50*	0.01	1.31	0.34	-13.83**	-15.20**
P6XP10	11.63**	6.13**	7.16**	1.15	-10.16**	-10.95**
P7XP8	-5.96**	-8.07**	-13.75**	-14.18**	0.46	-5.05
P7XP9	7.23**	6.26**	-4.17	-10.47**	12.41**	9.01**
P7XP10	9.04**	7.32**	-15.19**	-16.90**	8.31**	5.78*
P8XP9	-3.99*	-5.30**	0.17	-6.85**	7.14**	4.32
P8XP10	7.02**	6.28**	-10.74**	-12.97**	2.25	-1.13
P9XP10	-4.17*	-4.84*	4.03	-0.90	-1.78	-2.48
CD (%)	95%	99%	95%	99%	95%	99%
MP	3.282	4.270	3.426	4.457	2.995	3.897
BP	3.789	4.930	3.956	5.147	3.459	4.500
S.E.D						
MP		1.628		1.700		1.486
BP		1.880		1.963		1.716

Table-1.5 : Estimates of heterosis and heterobeltiosis.
Flag leaf area

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	23.76**	13.20	-15.75	-19.86	21.42	8.56
P1XP3	36.54**	30.75**	13.85	10.82	-15.70	-20.41
P1XP4	0.17	-9.43	26.07**	21.85*	4.54	1.28
P1XP5	2.57	-8.90	2.55	0.00	10.71	-0.56
P1XP6	13.12*	-4.17	5.76	-9.11	6.21	-11.17
P1XP7	7.42	-9.95	22.58*	18.63	11.87	1.19
P1XP8	56.64**	56.05**	21.03*	15.38	-12.58	-21.85*
P1XP9	32.75**	9.28	-5.71	-17.66*	-20.62*	-34.15**
P1XP10	21.66**	2.23	-12.74	-22.60*	-16.02	-29.43**
P2XP3	47.81**	29.99**	7.16	-0.65	-21.40*	-33.18**
P2XP4	27.03**	25.42**	-8.61	-10.11	20.36	10.76
P2XP5	8.08	4.62	-12.51	-14.72	13.09	12.51
P2XP6	-19.28**	-25.85**	-10.88	-19.94*	5.80	-19.06*
P2XP7	-14.61**	-22.47**	-7.38	-14.59	-32.16**	-44.45**
P2XP8	31.56**	19.98**	-10.34	-10.55	15.40	-6.47
P2XP9	24.76**	11.00*	-14.27	-21.67*	-2.45	-25.88**
P2XP10	9.60	-0.23	-36.32**	-40.85**	-15.49	-35.08**
P3XP4	24.94**	8.68	0.78	-5.08	-10.57	-18.04
P3XP5	-9.57	-22.66**	-17.36	-21.50	-15.83	-28.15**
P3XP6	56.01**	31.75**	-10.78	-25.03**	-37.48**	-45.07**
P3XP7	-2.43	-21.02**	19.04	18.33	-9.47	-13.51
P3XP8	55.25**	48.32**	2.02	-5.20	-7.41	-12.64
P3XP9	38.91**	10.54	-13.61	-26.27**	-10.68	-22.21**
P3XP10	-19.81**	-34.94**	-13.84	-25.35**	-20.30*	-29.62**
P4XP5	-23.00**	-24.52**	-27.38**	-28.04**	15.67	6.95
P4XP6	49.83**	39.27**	-12.16	-22.25**	-14.56	-30.33**
P4XP7	13.66*	4.39	26.27**	18.25	35.55**	19.19*
P4XP8	-9.77	-18.65**	-3.84	-5.20	-13.18	-24.52**
P4XP9	-25.28**	-32.76**	-27.76**	-34.98**	4.94	-15.10
P4XP10	-4.45	-11.99*	-13.41	-20.79*	-20.40*	-34.80**
P5XP6	41.90**	34.41**	-8.71	-19.83*	-30.68**	-46.77**
P5XP7	23.80**	15.84**	15.31	8.91	29.81**	6.72
P5XP8	48.03**	31.11**	11.73	9.16	-9.24	-26.15**
P5XP9	33.21**	22.07**	4.39	-6.79	5.66	-19.44*
P5XP10	-20.76**	-25.65**	-21.56*	-28.84**	-29.65**	-45.77**
P6XP7	-2.66	-3.91	-3.25	-19.10*	-36.28**	-41.65**
P6XP8	-4.10	-18.96**	-5.13	-14.96	-30.52**	-35.60**
P6XP9	0.81	-2.67	-7.68	-9.40	-30.20**	-30.90**
P6XP10	-35.15**	-35.80**	-8.93	-12.18	-45.83**	-46.14**
P7XP8	39.71**	16.82**	26.93**	17.29	-6.33	-7.56
P7XP9	-27.98**	-29.58**	-4.20	-18.65*	-23.85**	-30.90**
P7XP10	23.10**	22.73**	15.07	-0.81	-10.92	-18.00*
P8XP9	-10.43	-26.45**	-16.61*	-23.98**	-30.78**	-36.44**
P8XP10	54.69**	29.66**	4.41	-3.23	-31.55**	-36.21**
P9XP10	-24.14**	-26.04**	-14.16	-15.68	-22.10**	-23.32**
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	3.062	3.984	3.384	4.402	2.157	2.806
BP	3.536	4.601	3.907	5.083	2.490	3.240
S.E.D						
MP		1.519		1.679		1.070
BP		1.755		1.939		1.236

Table-1.6 : Estimates of heterosis and heterobeltiosis.
 Number of tillers per plant

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	7.69	0.00	-17.25	-22.63	-7.51	-17.58
P1XP3	2.72	-11.95	6.48	-1.70	-17.86	-30.78*
P1XP4	-7.69	-14.29	9.20	7.67	-19.77	-28.65
P1XP5	9.95	4.71	-18.34	-19.43	-12.84	-15.94
P1XP6	14.29	14.29	20.15	13.25	-24.09	-30.05*
P1XP7	12.82	4.76	-28.68*	-29.18*	-39.59**	-40.06**
P1XP8	33.33	14.29	11.63	5.10	-18.28	-23.60
P1XP9	0.00	0.00	3.99	-3.87	-16.32	-19.22
P1XP10	2.62	-4.71	-10.84	-16.03	-22.82	-34.06*
P2XP3	45.45*	33.33	-14.77	-15.94	14.55	7.47
P2XP4	16.67	16.67	1.79	-6.06	-8.18	-8.40
P2XP5	7.35	4.53	-20.97	-25.16	-11.06	-18.07
P2XP6	-7.69	-14.29	-2.09	-2.91	-41.99**	-44.08*
P2XP7	33.33	33.33	-24.85	-29.27*	-11.10	-21.32
P2XP8	27.27	16.67	-4.62	-5.31	-15.32	-19.58
P2XP9	28.21	19.05	14.24	12.86	-4.69	-12.29
P2XP10	33.33	33.33	5.11	4.32	-5.10	-9.56
P3XP4	23.58	13.28	6.98	-2.51	-30.04	-34.22
P3XP5	5.88	-5.26	-25.27	-30.14*	-36.25*	-44.60**
P3XP6	16.67	0.00	29.92*	27.08	-19.94	-27.42
P3XP7	33.33	22.22	-8.92	-15.37	-8.47	-23.35
P3XP8	60.00**	60.00*	-5.28	-7.24	10.05	-1.61
P3XP9	33.33	14.29	13.10	12.93	19.08	3.40
P3XP10	13.21	3.78	8.94	6.65	2.44	0.77
P4XP5	-2.70	-5.26	-31.51**	-33.37*	-27.25	-33.14*
P4XP6	23.08	14.29	-14.73	-20.69	-16.80	-19.99
P4XP7	18.33	18.33	14.91	12.53	-11.73	-22.04
P4XP8	27.27	16.67	0.84	-6.31	-28.49	-32.24
P4XP9	7.69	0.00	-21.33	-28.21*	-29.32*	-35.10*
P4XP10	0.00	0.00	-6.58	-13.18	12.15	7.11
P5XP6	35.00*	28.57	7.91	3.02	-11.16	-15.26
P5XP7	29.73	26.32	-3.13	-3.76	-22.24	-25.57
P5XP8	35.88*	21.58	-5.80	-10.17	-27.22	-29.54
P5XP9	35.00*	28.57	6.31	-0.48	9.91	9.80
P5XP10	6.22	3.42	-21.82	-25.42	-38.86*	-46.10**
P6XP7	-2.56	-9.52	-11.24	-15.79	-38.55**	-43.77**
P6XP8	0.00	-14.29	-8.75	-8.85	-23.15	-24.34
P6XP9	-4.76	-4.76	9.69	7.45	-39.51**	-42.35**
P6XP10	32.31*	22.86	-17.11	-17.18	-34.77*	-39.97*
P7XP8	63.64**	50.00*	5.57	0.05	12.52	4.43
P7XP9	17.95	9.52	24.04	15.42	-19.06	-22.46
P7XP10	16.67	16.67	0.58	-4.65	-13.09	-26.23
P8XP9	6.11	-9.05	2.62	0.64	-42.64**	-44.51**
P8XP10	45.45*	33.33	12.28	12.25	7.75	-2.24
P9XP10	10.05	2.19	3.90	1.87	-6.20	-17.39
CD (%)	95%	99%	95%	99%	95%	99%
MP	2.029	2.639	1.555	2.023	1.367	1.778
BP	2.342	3.048	1.795	2.336	1.578	2.054
S.E.D						
MP		1.007		0.771		0.678
BP		1.162		0.891		0.783

Table-1.7 : Estimates of heterosis and heterobeltiosis.

Spike length

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	-9.85	-25.96**	18.65	-5.65	10.98	-9.99
P1XP3	-15.35*	-23.98**	8.89	-2.89	15.47	0.46
P1XP4	-36.47**	-38.63**	23.59**	19.33*	10.17	7.61
P1XP5	-5.22	-19.16**	10.20	2.01	4.05	-8.05
P1XP6	-17.07**	-19.50**	22.85**	15.91	47.55**	22.10*
P1XP7	-13.71*	-14.95*	6.53	1.87	16.22	13.78
P1XP8	19.40**	2.93	48.74**	23.85**	34.42**	21.97*
P1XP9	-9.89	-14.46	-10.23	-12.46	-13.71	-18.72*
P1XP10	-13.07	-27.50**	5.60	-15.22	6.66	-1.29
P2XP3	32.02**	19.29*	59.06**	39.44**	58.31**	54.08**
P2XP4	1.91	-18.52**	25.06**	-3.11	37.31**	9.37
P2XP5	3.08	-1.54	4.38	-11.63	20.15	8.77
P2XP6	-21.24**	-36.80**	14.48	-4.66	38.17**	34.69*
P2XP7	-9.97	-25.20**	14.95	-5.35	7.78	-14.00
P2XP8	-2.23	-7.73	19.54	12.81	19.88	5.71
P2XP9	-0.61	-14.77	29.03**	4.58	8.84	-15.66
P2XP10	-1.62	-3.50	28.54*	26.90	32.69**	14.84
P3XP4	-20.57**	-30.81**	-9.59	-21.82*	15.86	-1.19
P3XP5	-2.01	-7.57	1.82	-2.23	20.15	18.01
P3XP6	6.88	-6.52	34.74**	26.89**	23.22	16.13
P3XP7	-16.08*	-23.64**	24.15**	15.38	28.67**	9.95
P3XP8	14.84	9.64	32.79**	22.77	40.18**	33.77**
P3XP9	10.48	4.18	3.67	-5.43	33.31**	10.26
P3XP10	-8.42	-15.79	16.57	3.34	25.91*	17.71
P4XP5	-14.89*	-29.44**	-14.95	-23.77**	7.46	-6.95
P4XP6	-5.38	-5.84	-4.48	-12.81	8.28	-12.04
P4XP7	-29.80**	-33.12**	10.94	2.59	13.38	13.11
P4XP8	-22.77**	-35.32**	25.95**	1.98	36.96**	21.67*
P4XP9	-28.27**	-34.09**	-10.39	-15.55	15.55	11.34
P4XP10	-9.43	-26.51**	11.37	-12.91	20.52*	9.15
P5XP6	16.31*	-3.20	8.90	6.71	48.11**	37.26**
P5XP7	18.38*	2.21	23.63**	19.49	50.87**	30.90**
P5XP8	31.27**	29.62**	49.10**	32.80**	37.17**	33.20**
P5XP9	20.76**	7.81	30.96**	24.14*	28.37**	7.73
P5XP10	1.72	-1.00	6.26	-9.07	2.83	-2.21
P6XP7	-27.76**	-30.87**	-6.94	-8.25	49.41**	21.58*
P6XP8	-12.99	-26.84**	15.99	1.49	54.35**	39.23**
P6XP9	-18.15**	-24.46**	21.40*	17.35	28.58**	1.52
P6XP10	-24.53**	-38.54**	15.33	-2.95	11.43	-1.40
P7XP8	2.01	-10.97	47.27**	27.31**	38.70**	23.48*
P7XP9	-18.00**	-21.07**	-12.42	-14.16	-6.14	-9.77
P7XP10	18.58*	0.07	45.52**	21.06*	33.40**	21.07*
P8XP9	-16.26*	-24.40**	12.29	-4.55	3.36	-11.11
P8XP10	46.04**	40.39**	59.84**	46.06**	46.46**	43.33**
P9XP10	9.65	-4.42	25.66*	2.87	-4.69	-16.50
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	1.793	2.333	1.897	2.468	1.759	2.289
BP	2.070	2.693	2.190	2.850	2.031	2.643
S.E.D						
MP		0.890		0.941		0.873
BP		1.027		1.087		1.008

Table-1.8 : Estimates of heterosis and heterobeltiosis.
 Number of grains per spike

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	-14.01**	-20.93**	6.95	-2.08	-26.09**	-33.32**
P1XP3	-8.56**	-14.64**	7.84	2.13	-34.61**	-39.07**
P1XP4	-15.19**	-19.41**	19.76**	15.49**	-23.21**	-23.21**
P1XP5	-13.84**	-24.33**	4.51	2.51	-0.98	-12.51**
P1XP6	-20.08**	-20.98**	26.64**	10.89*	-24.16**	-31.10**
P1XP7	-22.20**	-29.02**	0.93	-8.70	-38.98**	-40.80**
P1XP8	18.23**	5.89**	31.50**	13.09**	13.40**	9.41*
P1XP9	2.74	-6.34**	17.88**	9.39*	-14.85**	-15.78**
P1XP10	-7.02**	-16.08**	14.90**	-2.41	-26.21**	-29.90**
P2XP3	-3.63	-5.18	21.02**	16.75**	-1.27	-4.66
P2XP4	-11.64**	-14.65**	24.24**	17.71**	-8.39	-17.36**
P2XP5	-1.37	-6.23*	1.68	-5.22	-18.14**	-20.03**
P2XP6	-13.95**	-20.03**	-1.08	-5.83	-1.98	-2.74
P2XP7	2.53	1.65	5.38	3.99	-32.82**	-41.01**
P2XP8	3.32	0.37	9.69	2.36	-9.48*	-15.59**
P2XP9	-4.71	-5.61*	18.16**	16.45**	13.77**	3.64
P2XP10	-12.64**	-14.40**	9.36	0.65	-21.25**	-25.44**
P3XP4	-0.57	-2.42	0.18	-1.69	-7.04	-13.39**
P3XP5	5.08*	-1.61	-19.53**	-22.36**	26.26**	19.21**
P3XP6	13.77**	7.35**	24.14**	14.23**	0.89	-1.82
P3XP7	-7.25**	-9.51**	24.76**	18.85**	-28.12**	-34.88**
P3XP8	3.46	-1.06	30.81**	18.07**	0.86	-2.73
P3XP9	5.95*	3.29	22.72**	20.10**	-25.93**	-30.28**
P3XP10	-5.50*	-8.86**	8.52	-3.33	1.50	-0.56
P4XP5	-14.61**	-21.43**	-14.20**	-15.67**	18.60**	4.79
P4XP6	5.73**	1.58	15.08**	4.08	-14.36**	-22.20**
P4XP7	9.56**	4.96	27.54**	19.34**	-8.14*	-10.87**
P4XP8	-11.22**	-16.61**	12.97**	0.28	1.74	-1.84
P4XP9	-17.12**	-20.67**	-4.19	-7.95	-27.02**	-27.82**
P4XP10	1.14	-4.21	8.01	-5.37	-17.61**	-21.73**
P5XP6	18.76**	5.34*	-5.70	-16.02**	29.97**	26.00**
P5XP7	23.55**	18.43**	19.69**	10.20*	7.42	-7.55
P5XP8	27.69**	24.88**	25.18**	9.45	9.81*	0.21
P5XP9	27.24**	22.07**	20.88**	14.23**	-11.21*	-20.79**
P5XP10	7.51**	4.26	2.45	-11.56*	-23.57**	-29.21**
P6XP7	0.90	-6.98**	12.63*	8.60	-15.02**	-24.87**
P6XP8	-9.42**	-18.04**	3.17	1.02	16.29**	9.24
P6XP9	7.96**	-0.54	31.17**	23.15**	18.24**	8.49
P6XP10	-16.28**	-23.65**	17.93**	13.81*	-26.06**	-29.47**
P7XP8	25.72**	23.16**	42.42**	34.56**	3.85	-2.68
P7XP9	-11.77**	-11.85**	-6.81	-9.35	-29.38**	-32.20**
P7XP10	18.40**	17.00**	46.28**	36.29**	-8.30*	-15.35**
P8XP9	1.85	-0.14	18.27**	8.88	-21.78**	-23.72**
P8XP10	14.26**	13.27**	50.57**	48.35**	16.70**	14.84**
P9XP10	-5.27*	-6.31*	9.68	-0.40	-8.87*	-12.52**
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	2.307	3.001	3.687	4.797	2.845	3.701
BP	2.664	3.466	4.258	5.540	3.285	4.274
S.E.D						
MP		1.145		1.830		1.411
BP		1.322		2.113		1.630

Table-1.9 : Estimates of heterosis and heterobeltiosis.
1000 grain weight

Cross	Mid	Better	Mid	Better	Mid	Better
P1XP2	4.74	3.02	12.31**	4.88	-1.67	-4.12
P1XP3	8.05**	3.52	-7.75*	-8.84*	19.77**	11.94*
P1XP4	-12.42**	-14.84**	-4.39	-7.76*	17.27**	14.15**
P1XP5	14.48**	7.79*	4.61	-0.65	13.15**	12.11*
P1XP6	9.73**	8.99**	2.63	1.08	15.03**	14.71**
P1XP7	6.63*	3.48	-5.14	-7.86*	16.87**	12.73*
P1XP8	33.81**	27.96**	12.37**	8.16*	33.77**	30.47**
P1XP9	7.46**	3.40	-9.43*	-15.91**	7.45	6.95
P1XP10	3.41	-3.32	7.43*	-2.19	8.22	7.32
P2XP3	12.85**	9.87**	9.19*	3.12	26.57**	15.56**
P2XP4	4.26	-0.23	-3.87	-13.17**	9.89*	9.69
P2XP5	-3.68	-7.88*	4.79	2.94	-1.37	-4.68
P2XP6	-11.49**	-13.51**	5.35	-3.00	8.15	5.74
P2XP7	8.84**	7.36*	-3.72	-7.55	13.62**	6.96
P2XP8	0.33	-2.51	-11.82**	-14.56**	3.33	-1.67
P2XP9	10.46**	8.02*	18.83**	18.09**	8.02	5.81
P2XP10	-2.99	-7.88*	-3.21	-5.82	6.10	2.62
P3XP4	10.81**	3.37	-2.46	-6.96	26.52**	15.32**
P3XP5	10.54**	8.53*	-15.43**	-18.76**	29.55**	22.13**
P3XP6	30.25**	24.00**	-5.02	-7.54	31.62**	22.70**
P3XP7	4.11	2.75	-7.97*	-9.56*	11.95*	8.34
P3XP8	19.27**	19.03**	5.80	3.02	17.83**	12.78*
P3XP9	28.18**	27.62**	13.63**	6.68	31.56**	22.43**
P3XP10	21.76**	18.68**	4.00	-4.27	21.22**	14.19**
P4XP5	10.38**	1.24	-17.01**	-23.81**	25.25**	20.83**
P4XP6	28.87**	26.14**	-2.38	-4.41	28.16**	25.09**
P4XP7	8.52**	2.49	9.83**	3.04	32.92**	24.93**
P4XP8	3.32	-3.79	7.74*	0.19	19.47**	13.51**
P4XP9	-2.74	-8.90**	-1.89	-11.87**	1.22	-1.03
P4XP10	2.75	-6.40*	2.61	-9.54**	0.36	-3.10
P5XP6	24.97**	16.92**	8.97*	2.01	-7.08	-8.19
P5XP7	32.59**	28.51**	13.86**	11.25**	34.25**	30.67**
P5XP8	42.58**	40.27**	1.54	0.14	7.12	5.44
P5XP9	43.47**	40.26**	13.34**	10.65*	7.92	6.44
P5XP10	11.61**	10.77**	8.07*	3.35	1.77	1.68
P6XP7	10.29**	6.34*	12.50**	7.68*	1.86	-2.01
P6XP8	9.88**	4.41	10.87**	5.17	5.49	2.61
P6XP9	11.07**	6.18*	8.38*	-0.78	16.32**	16.11**
P6XP10	-7.27*	-13.85**	-4.15	-13.92**	-8.79	-9.80
P7XP8	14.51**	12.79**	9.97**	8.94*	19.47**	18.12**
P7XP9	-2.11	-2.97	17.15**	11.81**	7.47	3.21
P7XP10	30.56**	25.63**	22.29**	14.40**	29.77**	26.20**
P8XP9	6.75*	6.07	-1.26	-4.90	15.57**	12.21*
P8XP10	36.20**	33.01**	17.91**	11.28**	30.77**	28.60**
P9XP10	20.01**	16.47**	10.29*	7.99	12.44**	10.99*
CD (%)	95%	99%	95%	99%	95%	. 99%
MP	2.210	2.875	2.593	3.373	2.274	2.959
BP	2.552	3.320	2.994	3.895	2.626	3.417
S.E.D						
MP		1.097		1.287		1.128
BP		1.266		1.486		1.303

Table-1.10 : Estimates of heterosis and heterobeltiosis.

Harvest index (%)

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	-20.19**	-21.92**	19.04*	-2.39	1.44	-10.63**
P1XP3	-2.00	-5.45	22.07**	8.9	-0.39	-7.21
P1XP4	-11.07**	-12.32**	-14.41*	-22.1**	-0.74	-1.25
P1XP5	6.20	0.59	5.48	1.73	8.27*	-6.55
P1XP6	12.88**	12.31**	33.03**	21.74**	-2.90	-14.04**
P1XP7	6.88	2.89	17.61*	7.84	-6.39	-10.75**
P1XP8	32.61**	26.06**	32.96**	22.15**	6.78	-1.55
P1XP9	22.62**	17.19**	-1.65	-7.6	-3.56	-8.05*
P1XP10	5.82	-1.88	18.85*	-2.04	2.36	-9.38*
P2XP3	12.67**	11.07**	40.07**	36.27**	20.39**	13.35**
P2XP4	10.17**	6.31	9.92	-16.19*	1.47	-10.20**
P2XP5	-8.16*	-11.17**	18.23*	-0.16	-3.78	-6.05
P2XP6	-23.04**	-25.07**	39.14**	33.06**	-2.69	-3.22
P2XP7	0.47	-1.18	28.29**	13.37	-3.80	-11.48**
P2XP8	-6.01	-8.74*	39.28**	29.29*	5.30	0.19
P2XP9	-1.47	-3.81	31.22**	2.51	-7.61	-14.98**
P2XP10	-7.15	-12.11**	24.09*	23.27	1.93	1.37
P3XP4	4.18	-0.86	-1.27	-18.88**	-8.80*	-14.64**
P3XP5	-1.66	-3.52	-3.12	-10.66	1.27	-6.76
P3XP6	23.35**	18.43**	16.05	11.82	-9.45*	-14.30**
P3XP7	-1.95	-2.17	23.2**	19.53*	-2.14	-4.51
P3XP8	20.64**	18.81**	10.61	8.43	4.78	3.62
P3XP9	15.86**	14.73**	13.19	-4.39	5.59	3.04
P3XP10	-5.60	-9.40*	31.92**	20.5*	7.27	1.53
P4XP5	-14.55**	-20.15**	-25.48**	-34.35**	-6.21	-18.69**
P4XP6	20.88**	19.78**	18.82*	-11.79	-15.83**	-25.14**
P4XP7	18.54**	12.57**	6.34	-10.46	-1.21	-5.35
P4XP8	-18.75**	-23.79**	23.58**	-10.42	5.68	-2.11
P4XP9	-8.54*	-13.76**	-21.17**	-23.8**	-11.04**	-14.76**
P4XP10	-8.67*	-16.41**	-1.02	-24.18**	-2.39	-13.19**
P5XP6	24.15**	17.03**	40.67**	15.08	4.95	1.94
P5XP7	38.06**	35.74**	26.81**	20.32*	18.25**	6.48
P5XP8	37.42**	36.89**	47.31**	38.92**	19.23**	10.92*
P5XP9	42.26**	40.92**	23.16**	11.86	13.15**	1.88
P5XP10	4.30	1.98	7.61	-8.63	6.51	3.45
P6XP7	1.00	-3.24	36.71**	16.8	2.89	-4.84
P6XP8	-9.47*	-14.35**	22.69**	26.8**	1.04	-3.35
P6XP9	3.71	-1.36	21.12**	-7.98	-1.21	-8.63*
P6XP10	-21.14**	-27.21**	36.06**	30.03*	5.85	5.85
P7XP8	26.84	25.19**	41.12**	31.8**	7.89*	4.15
P7XP9	-1.55	-2.30	-4.13	-16.93*	-4.79	-4.79
P7XP10	17.79**	13.29**	37.11**	33.55**	20.90**	11.82**
P8XP9	-17.96**	-18.42**	12.15	-16.9*	-10.57**	-13.68**
P8XP10	2.95	0.29	49.82**	35.13**	19.62**	14.42
P9XP10	-10.67**	-13.46**	11.3	-12.63	7.75	-0.35
CD (%)	95%	99%	95%	99%	95%	99%
MP	2.969	3.863	2.988	3.887	2.148	2.794
BP	3.428	4.461	3.450	4.488	2.480	3.227
S.E.D						
MP		1.473		1.482		1.066
BP		1.701		1.712		1.231

Table-1.11 : Estimates of heterosis and heterobeltiosis.

Grain yield per plant

Cross	ENVIRONMENT 1		ENVIRONMENT 2		ENVIRONMENT 3	
	Mid	Better	Mid	Better	Mid	Better
P1XP2	-29.31**	-32.20**	19.04*	-2.39	33.37**	16.94
P1XP3	-16.44**	-24.30**	22.07**	8.9	16.59	11.58
P1XP4	-35.13**	-37.09**	-14.41*	-22.1**	-15.62	-20.01*
P1XP5	-15.31*	-27.54**	5.48	1.73	23.57*	11.58
P1XP6	-16.46**	-17.55**	33.03**	21.74**	40.74**	18.44
P1XP7	-23.69**	-28.84**	17.61*	7.84	9.27	7.24
P1XP8	30.10**	6.75	32.96**	22.15**	33.91**	29.92**
P1XP9	-9.94	-17.26**	-1.65	-7.6	11.22	7.79
P1XP10	-7.60	-27.54**	18.85*	-2.04	13.34	6.33
P2XP3	-5.45	-10.93	40.07**	36.27**	48.80**	35.73**
P2XP4	-20.75**	-26.20**	9.92	-16.19*	18.40	-0.83
P2XP5	-10.31	-20.42**	18.23*	-0.16	11.89	8.26
P2XP6	-24.28**	-28.29**	39.14**	33.06**	28.97*	22.94
P2XP7	-13.69*	-16.20*	28.29**	13.37	3.62	-10.60
P2XP8	-4.53	-18.94**	39.28**	29.29*	20.45	8.48
P2XP9	-12.63*	-16.47*	31.22**	2.51	15.08	-1.78
P2XP10	-12.58	-29.23**	24.09*	23.27	9.57	1.90
P3XP4	-18.05**	-27.78**	-1.27	-18.88**	6.51	-3.14
P3XP5	-11.96	-17.42*	-3.12	-10.66	18.39	11.38
P3XP6	9.66	-1.82	16.05	11.82	16.48	1.76
P3XP7	-18.90**	-21.39**	23.2**	19.53*	13.95	7.12
P3XP8	6.69	-4.53	10.61	8.43	16.78	15.14
P3XP9	-3.94	-5.42	13.19	-4.39	12.93	4.89
P3XP10	-4.90	-19.15*	31.92**	20.5*	32.32**	29.58*
P4XP5	-24.42**	-36.96**	-25.48**	-24.35**	38.31**	19.09
P4XP6	-4.31	-6.01	18.82*	-11.79	9.57	-11.69
P4XP7	-18.33**	-25.99**	6.34	-10.46	15.16	11.15
P4XP8	-20.83**	-36.58**	23.58**	-10.42	18.65*	9.30
P4XP9	-28.55**	-36.17**	-21.17**	-23.8**	3.30	0.96
P4XP10	-12.27	-32.71**	-1.02	-24.18**	9.67	-2.12
P5XP6	13.54*	-3.91	40.67**	15.08	30.69*	20.74
P5XP7	18.76**	8.20	26.81**	20.32*	38.33**	22.84*
P5XP8	41.48**	34.50**	47.31**	38.92**	35.65**	25.94*
P5XP9	33.76**	23.67**	23.16**	11.86	30.62**	14.69
P5XP10	6.73	-3.98	7.61	-8.63	7.24	2.94
P6XP7	-21.47**	-27.66**	36.71**	16.8	19.57	-0.89
P6XP8	-17.47**	-32.97**	22.69**	26.8**	33.19**	14.96
P6XP9	-13.27*	-21.26**	21.12**	-7.98	14.17	-6.32
P6XP10	-18.02**	-36.32**	36.06**	30.03*	11.59	-0.71
P7XP8	20.72**	5.10	41.12**	31.8**	28.72**	22.64*
P7XP9	-21.04**	-22.29**	-4.13	-16.93*	-3.00	-4.23
P7XP10	28.42**	6.41	42.11**	39.55**	43.03**	31.85**
P8XP9	-8.86	-19.55**	12.15	-16.9*	-0.68	-6.52
P8XP10	45.38**	37.15**	49.82**	35.13**	46.35**	41.35**
P9XP10	4.24	-12.50	11.3	-12.63	-1.32	-10.09
CD (%)	95%	99%	95%	99%	95%	99%
MP	3.304	4.299	2.594	4.911	2.988	3.888
BP	3.815	4.964	2.996	10.112**	3.451	4.489
S.E.D						
MP		1.639		1.40		1.483
BP		1.893		1.61		1.712

Table-12 : Top three of the crosses for their heterosis, heterobeltiosis and inbreeding depression estimates in individual environment for different characters.

Characters	Env.	Heterosis	Heterobeltiosis	Inbreeding depression
Days to heading	E ₁	DBW 621-50 X RAJ 4238	RAJ 3077 X HD 2967	RAJ 3765 X RAJ 4079
		RAJ 3765 X RAJ 4238	DBW 621-50 X RAJ 4238	DBW 621-50 X RAJ 3077
		RAJ 4238 X DBW 88	RAJ 3765 X RAJ 4238	DBW 621-50 X RAJ 4083
	E ₂	DBW 621-50 X RAJ 3077	HD 2967 X DBW 17	HD 2967 X RAJ 4238
		RAJ 4083 X RAJ 4238	DBW 621-50 X RAJ 3077	HD 2967 X RAJ 4083
		RA 3765 X RAJ 4238	RAJ 4083 X RAJ 4238	RAJ 4120 X DBW 88
	E ₃	RAJ 4079 X DBW 88	RAJ 4079 X DBW 88	RAJ 3077 X DBW 17
		RAJ 4083 X DBW 88	RAJ 3765 X HD 2967	DBW 621-50 X DBW 17
		DBW 621-50 X RAJ 3077	RAJ 3765 X RAJ 3077	RAJ 3077 X RAJ 4238
Days to maturity	E ₁	RAJ 4079 X HD 2967	RAJ 4079 X HD 2967	DBW 621-50 X RAJ 4083
		RAJ 4120 X DBW 88	RAJ 4120 X DBW 88	RAJ 4120 X DBW 88
		RAJ 4120 X DBW 17	RAJ 3765 X DBW 88	DBW 621-50 X HD 2967
	E ₂	RAJ 4120 X RAJ 4083	RAJ 4079 X RAJ 4083	DBW 621-50 X DBW 88
		RAJ 4079 X RAJ 4083	RAJ 4120 X RAJ 4083	RAJ 4120 X DBW 88
		RAJ 4120 X DBW 17	RAJ 4120 X DBW 17	RAJ 4079 X RAJ 4120
	E ₃	RAJ 3077 X DBW 17	RAJ 3077 X RAJ 4238	RAJ 4079 X RAJ 4083
		RAJ 3077 X RAJ 4238	RAJ 3077 X DBW 17	DBW 621-50 X RAJ 4079
		RAJ 3077 X HD 2967	RAJ 3077 X HD 2967	RAJ 4079 X DBW 88
Grain filling period	E ₁	HD 2967 X DBW 88	HD 2967 X DBW 88	RAJ 4083 X RAJ 4238
		HD 2967 X RAJ 4083	DBW 621-50 X RAJ 4120	HD 2967 X DBW 17
		RAJ 4120 X DBW 88	RAJ 4120 X DBW 88	RAJ 3077 X DBW 17
	E ₂	RAJ 3765 X HD 2967	RAJ 3765 X HD 2967	HD 2967 X RAJ 4083
		RAJ 4120 X DBW 17	RAJ 4120 X DBW 17	DBW 621-50 X DBW 17
		RAJ 4079 X RAJ 4083	RAJ 4079 X RAJ 4083	RAJ 4079 X DBW 17
	E ₃	RAJ 4079 X HD 2967	RAJ 4079 X HD 2967	RAJ 3077 X RAJ 4079
		DBW 621-50 X RAJ 4079	DBW 621-50 X RAJ 4079	RAJ 4079 X RAJ 4120
		RAJ 4079 X RAJ 4083	HD 2967 X RAJ 4083	HD 2967 X RAJ 4238
Plant height	E ₁	DBW 621-50 X DBW 88	DBW 621-50 X DBW 88	RAJ 4120 X DBW 17
		RAJ 4079 X RAJ 4238	DBW 621-50 X HD 2967	DBW 621-50 X RAJ 4238
		RAJ 4083 X RAJ 4238	DBW 621-50 X RAJ 4083	RAJ 4083 X DBW 88
	E ₂	RAJ 4079 X RAJ 4238	RAJ 4083 X DBW 88	HD 2967 X DBW 88
		RAJ 4083 X DBW 88	RAJ 4079 X RAJ 4083	RAJ 4083 X DBW 17
		RAJ 4120 X RAJ 4083	RAJ 4079 X RAJ 4238	HD 2967 X DBW 17
	E ₃	DBW 621-50 X RAJ 4238	DBW 621-50 X RAJ 4238	RAJ 3765 X HD 2967
		DBW 621-50 X RAJ 4083	RAJ 4120 X HD 2967	RAJ 3765 X RAJ 4120
		DBW 621-50 X HD 2967	DBW 621-50 X HD 2967	RAJ 4083 X DBW 88
Flag leaf area	E ₁	RAJ 3765 X RAJ 4238	RAJ 3077 X RAJ 4238	DBW 17 X DBW 88
		RAJ 3077 X RAJ 4238	RAJ 3765 X RAJ 4238	RAJ 4079 X DBW 17
		RAJ 4238 X DBW 88	RAJ 4120 X HD 2967	RAJ 4079 X DBW 88
	E ₂	RAJ 4083 X RAJ 4238	RAJ 3765 X RAJ 4079	DBW 621-50 X RAJ 4083
		RAJ 4079 X RAJ 4083	RAJ 4079 X RAJ 4083	HD 2967 X DBW 88
		RAJ 3765 X RAJ 4079	RAJ 4083 X RAJ 4238	RAJ 3765 X RAJ 4079
	E ₃	RAJ 4079 X RAJ 4083	RAJ 4079 X RAJ 4083	DBW 621-50 X RAJ 4083
		RAJ 4120 X RAJ 4083	DBW 621-50 X RAJ 4120	RAJ 3077 X HD 2967
		RAJ 3765 X DBW 621-50	DBW 621-50 X RAJ 4079	HD 2967 X RAJ 4083
Tillers per plant	E ₁	RAJ 4083 X RAJ 4238	RAJ 3077 X RAJ 4238	RAJ 3077 X HD 2967
		RAJ 3077 X RAJ 4238	RAJ 4083 X RAJ 4238	RAJ 3765 X DBW 17
		DBW 621-50 X RAJ 3077	DBW 621-50 X RAJ 3077	RAJ 3765 X DBW 88
	E ₂	RAJ 3077 X HD 2967	RAJ 3077 X HD 2967	RAJ 3765 X DBW 621-50
		RAJ 4083 X DBW 17	RAJ 4083 X DBW 17	RAJ 3765 X RAJ 4120
		RAJ 3765 X HD 2967	RAJ 3765 X HD 2967	HD 2967 X RAJ 4238
	E ₃	RAJ 3077 X DBW 17	RAJ 4120 X DBW 17	RAJ 3077 X RAJ 4120
		DBW 621-50 X RAJ 3077	DBW 621-50 X RAJ 3077	RAJ 4079 X DBW 17
		RAJ 4083 X RAJ 4238	RAJ 4079 X DBW 88	RAJ 3765 X HD 2967

Table-12 : Contd....

Characters	Env.	Heterosis	Heterobeltiosis	Inbreeding depression
Spike length	E ₁	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88
		DBW 621-50 X RAJ 3077	RAJ 4120 X RAJ 4238	RAJ 4079 X DBW 88
		RAJ 4120 X RAJ 4238	DBW 621-50 X RAJ 3077	RAJ 3765 X DBW 88
	E ₂	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88	RAJ 4083 X DBW 88
		DBW 621-50 X RAJ 3077	DBW 621-50 X RAJ 3077	DBW 621-50 X RAJ 4238
		RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4238	RAJ 4079 X HD 2967
	E ₃	DBW 621-50 X RAJ 3077	DBW 621-50 X RAJ 3077	HD 2967 X DBW 88
		HD 2967 X RAJ 4238	RAJ 4238 X DBW 88	RAJ 3765 X DBW 621-50
		RAJ 4120 X RAJ 4083	HD 2967 X RAJ 4238	RAJ 3765 X RAJ 3077
Grains per spike	E ₁	RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4238	RAJ 3765 X DBW 17
		RAJ 4120 X DBW 17	RAJ 4083 X RAJ 4238	RAJ 3765 X DBW 88
		RAJ 4083 X RAJ 4238	RAJ 4120 X DBW 17	DBW 621-50 X RAJ 4079
	E ₂	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88	RAJ 4120 X DBW 88
		RAJ 4083 X DBW 88	RAJ 4083 X DBW 88	RAJ 3765 X DBW 88
		RAJ 4083 X RAJ 4238	RAJ 4083 X RAJ 4238	RAJ 4120 X RAJ 4083
	E ₃	RAJ 4120 X HD 2967	RAJ 4120 X HD 2967	DBW 621-50 X RAJ 4083
		RAJ 3077 X RAJ 4120	RAJ 3077 X RAJ 4120	RAJ 3765 X RAJ 3077
		RAJ 4079 X RAJ 4120	RAJ 4238 X DBW 88	DBW 621-50 X RAJ 4120
	E ₁	RAJ 4120 X DBW 17	RAJ 4120 X RAJ 4238	DBW 621-50 X RAJ 4238
		RAJ 4120 X RAJ 4238	RAJ 4120 X DBW 17	RAJ 3077 X DBW 17
		RAJ 4238 X DBW 88	RAJ 4238 X DBW 88	RAJ 3765 X HD 2967
	E ₂	RAJ 4083 X DBW 88	DBW 621-50 X DBW 17	RAJ 4120 X HD 2967
		DBW 621-50 X DBW 17	RAJ 4083 X DBW 88	RAJ 4120 X RAJ 4083
		RAJ 4238 X DBW 88	RAJ 4083 X DBW 17	RAJ 4120 X DBW 17
	E ₃	RAJ 4120 X RAJ 4083	RAJ 4120 X RAJ 4083	DBW 621-50 X RAJ 4120
		RAJ 3765 X RAJ 4238	RAJ 3765 X RAJ 4238	RAJ 4120 X RAJ 4238
		RAJ 4079 X RAJ 4083	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88
Harvest index	E ₁	RAJ 4120 X DBW 17	RAJ 4120 X DBW 17	RAJ 4079 X RAJ 4120
		RAJ 4120 X RAJ 4083	RAJ 4120 X RAJ 4238	RAJ 3077 X RAJ 4083
		RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4083	RAJ 3765 X RAJ 4079
	E ₂	RAJ 4238 X DBW 88	RAJ 4120 X RAJ 4238	RAJ 4083 X DBW 17
		RAJ 4120 X RAJ 4238	DBW 621-50 X RAJ 3077	RAJ 3077 X RAJ 4120
		RAJ 4120 X HD 2967	RAJ 4238 X DBW 88	RAJ 4079 X RAJ 4238
	E ₃	RAJ 4083 X DBW 88	DBW 621-50 X RAJ 3077	RAJ 4120 X RAJ 4238
		DBW 621-50 X RAJ 3077	RAJ 4083 X DBW 88	DBW 17 X DBW 88
		RAJ 4238 X DBW 88	RAJ 4120 X RAJ 4238	RAJ 4083 X DBW 17
	E ₁	RAJ 4238 X DBW 88	RAJ 4238 X DBW 88	RAJ 3765 X DBW 88
		RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4238	RAJ 3077 X RAJ 4083
		RAJ 4120 X DBW 17	RAJ 4120 X DBW 17	DBW 621-50 X RAJ 4238
	E ₂	RAJ 4238 X DBW 88	RAJ 4083 X DBW 88	RAJ 3765 X RAJ 4079
		RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4238	RAJ 4120 X RAJ 4083
		RAJ 4083 X DBW 88	DBW 621 50 XRAJ 3077	RAJ 4079 X RAJ 4083
	E ₃	DBW 621-50 X RAJ 3077	RAJ 4238 X DBW 88	HD 2967 X DBW 88
		RAJ 4238 X DBW 88	DBW 621-50 X RAJ 3077	RAJ 3765 X RAJ 4079
		RAJ 4083 X DBW 88	RAJ 4083 X DBW 88	RAJ 4083 X DBW 17

dominance, non-allelic interaction or epistasis and intra locus or inter-allelic interactions referred to as over dominance.

Among several theories the dominant linked gene hypothesis (Jones, 1917) is most effective in self-pollinated crops to explain the genetic basis of

heterosis. Both additive and non-additive gene effects have been suggested to explain heterosis. It can be possible to fix alleles at interacting loci to preserve the heterotic effects in the pure lines if heterosis is due to epistatic gene action, particularly of additive x additive type or due to repulsion phase linked loci, exhibiting partial or complete dominance. In addition, the heterotic

hybrid can also produce desirable transgressive segregants in their advance generations (Arunachalam *et al.* 1984). Thus, crosses involving them may throw desirable recombinants in later generations. However, dispersion of alleles can not be ruled out as enough evidence now supports dispersion of complementary genes as the major cause of heterosis (Singh and Singh, 1984).

In present investigation, the maximum range of heterosis has been estimated for all the characters. An overall appraisal of the Table 1-11 revealed range of heterosis for days to heading -12.34 per cent to 9.87 per cent in E₁; -5.26 per cent to 8.83 per cent in E₂ and -6.73 per cent to 4.97 per cent in E₃; for days to maturity from -5.90 per cent to 9.89 per cent in E₁; -10.78 per cent to 8.76 per cent in E₂ and -8.81 per cent to 6.50 per cent in E₃; for grain filling period from -21.74 per cent to 17.40 per cent in E₁; -29.38 per cent to 32.02 per cent in E₂ and -52.50 per cent to -6.30 per cent in E₃; for plant height from -10.86 per cent to 19.51 per cent in E₁; -15.26 per cent to 10.23 per cent in E₂ and -16.33 per cent to 21.63 per cent in E₃; for flag leaf area from -35.15 per cent to 56.64 per cent in E₁; -36.32 per cent to 26.93 per cent in E₂ and -45.83 per cent to 35.55 per cent in E₃; for number of tillers per plant from -7.69 per cent to 63.64 per cent in E₁; -31.51 per cent to 29.92 per cent in E₂ and -42.64 per cent to 19.08 per cent in E₃; for spike length from -36.47 per cent to 46.04 per cent in E₁; -14.95 per cent to 59.84 per cent in E₂ and -13.71 per cent to 58.31 per cent in E₃; for number of grains per spike from -22.20 per cent to 27.69 per cent in E₁; -19.53 per cent to 50.57 per cent in E₂ and -38.98 per cent to 29.97 per cent in E₃; for 1000-grain weight from -12.42 per cent to 43.47 per cent in E₁; -17.01 per cent to 22.29 per cent in E₂ and -8.79 per cent to 34.25 per cent in E₃; for harvest index from -23.04 per cent to 42.26 per cent in E₁; -25.48 per cent to 49.82 per cent in E₂ and -15.83 per cent to 20.90 per cent in E₃ and for grain yield per plant from -35.13 per cent to 45.38 per cent in E₁; -25.48 per cent to 49.82 per cent in E₂ and -15.62 per cent to 48.80 per cent in E₃. The results in varying environments for different characters are in conformity with the findings of Subhani *et al.* (2000), Rasul *et al.* (2002), Singh *et al.* (2003), Joshi *et al.* (2003.b), Singh *et al.* (2004) and Pancholi *et al.* (2012) also reported maximum heterosis for grain yield per plant.

The superiority of hybrids particularly over better parent (heterobeltiosis) is more important and useful in determining the feasibility of commercial exploitation of heterosis and also indicating the parental combinations capable of producing the highest level of transgressive segregants.

Three best heterotic and heterobeltiotic crosses for

grain yield per plant are presented in Table 5.2. Perusal of this table indicated that the crosses Raj 4238 X DBW 88 in all the environments and Raj 4120 X Raj 4238 in E₁ and E₂ and Raj 4083 X DBW 88 in E₂ and E₃ emerged as good heterotic as well as heterobeltiotic crosses for grain yield per plant. Among top three crosses for grain yield per plant in all the environments, the crosses Raj 4238 X DBW 88 showed desirable heterosis and heterobeltiosis for one or more characters in all the environments. Hence, this cross may be considered as promising type for tangible advancement of bread wheat yield under normal sown and thermal stress condition.

Assessment of Table-12 revealed an interesting relation between heterosis and heterobeltiosis of grain yield per plant and other yield attributing traits. The parents, who showed desirable heterosis and heterobeltiosis for grain yield per plant, also exhibited desirable heterosis and heterobeltiosis at least for one or more yield attributing traits. Such as, heterosis and heterobeltiosis for grain yield per plant was mainly contributed by 1000 grain weight. Findings of this investigation supported the contentions of Grafius (1959), who suggested that there could be no separate gene system for yield *per se* as yield is an end product of the multiplicative interactions among its various contributing attributes. Thus, heterobeltiosis for various yield contributing characters might be result in the expression of heterobeltiosis for grain yield. However, the crosses showing heterotic expression for grain yield per plant were not heterotic for all the characters. It was also noted that the expression of heterosis and heterobeltiosis was influenced by the environments for almost all the characters. This was because of significant G x E interaction. The results of the present findings are in agreement with the results of Prasad *et al.* (1998), Deshpande and Nayeem (1999), Munir *et al.* (1999), Subhani *et al.* (2000), Dubey *et al.* (2001), Salgotra *et al.* (2002), Joshi *et al.* (2003b), Punia (2003), Singh *et al.* (2004), Verma *et al.* (2007), Pancholi *et al.* (2011), Singh *et al.* (2012), Raj and Kandalkar (2013), Kumar and Kerkhi (2014), Kumar *et al.* (2015).

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Assess the Problems of Organic Farming Practices in Bikaner District of Rajasthan

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Abstract

India is bestowed with lot of potential to produce all varieties of organic products due to its various agro climatic conditions. In several parts of the country, the inherited tradition of organic farming is an added advantage. India produced around 3.49 million tonne of certified organic products which includes all varieties of food products. Madhya Pradesh has covered largest area under organic certification followed by Rajasthan, Maharashtra, Gujarat, Karnataka, Odisha, Sikkim and Uttar Pradesh. In 2020-21, the total volume of organic products export was 8.88 lakh metric tone. The present study was undertaken for studying constraints of organic farming practices in Bikaner district of Rajasthan. This district was selected purposively as it has large area under rainfed farming and mostly fertilizers and pesticides are not being used in this area. For the study 30 farmers practicing organic farming were selected. The results revealed that the important constraint faced by the farmers of study area were non availability of sufficient organic manure, low productivity of organic farming, lack of selling outlets, marketing of organic farming produce is the main problem, certification facility is not available of organic farming, unawareness of organic farming, price of the organic products is the high and cost of certification organic farming is high. The study of constraints revealed that about 71.80 per cent farmers of the study area faced the problem about no availability of sufficient organic manure. The problem faced by the farmer is related to low productivity of organic farming was worked out about 61.9 per cent. About 73.02 per cent farmers reported the problem of selling.

Key words : Constraints, manures, marketing, organic farming, rainfed farming.

Introduction

India is the world's largest producer of milk, second largest producer of rice, wheat, sugar, fruits and vegetables, and the third largest producer of cotton, just only to mention a few. The direct contribution of the agricultural sector to national economy is reflected by its share in total GDP, its foreign exchange earnings, and its role in supplying savings and labor to other sectors. The negative consequences of higher use of chemical fertilizers and pesticides are reduction in crop productivity and deterioration in the quality of natural resources. India is bestowed with lot of potential to produce all varieties of organic products due to its various agro climatic conditions. In several parts of the country, the inherited tradition of organic farming is an added advantage. This holds promise for the organic producers to tap the market which is growing steadily in the domestic and export sector.

(www.organicworld.net/yearbook/yearbook-2020.html.)

As per the available statistics, India's rank 8th in terms of World's Organic Agricultural land and 1st in terms of total number of producers as per 2020 data (Source: FIBL & IFOAM Year Book, 2020). Organic farming is a method of farming that works at grass-roots level, preserving the reproductive and regenerative capacity of the soil, good

plant nutrition, and sound soil management, produces nutritious food, rich in vitality and disease resistance. Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. Organic agriculture is an environmentally and socially sensitive food supply system. The primary goal of organic agriculture is to optimize the health and productivity of independent communities of soil life, plants and animals and people. (Gupta, 2002)

The global organic market continues to grow worldwide and has reached 97 billion US dollars. The market research company Ecovia Intelligence estimated that the global market for organic food reached 97 billion US dollars in 2017 (approx. 90 billion Euros). The United States is the leading market with 40 billion Euros, followed by Germany (10 billion Euros), France (7.9 billion Euros), and China (7.6 billion Euros). In 2017, many major markets continued to show double-digit growth rates, and the French organic market grew by 18 percent. The Swiss spent the most on organic food (288 Euros per capita in 2017). Denmark had the highest organic market share (13.3 percent of the total food market) (Willer, 2019). Almost three million producers worldwide: In 2017, 2.9 million organic producers were reported, which was 5

Table-1 : Constraints perceived by farmers in adoption of organic farming.

S. No.	Constraints	Garrett score	Rank
1	Certification facility is not available for organic farming	73.89	1
2.	Problem in selling the produce	73.02	2
3.	No availability of sufficient organic manure	71.80	3
4.	Low productivity of organic farming	58.72	4
5.	Price of the inputs for organic production is high	47.07	5
6.	Unawareness of organic farming	43.37	6
7.	Unavailability of processors for organic produce	41.09	7
8.	Cost of certification of organic farming is high	33.03	9

percent more than in 2016. India continues to be the country with the highest number of producers (835,200), followed by Uganda (210,352) and Mexico (210,000) (Willer, 2019). A total of 69.8 million hectares were organically managed at the end of 2017, representing a growth of 20 percent or 11.7 million hectares over 2016, the largest growth ever recorded. Australia has the largest organic agricultural area (35.6 million hectares), followed by Argentina (3.4 million hectares), and China (3 million hectares). Due to the large area increase in Australia, half of the global organic agricultural land is now in Oceania (35.9 million hectares). Europe has the second largest area (21 percent; 14.6 million hectares), followed by Latin America (11.5 percent; 8 million hectares). The organic area increased in all continents. Globally, 1.4 percent of the farmland is organic. However, many countries have far higher shares. The countries with the largest organic share of their total farmland are Liechtenstein (37.9 percent), Samoa (37.6 percent), and Austria (24 percent). In fourteen countries, 10 percent or more of all agricultural land is organic (www.organicworld.net/yearbook/yearbook-2019.html). The trademark 'India Organic' is owned by the Government of India. Only those producers, exporters, manufacturers and processors whose products are duly certified by the accredited inspection and certification agencies, are granted the license to use the logo.

In 2020-21, India produced around 3.49 million tonne of certified organic products which includes all varieties of food products namely oil seeds, sugarcane, cereals, millets, cotton, pulses, aromatic & medicinal plants, tea, coffee, fruits, spices, dry fruits, vegetables, processed foods etc. Madhya Pradesh has covered largest area under organic certification followed by Rajasthan, Maharashtra, Gujarat, Karnataka, Odisha, Sikkim and Uttar Pradesh. In 2020-21, the total volume of organic products export was 8.88 lakh metric tonne and the export realization was around ₹7,078 crores or \$1 billion (www.apeda.in). India is bestowed with lot of potential to produce all varieties of organic products due to its various agro-climatic regions. In several parts of the country, the inherited tradition of organic farming is an

added advantage which resulted in making the country to stand number one in terms of number of organic farm producers and eight in terms of percentage of the of area under organic farming practice to its total area under farming. India produced around 3,96,997 MT of certified organic products, which include all varieties of food products namely basmati rice, cereals, pulses, oil seeds, tea, coffee, spices, fruits, herbal medicines, honey, processed food and their value added products (Chettri, B., 2015). The production is not only limited to the edible sector, but also to that of organic cotton fiber, garments, cosmetics, functional food products, body care products etc.

Research Methodology

Socio economics condition of selected area : Bikaner district was selected purposively as it has large area under rainfed farming and mostly fertilizers and pesticides are not being used in this area. Looking to the virginity of land government is also taking initiatives to bring much area under organic farming under Paramparagat Krishi Vikas Yojana (PKVY) in this region.

Selection of Panchayat Samities : This scheme was started mainly in Nokha tehsil of Bikaner district in which two *panchayat samities* viz., Nokha and Panchu were having maximum number of farmers adopting organic farming therefore, these two *panchayat samities* were selected for selecting villages.

Selection of villages : A list of all the villages falling under the selected *tehsil* was prepared and two villages having more potential for organic farming (both in *kharif* and *rabi*) were selected. The selected villages were Jasrasar and Jangloo.

Selection of farmers : A list of all the farmers practicing organic farming was prepared and categorized into standard size groups viz, Small (< 2 ha), Medium (2- 4 ha) and large (> 4ha) land.

Analytical tools : To identify the various constraints in organic farming in the study area, first of all the various

constraints were identified from review of literature. Then identify the various Constraint in Production, Marketing and Certification facility of organic farming practices various constraints was identified from review of literature then validation of the questionnaire.

The data was analyzed with Garrett ranking method, respondents was asked to assign the rank for all constraints and the outcome of such ranking was converted into score value with the help of the following formula :

Per cent position = $100 (R_{ij} - 0.5) / N_j$

Where, R_{ij} = Rank given for the i th variable by the j th respondent ($i=1,2,3,\dots$) factor by the j^{th} ($j=1,2,3,\dots$)

N_j = number of variables ranked by the j th respondent

Once the per cent positions were found, the per cent position of each rank was converted to scores by referring to table given in garret and woods worth (1969). Then the scores for each factor was summed over the number of sample farmers who ranked that factor.

Results and Discussion

The study of constraints (table-1) revealed that about 71.80 per cent farmers of the study area faced the problem about no availability of sufficient organic manure. About 73.02 per cent farmers reported the problem of selling and 41.09 per cent producers found difficulty in finding the processors for organic produce. Certifications facility was another major problem and about 73.89 per cent farmers above facing such problem. About 58.72 per cent farmers were not much familiar about the advantage of organic farming. Higher marketing price of inputs for organic production was also major problems and about 47.07 per cent farmers faced their problem. Some of the farmers (about 33.03 per cent) reported that cost of certification of organic product was higher.

The study of constraints faced by the farmers in use and adoption of organic farming revealed that the important constraint faced by the farmers of study area were non availability of sufficient organic manures, difficult adopted to organic farming, low productivity of organic farming, lack of organic sale units, marketing of organic farming produce is the main problem, certification facility is not available of organic farming, unawareness of organic farming, price of the organic products is the high and cost of certification organic farming is high. The major problem faced by the farmer is related to difficulty in adoptions of organic farming was worked out about 43.37 per cent. About 73.02 per cent farmers reported the problem of selling. This scenario appears poor compared to many other countries. Farmers apprehension towards

of in India is rooted in non availability of sufficient organic supplements, bio fertilizers and local market for organic produce and poor access to guidelines, certification and input costs. Capital driven regulation by contracting firms further discourage small farm holders. An integrated effort is needed from government and non government agencies to encourage farmers to adopt of as a solution to climate change, health and sustainability issue (Pandey and Singh, 2012). Irrigated north western plain zone of Rajasthan, Lack of standard package of practices, costly and complex certification process and inadequate marketing facilities had been identified as major constraints faced by the organic farmers. (Meena, B.S. 2010).

Conclusions

Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. India produced around 3.49 million tonne of certified organic products which includes all varieties of food products. Madhya Pradesh has covered largest area under organic certification followed by Rajasthan, Maharashtra, Gujarat, Karnataka, Odisha, Sikkim and Uttar Pradesh. In 2020-21, the total volume of organic products export was 8.88 lakh metric tone. The present study was undertaken for studying constraints of organic farming practices in Bikaner district of Rajasthan. The study of constraints revealed that about 71.80 per cent farmers of the study area faced the problem about no availability of sufficient organic manure. About 73.02 per cent farmers reported the problem of selling and 41.09 per cent producers found difficulty in finding the processors for organic produce.

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Effect of Wool Waste in Conjunction with FYM and Fertilizer on Nutrient Content and Uptake by Cabbage Crop

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Abstract

A field experiment was conducted to study the effect of wool waste along with FYM and inorganic fertilizer on nutrient content and uptake by cabbage crop during 2015-16 at Agriculture Research Station, SKRAU, Bikaner, Rajasthan. The experiment consisted of twenty treatment combinations of five levels of organic manures and four levels of fertilizer. It was laid out in a split-plot design with three replications. The obtained results indicated that application of wool waste along with FYM and fertilizer significantly increased dry matter, nutrient content and uptake of cabbage head and leaves during the course of study. The maximum dry matter, macronutrient (N, P, K and S) content and uptake values were recorded with the application of wool waste @ 7.5 t ha⁻¹ in conjunction with FYM @ 7.5 t ha⁻¹ (W₁) and 125% fertilizer application, whereas, minimum uptake of these values were registered with control plot. The total uptake of N, P, K and S by cabbage was 167.11, 146.26, 120.45 and 218.66% more in W₁ treatment as compared to control.

Key word : Wool waste, nutrient content and uptake

Introduction

India is the world's second largest cabbage grower with a yield of 9.039 million tonnes from 0.400 million hectares, (Anon, 2014). Cabbage (*Brassica oleracea* L.) is a member of cole crops under the family Brassicaceae. It is low in fat, high in dietary fibre, foliate, water and vitamin C, processing a very high nutritional density which can help to protect a range of diseases from cancer to cataract (Krish et al., 2007). It is commonly used as a cooked vegetable as well as in salads, sandwiches, burgers, noodles, pasta and other dishes all across the world. Cabbage requires a variety of nutrients during its production cycle to maintain healthy growth, including nitrogen, phosphorus, and potassium in various amounts (Ceronio et al., 2012).

Use of organic fertilizer along with inorganic fertilizer has grown in popularity in recent years as consumers have become more aware of food safety issues and environmental concerns (Worthington, 1998; Worthington, 2001). Vegetables grown with this integrated use are also gaining popularity due to less chemical residues and a better taste (Patil et al., 2016) and also good for soil and human health. Now a days, Imbalance use of fertilizer in vegetable and other crop production is a common practice in India. The yield of vegetable crops condensed due to depleted soil fertility. The farmers use chemical fertilizers as a readily

supplemental source of nutrients but they do not apply in balanced proportion (BARC, 2005).

The use of by-products and wastes as a nutrient source for vegetable and crop production has a long history. However, there are some widely available by-products and waste material that have not yet been utilized and that may have potential value as nutrient sources for crops. Examples include sheep wool-waste generated during the process of cleaning raw wool (Kroening et al., 2004). Because of high N-content, waste wool has been used as a feedstock for composting (Plat et al., 1984; Das et al., 1997; Verville, 1996) and as mulch for weed control (Hartley et al., 1996; Duppong et al., 2004; Hartley et al., 1997). Many researchers demonstrated that wool waste when use as an organic source of fertilizer, it acts as a slow-release fertilizer (Zheljaskov, 2005; Zheljaskov et al., 2009). It maintains soil environment without showing any harmful effect.

The combined use of organic and chemical fertilizer maintains soil health and assist in maximizing vegetable and crop production as it involves utilization of source and hence, turned to be realistic, balanced and economically worthwhile way to provide nutrient to the crop (Singh et al., 2018). Hence present study was undertaken to know the effect of integrated use of wool waste along with FYM and inorganic fertilizer and their interaction effect on nutrient content and uptake of cabbage crop.

Materials and Methods

The experiment was laid down during Rabi season of 2015-16 at the ARS, SKRAU, Bikaner, Rajasthan. It is located 10 km away from the Bikaner city at 28° 01' N latitude, 73° 22' E longitude and at an altitude of 234.70 m above mean sea level. Annual average rainfall of about 20 to 30 cm. Southwest monsoon is predominant in this region. During summers, In the summer, the highest temperature may reach 48°C, while in the winter, it can drop to 0°C. The soil texture of the experimental field was sandy, low in organic carbon (0.16 %), nitrogen (89.24 kg ha⁻¹), phosphorus (27.64 kg ha⁻¹), iron (6.60 ppm) and zinc (0.97 ppm) and medium in potash (224.29 kg ha⁻¹) and alkaline pH (8.55) in reaction. The details of the treatments are given below :

- W₀ : control
 W₁ : 7.5 t ha⁻¹ each wool waste and farm yard manure
 W₂ : wool waste @ 5 t ha⁻¹ + farm yard manure @ 10 t ha⁻¹
 W₃ : wool waste @ 3.75 t ha⁻¹ + farm yard manure @ 11.25 t ha⁻¹
 W₄ : farm yard manure @ 15 t ha⁻¹
 F₀ : control
 F₁ : 75 % recommended dose of fertilizer (NPKS)
 F₂ : 100 % recommended dose of fertilizer (NPKS)
 F₃ : 125 % recommended dose of fertilizer (NPKS)

The experiment was replicated thrice in a split plot design. Wool waste and farm yard manure in different combinations were applied as per treatments before one month of transplant. The dose of N, P₂O₅, K₂O and S were applied as urea, DAP, MOP and elemental sulphur, respectively, as per treatment combination. Half dose of N, full dose of P and K were applied as basal at the time of transplanting. The remaining N was applied after 30 days of transplanting. Sulphur was applied as per treatment combination @ 40 kg ha⁻¹ through elemental sulphur before 10 days of transplanting. Cabbage crop (var. *Valina* hybrid) was transplanted in the field during November, 2015 and harvested at maturity stage, i.e., March, 2016. Soil samples were collected after harvesting of the crop and analysed by the standard scientific procedure. Cabbage head collected at maturity from each experimental plot and analyse dry matter, nutrient content and uptake. The experimental data recorded were subjected to statistical analysis using analysis of variance. The critical difference for the treatment's comparison were worked out, wherever the 'F' test was found significant at 5% level of significance.

Results and Discussion

The results obtained from the present investigation are summarized below in the following sub heads.

Dry matter production : Data pertaining to dry matter accumulation of cabbage in both head and leaves at maturity stage as affected by wool waste in conjunction with FYM and chemical fertilizer levels are presented in Table-1. Data revealed that application of various combinations of organic materials had significantly influence the dry matter yield at maturity stage of cabbage. Treatment W₁ produced highest head and leaf dry matter yield (12.19 % and 11.35 %) as compared to rest of the treatment. While, lowest was observed 10.14 and 10.55 %, respectively in control treatment (W₀). The successive increase in the levels of fertilizer application exhibited significant increase in the dry matter yield of cabbage crop. The maximum dry matter yield of cabbage head (12.18 %) and leaf (11.66 %) during experimental year was registered with the treatment F₃. The lowest head and leaf dry matter accumulation was recorded in control plot (F₀) with a value of 11.42 and 10.79 %, respectively. Increased application of N, P, K and S might have increased the meristematic activity and development of floral primordia through differentiation of tissue from somatic to reproductive sages, resulting in more dry matter yield (Singh *et al.* 2016).

Table-1 : Effect of wool waste in conjunction with FYM and chemical fertilizer on dry matter of cabbage at maturity stage.

Treatments	Dry matter (%)	
	Head	Leaf
Organic materials (t ha⁻¹)		
W ₀	10.14	10.55
W ₁	12.19	11.35
W ₂	12.16	11.33
W ₃	12.13	11.31
W ₄	12.11	11.06
S Em ±	0.015	0.022
CD 5%	0.050	0.073
Fertilizer Levels (kg ha⁻¹)		
F ₀	11.42	10.79
F ₁	11.59	10.80
F ₂	11.80	11.23
F ₃	12.18	11.66
S Em ±	0.037	0.036
CD at 5%	0.106	0.105

Nutrient content by cabbage head and leaf : An examination of data presented in Table-2 revealed that application of each different levels of organic materials and fertilizer levels significantly enhanced on nutrient content (N, P, K and S) in head and leaf of cabbage crop. Maximum nutrient content (N, P, K and S) in cabbage head and leaf were (2.27% and 1.88% N), (0.49% & 0.34% P), (2.46% & 1.95 K) and (0.75% & 0.46% S), respectively recorded with 7.5 t ha⁻¹ each wool waste and farm yard manure (W₁) and minimum nutrient content was

Table-2 : Effect of wool waste in conjunction with FYM and chemical fertilizer on nutrient content of cabbage.

Treatments	N %		P%		K%		S%	
	Head	Leaf	Head	Leaf	Head	Leaf	Head	Leaf
Organic materials (t ha⁻¹)								
W ₀	1.76	1.36	0.41	0.26	2.26	1.81	0.46	0.35
W ₁	2.27	1.88	0.49	0.34	2.46	1.95	0.75	0.46
W ₂	2.20	1.80	0.46	0.30	2.40	1.90	0.67	0.43
W ₃	2.12	1.73	0.44	0.29	2.39	1.88	0.61	0.39
W ₄	2.05	1.67	0.43	0.28	2.32	1.87	0.51	0.37
S Em ±	0.018	0.022	0.006	0.007	0.023	0.044	0.008	0.005
CD 5%	0.06	0.07	0.019	0.02	0.074	0.145	0.025	0.017
Fertilizer Levels (kg ha⁻¹)								
F ₀	1.94	1.55	0.41	0.25	2.26	1.78	0.49	0.33
F ₁	2.08	1.70	0.43	0.29	2.32	1.83	0.57	0.38
F ₂	2.14	1.74	0.46	0.32	2.40	1.92	0.65	0.43
F ₃	2.16	1.76	0.48	0.33	2.48	1.99	0.70	0.46
S Em ±	0.012	0.012	0.004	0.005	0.028	0.025	0.009	0.004
CD at 5%	0.03	0.03	0.013	0.01	0.080	0.071	0.025	0.013

Table-3 : Effect of wool waste in conjunction with FYM and Chemical fertilizer on Nutrient uptake in head, leaves and total uptake of cabbage crop.

Treatments	N Uptake (kg ha ⁻¹)			P Uptake (kg ha ⁻¹)			K Uptake (kg ha ⁻¹)			S Uptake (kg ha ⁻¹)		
	Head	Leaf	Total	Head	Leaf	Total	Head	Leaf	Total	Head	Leaf	Total
Organic materials (t ha⁻¹)												
W ₀	27.90	12.05	39.95	6.61	2.35	8.95	35.76	15.97	51.73	7.48	3.13	10.61
W ₁	78.55	28.16	106.71	16.93	5.11	22.04	84.88	29.15	114.04	26.81	7.00	33.81
W ₂	68.33	25.84	94.17	14.11	4.36	18.47	74.26	27.29	101.55	21.01	6.23	27.24
W ₃	61.43	23.05	84.47	12.80	3.90	16.70	69.19	25.11	94.30	18.08	5.33	23.41
W ₄	57.75	18.84	76.59	12.21	3.23	15.44	65.46	21.06	86.52	14.61	4.27	18.88
SE m ±	1.25	0.62	1.57	0.36	0.12	0.45	1.55	1.06	1.79	0.49	0.19	0.56
CD 5%	4.08	2.01	5.11	1.19	0.41	1.45	5.04	3.47	5.83	1.60	0.63	1.83
Fertilizer Levels (kg ha⁻¹)												
F ₀	38.22	15.54	53.75	8.10	2.48	10.58	43.97	17.64	61.61	9.67	3.32	13.00
F ₁	55.44	20.34	75.78	11.46	3.42	14.88	60.89	21.69	82.58	15.50	4.49	20.00
F ₂	68.09	23.96	92.05	14.47	4.37	18.85	75.61	26.03	101.64	21.09	5.97	27.06
F ₃	73.42	26.51	99.93	16.10	4.88	20.97	83.18	29.50	112.68	24.13	6.97	31.10
S Em ±	0.94	0.51	1.16	0.22	0.10	0.27	1.35	0.54	1.40	0.37	0.14	0.42
CD at 5%	2.71	1.46	3.35	0.64	0.30	0.78	3.89	1.56	4.03	1.06	0.40	1.22

recorded with control (W₀) during course of investigation. Wool waste typically has appreciable amount of total and available nitrogen, organic matter, phosphorus, potassium, sulphur (Choudhary *et al.*, 2019). It is potential source of readily available nutrients; growth enhancing substances and provide healthy environment to microbes. Dixit and Gupta (2000) demonstrate that application organic fertilizers increased efficiency of chemical fertilizer and nutrient content in cabbage.

A marked increased in nitrogen, phosphorus, potash and sulphur content of cabbage was significantly affected by increasing levels of fertilizer dose. Application of 125 % recommended dose of fertilizer (F₃) gave highest nitrogen content (2.16% N, 1.76% N), phosphorus (0.48% P, 0.33% P), potassium (2.48% K, 1.99% K) and sulphur (0.70% S, 0.46% S) in cabbage head and leaf respectively. Whereas most of the nutrient content were at par with 100% RDF (F₂).

Nutrient uptake in head and leaf : Data presented in Table-3 revealed that total nutrient uptake by cabbage (head + leaf) significantly increased with application of wool waste and FYM in 1:1 ratio (7.5 t ha⁻¹ each wool waste and farm yard manure (W₁) and increasing levels of fertilizer. Nitrogen, phosphorus potash and sulphur uptake by the cabbage crop were significantly highest under 7.5 t ha⁻¹ each wool waste and farm yard manure (W₁) over control and rest of the treatment. The percent increase in total nutrients uptake under W₁ was higher to the tune of 167.11% in nitrogen, 146.26% higher in phosphorus, 120.45 % higher in potash and 218.66% higher in sulphur uptake over control. It was also demonstrated that the activity of soil microbes under higher FYM applications might had led to increased nutrient uptake (Yassen *et al.* 2010, Parewa *et al.*, 2021). Wool waste is made up of keratin (a type of protein) and contains an adequate amount of essential plant nutrients like, N, C and S

Table-4 : Combined effect of wool waste in conjunction with FYM and chemical fertilizer on total uptake of nitrogen (kg ha⁻¹) in cabbage crop.

W x F	Total N uptake (kg ha ⁻¹)					Total P uptake (kg ha ⁻¹)				
	Organic materials (t ha ⁻¹)					Organic materials (t ha ⁻¹)				
	W ₀	W ₁	W ₂	W ₃	W ₄	W ₀	W ₁	W ₂	W ₃	W ₄
Fertilizer Levels (kg ha⁻¹)										
F ₀	28.4	70.0	61.1	57.6	51.7	5.6	13.8	12.2	11.2	10.0
F ₁	36.9	98.4	92.9	80.3	70.4	7.7	19.8	17.6	15.4	14.0
F ₂	43.6	125.9	107.9	96.6	86.3	10.1	26.8	20.8	18.8	17.7
F ₃	50.9	132.5	114.9	103.3	98.0	12.4	27.8	23.2	21.4	20.1
CD-I at 5%	5.11					1.45				
CD-II at 5%	4.00					1.07				
W x F	Total K uptake (kg ha ⁻¹)					Total S uptake (kg ha ⁻¹)				
	Organic materials (t ha ⁻¹)					Organic materials (t ha ⁻¹)				
	W ₀	W ₁	W ₂	W ₃	W ₄	W ₀	W ₁	W ₂	W ₃	W ₄
Fertilizer Levels (kg ha⁻¹)										
F ₀	37.5	77.0	68.7	65.6	59.2	6.7	18.0	15.4	13.2	11.6
F ₁	47.4	103.5	98.5	85.8	77.7	9.2	28.5	24.7	21.5	16.0
F ₂	55.2	133.6	114.1	107.5	97.8	12.1	40.7	32.6	28.2	21.7
F ₃	66.8	142.0	124.9	118.2	111.4	14.4	48.0	36.3	30.7	26.1
CD-I at 5%	5.83					1.83				
CD-II at 5%	4.65					1.44				

(Gorecki and Gorecki, 2010), K, Na, P, Mg, Fe, Mn, and Zn (Zheljaskov *et al.*, 2008) and it act as a slow-release fertilizer for plants. Application of organic manures improved the nutrient availability and uptake which builds up amino acids and phosphorus content, which might have contributed to large photosynthetic activity and higher synthesis of nutrients in vegetables.

Numerically higher value of total nutrients uptake (N 99.93 kg ha⁻¹, P 20.97 kg ha⁻¹, K 112.68 kg ha⁻¹ and S 31.10 kg ha⁻¹) were recorded under highest dose of fertilizer i.e., 125% RDF (F₃) level, providing its superiority over control and rest of the treatment and recording 85.92%, 98.20%, 82.89% and 139.23% increase in nitrogen, phosphorus, potash and sulphur uptake, respectively over control treatment (F₀). Many researchers (Srinivasan *et al.*, 2014; Parewa *et al.*, 2021) also reported that recommended dose of fertilizer significantly enhanced the nutrient uptake in cabbage and wheat crop.

Interaction effect of organic manures and Fertilizer :

Data presented in Tables-4 showed that there was significant interaction between organic manure (wool waste along with FYM) and fertilizer levels on nutrient uptake by cabbage. The data of combined effect of organic materials and fertilizers shows that the maximum N uptake was recorded 132.5 kg ha⁻¹ with W₁F₃ followed by 125.9 kg ha⁻¹ with W₁F₂. The highest total N, P, K and S (132.50, 27.80, 142.00 and 48.00 kg ha⁻¹, respectively), uptake was recorded with treatment involving application of 7.5 t ha⁻¹ each wool waste and farm yard manure and

125% NPKS fertilizer followed by other treatment combinations. Yassen *et al.*, (2010) suggested that combination of organic manure increased the transfer of elements between the solid phase and soil solution which again could be a reason for the higher nutrient uptake.

Conclusions

The results of the present investigation clearly indicated that in comparison to individual application of organic manure, the combined application of wool waste along with FYM and recommended dose of fertilizer could give significantly higher nutrient uptake.

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Optimizing Fertilizer Use Efficiency and Profitability of Cabbage Following Organic Materials and Fertilization

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Abstract

The field experiment was conducted during rabi season 2015-16 at ARS, SKRAU, Beechwal, Bikaner (Rajasthan) to find out impact of combined use of wool waste and FYM and chemical fertilizer for higher productivity of cabbage in Torripsamment. Total twenty treatment combinations of five levels of organic source with different proportion and four levels of chemical fertilizer was used. It was laid out in split plot design with three replications. Maximum fertilizer use efficiency and B:C ratio value were observed with the application of wool waste with FYM @ 7.5 t ha⁻¹ each and 100 % inorganic fertilizer (W₁F₂) with a value of 69.47 kg yield kg⁻¹ applied fertilizer and 2.15, respectively. Whereas, higher value of net returns observed with W₁F₃ (113538.41 Rs ha⁻¹), which was at par with W₁F₂ (Rs. 113202.63 Rs ha⁻¹).

Introduction

Cabbage is one of the most popular vegetables grown in India. It is grown in 3.98 lakh hectares with a production of 90.37 lakh tonnes and a productivity of 22.70 tonnes per hectare (Anno, 2018). The major cabbage producing states are West Bengal, Odisha, Madhya Pradesh, Bihar, Assam, Gujarat and Uttar Pradesh. It is used as salad, boiled vegetable and dehydrated vegetable as well as in cooked curries and pickles. Cabbage is rich in minerals and vitamins A, B₁, B₂ and C (Hanif *et al.*, 2006). India has achieved “self-sufficiency” in vegetable production, but several factors have become major concerns in India, including reduced nutrient utilization, poor nutrient use efficiency, and soil nutrient balance. The implementation of the Green Revolution had a strong impact on our motherland. As the goal of increasing food grain production was met, there were signs of a decrease in partial and total factor productivity, the only reason being a decrease in the natural fertility of the soil (Ramakrishna *et al.*, 2014). Managing agricultural nutrients to provide a safe food supply and secure the environment remains one of the immense challenges of the 21st century (Zhang *et al.*, 2012). The application of fertilizers for crop production is increasing rapidly. However, the average N recovery efficiency and P recovery efficiency are less than 50% and 20%, respectively (Rakshit *et al.*, 2019). Crop nutrient uptake and crop yields are the principal factors that determine optimal fertilization practices (Ju *et al.*, 2011). Therefore, it is very important to apply fertilizers in an

efficient way to minimize loss and to improve the nutrient use efficiency (Li *et al.*, 2009)

Intensive agriculture with high yielding varieties has led to heavy withdrawal of nutrients from the soil and injudicious application of chemical fertilizers decreased the biological power of soil lowering the soil fertility and crop productivity (Chand, 2008).

As we fulfilled our target of increased food grain production, there are indications of declining partial and total factor productivity, and the sole cause has been attributed to diminishing native soil fertility. Therefore, the dwindling natural resource base has raised sustainability concerns and integrated resource management in the present agricultural system. Lourduraj (2000) has also reported that the combined application of inorganic and organic manures significantly enhanced the growth attributes and yield of vegetable as compared to the sole application of either of them.

Looking to the facts, the present investigation was carried out on impact of combined use of wool waste and FYM and chemical fertilizer for higher productivity of cabbage.

Materials and Methods

Field experiment was conducted at Research field of Agriculture Research Station, Swami Keshwanand Rajasthan Agricultural University, Beechwal, Bikaner during rabi season 2015-16, situated at an altitude of 234.7 m above sea level at latitude 28° 01' N and longitude 73° 22' E. The soil of the experimental area is

sandy with slightly alkaline pH (8.55), EC (0.10 dSm⁻¹), low in organic carbon (0.158%). Available N, P₂O₅, K₂O and S are 89.24 kg ha⁻¹, 27.64 kg ha⁻¹, 224.29 Kg and 21.92 kg ha⁻¹, respectively and DTPA extractable Zn, Fe, Mn and Cu are 0.97 ppm, 6.60 ppm, 7.42 ppm and 0.42 ppm, respectively. *Valina* hybrid variety of cabbage was used as test crop. The experiment was replicated three times in a split-plot design. Prior to a month of transplanting, wool waste and FYM were applied in different combinations according to the treatments. The dose of N, P₂O₅, K₂O and S were applied as urea, DAP, MOP and elemental sulphur, respectively, as per treatment combination. Half dose of N, full dose of P and K were applied as basal at the time of transplanting. The remaining N was applied after 30 days of transplanting. Sulphur was applied as per treatment combination @ 40 kg ha⁻¹ through elemental sulphur before 10 days of transplanting. Cabbage crop (var. *Valina* hybrid) was transplanted in the field during November, 2015 and harvested at maturity stage. Fertilizer use efficiency was computed as head yield per kilogram of nutrient applied. Economics was worked out based on the prevalent prices of inputs and sale price of cabbage head.

Results and Discussion

Fertilizer use efficiency : Data presented in table-1 clearly shows that organic materials have significant effect on fertilizer use efficiency after harvest of cabbage crop. The trend of fertilizer use efficiency was as follows W₁>W₂>W₃>W₄. Maximum fertilizer use efficiency value was recorded with W₁ i.e., wool waste @ 7.5 t ha⁻¹ and FYM @ 7.5 t ha⁻¹ with value of 47.94 kg yield kg⁻¹ applied fertilizer. It decreases with the proportion of wool waste decrease (figure 1) from W₁ to W₂ (17.07 %), W₂ to W₃ (12.47 %) and W₃ to W₄ (5.48 %), respectively. The fertilizer use efficiency increased with increased application of wool waste. The increase in fertilizer use efficiency can be attributed to: wool waste supplying more plant nutrients than other sources (Choudhary *et al.*, 2019); overcoming of deficiency (Shaji *et al.*, 2021); balancing of nutrients improvement of soil properties (Maheswarappa *et al.*, 1999, Ciesielczuk *et al.*, 2015); reduced losses; higher uptake and enhanced metabolic activities.

The fertilizer use efficiency decreased significantly with the increase in fertilizer level from 75 % (F₁) to 100 % (F₂) and 125 % (F₃) of recommended dose, respectively. The fertilizer use efficiency values were 48.64 to 47.61 and 40.47 kg yield kg⁻¹ applied fertilizer with the application of 75 per cent to 100 percent and 125 per cent, respectively.

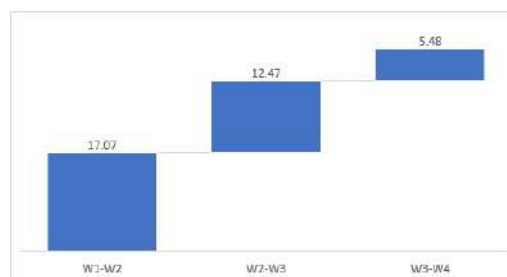


Fig-1 : Difference between two treatments in NUE (%).

The interaction effect of organic and inorganic fertilizer of fertilizer use efficiency is presented in table-2. The highest fertilizer use efficiency of 69.47 was registered with W₁F₂ i.e., application of wool waste @ 7.5 t ha⁻¹ in conjunction with FYM @ 7.5 t ha⁻¹ and 100 per cent recommended fertilizer dose, followed by with W₁F₁ (65.81) and W₂F₁ (62.01).

Table-1 : Effect of wool waste in conjunction with FYM and chemical fertilizer on fertilizer use efficiency (kg yield kg⁻¹ applied fertilizer).

Treatments	FUE
Organic materials (t ha⁻¹)	
W ₀	11.10
W ₁	47.94
W ₂	40.95
W ₃	36.41
W ₄	34.52
S Em±	1.44
CD at 5%	4.71
Fertilizer Levels (kg ha⁻¹)	
F ₀	0.00
F ₁	48.64
F ₂	47.61
F ₃	40.47
S Em±	0.95
CD at 5%	2.74

Table-2 : Combined effect of Wool waste in conjunction with FYM and chemical fertilizer on fertilizer use efficiency (kg yield kg⁻¹ applied fertilizer).

W x F	Organic materials (t ha ⁻¹)				
	W ₀	W ₁	W ₂	W ₃	W ₄
Fertilizer Levels (kg ha⁻¹)					
F ₀	0.00	0.00	0.00	0.00	0.00
F ₁	10.87	65.81	62.01	54.27	50.25
F ₂	15.60	69.47	55.57	49.94	47.50
F ₃	17.92	56.49	46.22	41.41	40.32
CD-I at 5%	4.70				
CD-II at 5%	3.55				

Table-3 : Effect of Wool waste in conjunction with FYM and chemical fertilizer on economics.

Treatments	Head yield (t ha ⁻¹)	Cost of cultivation (Rs. ha ⁻¹)	Gross returns (Rs. ha ⁻¹)	Net returns (Rs. ha ⁻¹)	B:C ratio (Net returns basis)
Organic materials (t ha⁻¹)					
W ₀	15.48	35305.60	77400.48	42094.87	1.174
W ₁	28.04	51055.60	140223.44	89167.84	1.722
W ₂	25.15	48805.60	125735.42	76929.81	1.557
W ₃	23.64	47680.60	118210.83	69296.58	1.410
W ₄	23.01	44305.60	115044.26	70738.66	1.581
S Em±	0.46	-	2276.38	2276.38	0.055
CD at 5%	1.48	-	7423.68	7423.68	0.178
Fertilizer Levels (kg ha⁻¹)					
F ₀	16.78	40496.00	83888.19	42405.27	1.021
F ₁	22.26	45430.60	111285.94	65855.33	1.426
F ₂	26.10	47075.47	130491.67	83416.20	1.742
F ₃	27.13	48720.34	135625.75	86905.41	1.766
S Em±	0.36	-	1785.94	1785.94	0.043
CD at 5%	1.03	-	5158.16	5158.16	0.124

Table-4 : Combined effect of wool waste in conjunction with FYM and chemical fertilizer on net returns (Rs. ha⁻¹).

W x F	Organic materials (t ha ⁻¹)				
	W ₀	W ₁	W ₂	W ₃	W ₄
Fertilizer Levels (kg ha⁻¹)					
F ₀	27129.00	49771.62	45122.33	41299.40	48704.00
F ₁	36254.40	80158.68	77487.73	68602.73	66773.12
F ₂	47458.10	113202.63	91472.86	82891.20	82056.20
F ₃	57538.00	113538.41	93636.33	84393.00	85421.33
CD-I at 5%	7423.68				
CD-II at 5%	5934.84				

Table-5 : Combined effect of wool waste in conjunction with FYM and chemical fertilizer on B : C ratio.

W x F	Organic materials (t ha ⁻¹)				
	W ₀	W ₁	W ₂	W ₃	W ₄
Fertilizer Levels (kg ha⁻¹)					
F ₀	0.89	1.08	1.03	0.87	1.24
F ₁	1.03	1.57	1.59	1.44	1.51
F ₂	1.28	2.15	1.81	1.68	1.79
F ₃	1.49	2.09	1.80	1.66	1.79
CD-I at 5%	0.18				
CD-II at 5%	0.14				

Economics : The results revealed that economics was affected by the application of wool waste, FYM and fertilizer (Table-3). Total cost increased with increased dose of wool waste but in the case of net returns and benefit cost ratio application of wool waste @ 7.5 t ha⁻¹ and FYM @ 7.5 t ha⁻¹ gave the maximum net returns and net returns per rupee of investment. Among the organics wool waste and FYM @ 7.5 t ha⁻¹ each (W₁) gave highest net return (89167.84 Rs ha⁻¹) and B:C ratio 1.722. Similarly highest dose of enhanced fertilizer i.e., 125 % RDF gave maximum net return (86905.41 Rs ha⁻¹) and B:C ratio of 1.766 (Table 3). The combined application of

wool waste @ 7.5 t ha⁻¹ and FYM @ 7.5 t ha⁻¹ (1:1) along with 125 per cent recommended dose of fertilizer gave the highest net returns (113538.41 Rs ha⁻¹) whereas application of wool waste @ 7.5 t ha⁻¹ and FYM @ 7.5 t ha⁻¹ (1:1) along with 100 per cent recommended dose of fertilizer W₁F₂ (113202.63 Rs ha⁻¹) gave at par net return and highest B:C ratio of 2.15 (Table 5). Hence, application of wool waste @ 7.5 t ha⁻¹ in conjunction with FYM @ 7.5 t ha⁻¹ + 100 per cent recommended dose of fertilizer (W₁F₂) was found most economical in terms of net returns and B:C ratio.

Conclusions

From the above study it can be concluded that integration of wool waste with FYM @ 7.5 t ha⁻¹ each and 100 % recommended dose of fertilizer economically profitable for cabbage production.

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Identification of Blast Resistant and Trait Specific Finger Millet Breeding Lines

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Abstract

Finger millet is an important nutri-cereal which can provide food and fodder to the teemingly growing population. Identification of trait specific lines in finger millet paves a path for effective breeding of disease resistant high yielding varieties. Hence, an experiment was undertaken at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2017 to 2020 to identify trait specific lines. The results revealed that significant variations existed among the 30t entries tested for Neck blast, finger blast banded blight diseases ear length(cm), finger length(cm), finger width(cm), productive tillers per plant, days to 50% flowering, days to maturity, fodder yield and grain yield. It was observed that VR 1128, VR 1125 and VR 1142 for neck blast and VR 1122, VR 1125 and VR 1132 for finger blast resistance consistently over four years of testing while VR 1141, VR 1135, VR 1128, VR 1136, VR 1125, VR 1122 and VR 1133 recorded lesser score of banded blight than the resistant check, GE 4999. Longer ear and finger length was observed consistently in VR 1137 compared to the check, VL 352. Consistent performance of earliness was recorded in VR 1143 followed by VR 1133 than the early check, VL 352. Number of fingers per ear were in VR 1141 followed by VR 1131 while the grain and fodder yield was more in VR 1125 compared to the best check.

Key words : Finger millet, blast resistance, trait specific, ear length, maturity.

Introduction

Finger millet (*Eleusine coracana*), is an important small millet in India and Africa grown for food and fodder in antiquity and today it is mostly gaining popularity due to its nutritional benefits and climate resilience. It is adapted to wide range of temperatures, moisture-regimes and input conditions supplying food and feed to millions of dry land farmers (Eric *et al.*, 2016). Finger millet ranks first in area and production among all small millets and among cereals it occupies sixth position sixth after wheat, rice, maize, sorghum and bajra.

Finger millet production is mostly hampered by the blast disease caused by *Pyricularia grisea*. The extent of damage depends on the severity and time of onset of disease. Finger millet blast has been reported to cause an average loss of 28% and has been reported as high as 80-90% in endemic areas (Patro and Anuradha, 2019). Throughout the plant's life cycle, from seedling to grain formation, the disease can affect the plant. Young seedlings are susceptible to the disease both in the nursery and in the field. The most viable, cost-effective and environmentally safe method of managing disease is through the use of high yielding resistant and tolerant cultivars. Consequently, it is most remunerative to farmers and identification of the source of the resistance is a fundamental step in breeding for disease resistance. Moreover the yielding potential of a genotype is determined by many agronomic characters' like number of productive tillers, number of finger per ear, ear length

etc., In order to breed high yielding varieties, genetic variability studies are required to identify trait-specific lines for various agronomic traits. Hence, the present investigation was carried out to identify sources of resistance against finger blast disease and also identification of trait specific breeding lines.

Materials and Methods

In the present investigation, 30 finger millet genotypes including two local check varieties, Sri Chaitanya, Bharathi, one national check, PR 202, one blast resistant check, GE 4999 and one susceptible check, VR 708 were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2017 to 2020. Genotypes were sown in a randomized complete block design (RCBD) in two replications with a spacing of 22.5 × 10 cm per each entry. Each genotype was grown in 4 lines of 3 m length. Fertilizers, 50-40-25 NPK kg/ha and need based plant protection measures were taken to raise a healthy crop. Five randomly selected plants were selected from each genotype/replication for recording the observations on plant height (cm), ear length (cm), finger length (cm), finger width (cm), productive tillers per plant and disease incidence. Days to 50% flowering, maturity, fodder yield (q/ha) and grain yield (q/ha) were recorded on plot basis.

The genotypes of finger millet were screened under natural epiphytotic conditions and no artificial inoculation was made. According to grades exhibited, the entries were categorized as I (Immune), HR (Highly resistant), R (Resistant), MS (Moderately susceptible) and S

(Susceptible) (Hittalmani, 2004) [4]. (Table-1 and 2). Neck blast (%) and finger blast (%) was calculated by using the following formula:

Analysis of variance and summary statistics was calculated as per Panse and Sukathme (1967).

$$\text{Neck blast (\%)} = \frac{\text{No. of infected panicles}}{\text{Total no. of panicles}} \times 100$$

$$\text{Finger blast (\%)} = \frac{\text{No. of infected fingers}}{\frac{\text{Average number of fingers}}{\text{Total Number of panicles}}} \times 100$$

Table-1 : Standard Evaluation System (SES) scale for neck blast disease.

Reaction Disease rating (%)	Reaction Disease rating (%)
Immune (I)	0.0
Resistant (R)	0.1-5.0
Moderately susceptible (HS)	5.1-10.0
Susceptible (S)	10.1-25.0
Highly susceptible (HS)	>25.0

Table-2 : Scale for Finger blast disease (Babu et al., 2013).

Reaction Disease rating (%)	Reaction Disease rating (%)
Immune (I)	0.0
Resistant (R)	1-10.0
Moderately susceptible (MS)	10.1-20.0
Susceptible (S)	20.1-30.0
Highly susceptible (HS)	>30.0

Results and Discussion

In four consecutive kharif seasons (2017-20), 30 finger millet advanced breeding lines were evaluated for all the agronomic traits and blast disease under natural field condition under high disease pressure.

1. Disease Resistance : Neck blast, finger blast and banded blight diseases studies recorded significant differences among the test entries (ANOVA not given here) during all the testing years. The mean data of the disease score is given in the table No. 3.

1.1 Neck Blast : The neck blast disease ranged from 2.83 % (VR 1128) to 61.60 % (VR 708) during 2017 and it was from 1.34 % (VR 1144) to 64.04% (VR 708) during 2018, while it was from 1.85% (VR 1128) to 69.50 % (VR 708) during 2019, whereas it was from 1.27% (VR 1142) to 60.34 % (VR 708) during 2020. The pooled mean over four years ranged from 2.10 % (VR 1128) to 63.87 % (VR 708). All the entries recorded significantly lower neck blast incidence than the susceptible check, VR 708. Most of the entries recorded resistant reaction. Entries, VR 1128, VR 1125, VR 1142 and VR 1135 recorded significantly lower incidence of neck blast disease over the resistant check,

GE 4999 during 2017, while VR 1144, VR 1128, VR 1142, VR 1123, VR 1134 and VR 1125 recorded significantly lower incidence of neck blast disease over the resistant check, GE 4999 during 2018. During 2019, 13 entries, Viz., VR 1128, VR 1123, VR 1135, VR 1125, VR 1122, VR 1143, VR 1144, VR 1142, VR 1129, VR 1136, VR 1140, VR 1132 and VR 1130 recorded significantly lower score of neck blast disease over the resistant check, GE 4999 while during 2020, 12 entries; VR 1142, VR 1122, VR 1135, VR 1133, VR 1128, VR 1139, VR 1140, VR 1136, VR 1125, VR 1137, VR 1131, VR 1126 and VR 1123 recorded lower score of neck blast disease than the resistant check, GE 4999. It was observed that VR 1128, VR 1125 and VR 1142 consistently recorded significantly lower neck blast score than the resistant check, GE 4999.

1.2 Finger Blast : The finger blast disease ranged from 2.62 % (VR 1122) to 63.10 % (VR 708) during 2017 and it was from 1.35 % (VR 1122) to 48.26 % (VR 708) during 2018, while it was from 1.85% (VR 1128) to 69.50 % (VR 708) during 2019, whereas it was from 1.44% (VR 1122) to 65.59 % (VR 708) during 2020. The pooled mean over four years ranged from 2.14 % (VR 1122) to 56.19% (VR 708). All the entries recorded significantly lower finger blast incidence than the susceptible check, VR 708. Most of the entries recorded resistant reaction.

Entries, VR 1122, VR 1125 and VR 1132 recorded significantly lower incidence of finger blast disease over the resistant check, GE 4999 during 2017, while VR 1122, VR 1132, VR 1123, VR 1140, VR 1138, VR 1135 and VR 1143 recorded lesser score of finger blast disease over the resistant check during 2018.

During 2019, 3 entries, viz., VR 1122, VR 1125, and VR 1140 recorded significantly lower score of finger blast disease over the resistant check, GE 4999 while during 2020, 3 entries; VR 1122, VR 1135 and VR 1132 recorded significantly lower score of finger blast disease than the resistant check, GE 4999. It was observed that VR 1122, VR 1125 and VR 1132 consistently recorded significantly lower finger blast score than the resistant check, GE 4999. VR 1125 recorded both neck and finger blast resistance consistently over four years of testing.

1.3 Banded Blight : The banded blight disease ranged from 3.99 % (VR 1128) to 28.85 % (VR 708) during 2017 and it was from 1.54 % (VR 1141) to 25.80% (VR 708) during 2018, while it was from 1.88% (VR 1135) to 26.07 % (VR 708) during 2019, whereas it was from 4.81% (VR 1141) to 33.31 % (VR 708) during 2020. The pooled mean over four years ranged from 3.24 % (VR 1141) to 28.53 % (VR 708). All the entries recorded significantly lower neck blast incidence than the susceptible check, VR 708. Most

Table-3 : Reaction of finger millet varieties against blast and banded blight disease resistance during *kharif*, 2017 to 2020.

S. No.	Entry	Neck Blast (%)				Finger Blast (%)				Banded blight (%)						
		2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean
1.	VR 1121	14.19	12.91	19.91	8.43	13.86	13.76	15.87	13.11	9.66	13.10	15.32	16.17	7.90	15.96	13.84
2.	VR 1122	5.82	6.05	4.96	1.45	4.57	2.62	1.95	1.44	2.57	2.14	7.07	5.22	4.44	5.78	5.63
3.	VR 1123	4.46	2.14	3.62	6.46	4.17	5.62	3.12	6.56	4.96	5.06	4.31	7.25	9.51	4.98	6.51
4.	VR 1124	12.61	9.02	16.16	8.84	11.66	10.92	10.66	10.59	8.17	10.08	13.29	14.29	15.56	15.25	14.59
5.	VR 1125	3.20	2.21	4.94	3.63	3.50	2.72	1.35	3.10	4.94	3.02	5.83	6.28	3.74	5.73	5.39
6.	VR 1126	5.10	3.84	9.40	6.41	6.19	10.28	10.41	13.85	11.53	11.52	6.92	6.04	6.11	8.00	6.77
7.	VR 1127	9.33	12.15	9.18	7.26	9.48	5.32	7.10	7.04	7.43	6.72	11.33	10.22	18.64	14.47	13.66
8.	VR 1128	2.83	1.35	1.85	2.36	2.10	10.22	9.94	9.85	8.32	9.58	4.22	3.70	3.15	7.37	4.61
9.	VR 1129	9.52	7.77	6.62	9.86	8.44	9.22	7.84	5.53	11.97	8.64	13.70	10.53	11.72	16.17	13.03
10.	VR 1130	7.80	2.91	8.60	8.30	6.90	5.27	6.28	6.56	9.27	6.84	9.84	8.34	8.30	6.98	8.36
11.	VR 1131	10.54	5.09	13.34	5.34	8.58	8.82	8.11	4.84	10.92	8.17	12.59	10.93	7.85	11.69	10.76
12.	VR 1132	8.09	11.63	7.61	12.65	9.99	3.92	2.23	5.60	3.35	3.77	11.64	8.88	9.53	12.23	10.57
13.	VR 1133	6.39	5.03	9.59	1.99	5.75	15.68	12.59	10.78	14.04	13.27	6.85	5.67	6.37	6.62	6.38
14.	VR 1134	8.13	2.21	12.38	9.68	8.10	7.92	8.91	8.63	24.18	12.41	5.29	10.87	9.86	6.81	8.20
15.	VR 1135	3.66	5.89	4.94	1.61	4.02	4.52	4.34	4.35	2.67	3.97	4.0	2.58	1.875	6.865	3.83
16.	VR 1136	9.52	5.56	7.07	3.15	6.32	11.35	10.96	12.24	17.07	12.91	5.61	3.25	6.90	4.81	5.14
17.	VR 1137	7.80	9.50	11.57	4.73	8.40	7.92	6.68	4.80	10.13	7.38	13.82	11.05	17.52	15.30	14.42
18.	VR 1138	10.53	4.42	9.59	11.88	9.10	4.52	4.33	7.08	5.04	5.24	8.89	8.52	6.98	7.12	7.88
19.	VR 1139	8.13	5.31	10.34	2.71	6.62	9.24	8.03	4.63	7.67	7.39	10.86	11.27	9.93	16.44	12.12
20.	VR 1140	4.42	7.32	7.55	3.04	5.58	4.34	3.34	3.14	4.40	3.81	11.33	10.71	9.02	9.53	10.15
21.	VR 1141	12.62	8.10	15.80	12.91	12.36	15.68	18.71	15.05	13.80	15.81	4.64	1.54	2.41	4.38	3.24
22.	VR 1142	3.22	2.03	6.13	1.27	3.16	7.38	5.89	5.90	7.67	6.71	10.90	8.64	6.54	10.35	9.10
23.	VR 1143	5.11	4.95	5.06	7.70	5.70	4.85	4.40	5.21	4.94	4.85	11.55	10.72	8.71	11.34	10.58
24.	VR 1144	11.71	1.34	5.54	13.23	7.95	8.93	6.83	8.00	10.36	8.53	10.41	8.73	8.43	10.11	9.42
25.	VR 847 ©	13.25	13.63	11.30	12.23	12.60	13.11	22.18	10.00	12.92	14.55	12.97	9.76	11.53	17.45	12.92
26.	VL 352 ©	15.25	13.37	12.48	11.61	13.18	15.62	16.44	15.12	17.25	16.10	12.35	13.05	14.08	15.29	13.69
27.	VR 762 ©	19.77	11.92	24.10	13.31	17.27	22.20	17.88	17.68	26.33	21.02	14.71	16.21	16.13	14.67	15.43
28.	PR 202 ©	17.52	23.90	11.91	19.95	18.32	12.94	14.42	14.92	9.55	12.96	6.67	16.49	17.18	9.60	12.48
29.	VR 708 ©	61.60	64.04	69.50	60.34	63.87	63.10	48.26	47.81	65.59	56.19	28.85	25.80	26.07	33.39	28.53
30.	GE 4999 ©	7.50	8.06	10.05	9.03	8.66	7.02	5.15	6.63	7.0	6.45	6.00	4.96	7.51	7.41	6.47
	Mean	10.63	9.08	11.67	9.23	10.09	10.83	10.14	9.66	11.79	10.82	10.06	9.59	9.78	11.07	10.15
	Min	2.83	1.34	1.85	1.27	2.10	2.62	1.35	1.44	2.57	2.14	3.99	1.54	1.88	4.38	3.24
	Max	61.60	64.04	69.50	60.34	63.87	63.10	48.26	47.81	65.59	56.19	28.85	25.80	26.07	33.39	28.53
	CD (5%)	3.28	2.35	1.94	1.98		2.94	3.31	2.66	2.90		2.42	2.61	2.23	2.09	
	CV (%)	15.08	12.65	8.14	10.48		13.27	15.98	13.47	12.02		11.75	13.31	11.15	9.22	

Table-4 : Ear length, finger length and finger width of finger millet varieties during *kharrif*, 2017 to 2020.

S. No.	Entry	Ear length (cm)				Finger length (cm)				Finger width (cm)						
		2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean
1.	VR 1121	8.39	7.60	10.77	9.48	9.06	7.19	7.06	10.36	9.23	8.46	1.10	0.85	1.40	1.15	1.13
2.	VR 1122	8.65	8.97	6.97	6.96	7.89	6.81	9.32	6.58	6.48	7.30	1.05	0.80	1.25	1.28	1.10
3.	VR 1123	8.83	6.78	9.67	11.02	9.07	7.28	6.27	9.09	10.79	8.36	0.90	0.60	0.95	0.85	0.83
4.	VR 1124	6.82	8.57	7.66	8.72	7.94	5.74	7.99	7.25	8.26	7.31	1.15	0.95	1.40	1.05	1.14
5.	VR 1125	8.57	9.74	8.64	9.45	9.10	7.19	9.45	8.19	9.15	8.49	1.10	1.35	1.05	1.00	1.13
6.	VR 1126	7.52	9.05	8.98	8.8	8.59	6.86	8.41	8.33	8.68	8.07	1.20	1.40	1.20	0.95	1.19
7.	VR 1127	8.11	8.70	8.08	7.2	8.02	7.30	8.27	7.81	7.07	7.61	0.95	1.05	0.80	1.05	0.96
8.	VR 1128	7.99	9.37	9.39	10.85	9.40	7.06	8.69	9.06	10.41	8.81	1.00	1.05	1.05	0.95	1.01
9.	VR 1129	8.07	8.03	8.18	9.56	8.46	6.64	8.20	7.83	9.47	8.03	1.10	0.85	0.95	0.90	0.95
10.	VR 1130	7.75	8.03	9.43	9.93	8.78	6.35	7.21	8.89	9.58	8.01	1.10	1.05	1.10	1.00	1.06
11.	VR 1131	9.93	10.73	9.21	9.79	9.92	8.36	10.24	8.84	9.48	9.23	1.00	1.20	1.10	0.95	1.06
12.	VR 1132	6.85	8.16	7.82	6.42	7.31	5.99	7.29	6.93	6.13	6.58	1.00	1.10	1.15	1.00	1.06
13.	VR 1133	8.44	8.94	7.3	8.21	8.22	6.79	8.74	6.66	7.92	7.53	1.00	0.80	0.85	1.10	0.94
14.	VR 1134	8.64	9.75	7.83	8.68	8.73	6.83	9.24	7.39	8.56	8.00	1.10	0.95	1.00	1.20	1.06
15.	VR 1135	8.59	10.02	7.82	8.26	8.67	7.07	9.68	7.60	8.03	8.09	1.15	1.35	1.25	1.20	1.24
16.	VR 1136	9.02	8.76	9.00	9.02	8.95	6.98	8.27	8.32	8.85	8.10	1.15	1.30	1.35	1.10	1.23
17.	VR 1137	10.90	11.02	9.98	10.18	10.52	9.30	10.57	9.97	10.03	9.97	1.00	1.10	0.80	0.80	0.93
18.	VR 1138	8.75	8.52	9.3	7.97	8.64	8.09	8.14	9.02	7.67	8.23	1.15	1.00	0.95	0.85	0.99
19.	VR 1139	7.98	8.82	9.14	5.96	7.97	7.14	8.03	8.92	5.62	7.43	0.88	0.93	0.90	1.05	0.94
20.	VR 1140	8.64	6.62	6.06	8.82	7.54	8.12	6.06	6.41	8.66	7.31	1.05	1.10	1.25	1.15	1.14
21.	VR 1141	7.69	8.55	9.53	9.99	8.94	5.58	8.06	9.71	9.66	8.25	1.18	1.48	0.93	1.20	1.19
22.	VR 1142	8.27	6.11	8.99	10.41	8.44	6.33	5.76	8.29	10.01	7.60	1.20	1.35	1.20	1.05	1.20
23.	VR 1143	7.72	10.51	6.26	5.00	7.37	6.19	9.78	5.58	4.65	6.55	0.90	0.85	0.90	0.75	0.85
24.	VR 1144	7.31	5.97	7.25	8.39	7.23	5.92	5.40	6.53	8.03	6.47	1.20	1.00	1.45	1.00	1.16
25.	VR 847 ©	7.71	8.91	6.75	8.07	7.86	6.42	8.20	6.94	7.75	7.33	1.05	0.85	0.95	1.05	0.98
26.	VL 352 ©	8.77	9.39	9.66	8.86	9.17	7.96	8.71	8.63	8.57	8.47	1.05	1.15	1.25	1.20	1.16
27.	VR 762 ©	6.53	6.64	7.67	8.64	7.37	7.09	6.20	7.31	8.36	7.24	1.00	1.10	0.90	1.15	1.04
28.	PR 202 ©	7.78	7.38	8.68	7.94	7.95	7.31	7.30	8.00	7.69	7.57	1.00	1.15	0.85	1.15	1.04
29.	VR 708 ©	7.28	9.03	6.27	6.14	7.18	7.09	7.84	6.85	5.86	6.91	1.00	0.90	0.90	0.90	0.93
30.	GE 4999 ©	7.54	6.95	7.57	7.06	7.28	7.16	6.44	6.82	6.57	6.75	1.10	1.35	0.85	0.90	1.05
	Mean	8.17	8.52	8.33	8.53	8.39	7.00	8.03	7.94	8.24	7.80	1.06	1.07	1.06	1.03	1.06
	Min	6.53	5.97	6.06	5.00	7.18	5.58	5.40	5.58	4.65	6.47	0.88	0.60	0.80	0.75	0.83
	Max	10.90	11.02	10.77	11.02	10.52	9.30	10.57	10.36	10.79	9.97	1.20	1.48	1.45	1.28	1.24
	CD (5%)	1.16	1.40	1.77	1.31		1.33	1.33	1.50	1.39		0.21	0.26	0.27	0.30	
	CV (%)	6.92	8.04	10.39	7.53		9.33	8.12	9.26	8.25		9.65	11.83	12.50	14.25	

Table-5 : Days to 50% flowering, days to maturity and number of productive tillers plant in finger millet varieties during *kharif*, 2017 to 2020.

S. No.	Entry	Days to 50% flowering				Days to maturity				Number of productive tillers/plant						
		2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean
1.	VR 1121	86.5	84.5	90.5	83.0	86.1	118.5	114.5	121.0	113.5	116.9	2.6	3.7	3.6	2.9	3.2
2.	VR 1122	88.0	82.5	88.5	87.0	86.5	117.0	112.5	119.5	117.5	116.6	3.3	4.3	4.7	4.4	4.1
3.	VR 1123	94.5	91.5	97.5	96.0	94.9	126.5	124.5	130.5	129.5	127.8	2.4	2.4	3.1	2.9	2.7
4.	VR 1124	86.5	82.0	88.0	83.5	85.0	115.5	112.5	118.5	114.0	115.1	3.3	3.7	4.3	3.8	3.8
5.	VR 1125	86.5	79.5	85.5	87.0	84.6	118.0	109.5	115.5	117.5	115.1	2.6	4.2	3.4	2.6	3.2
6.	VR 1126	92.0	86.0	92.0	88.0	89.5	124.0	119.0	123.5	120.0	121.6	2.1	3.7	2.8	2.3	2.7
7.	VR 1127	85.0	77.5	83.5	83.0	82.3	114.5	107.5	114.0	113.5	112.4	2.6	4.4	2.9	2.9	3.2
8.	VR 1128	98.0	95.5	93.5	93.0	95.0	129.0	127.5	126.5	123.5	126.6	2.5	3.4	3.2	3.5	3.2
9.	VR 1129	95.5	88.0	94.0	93.0	92.6	127.5	118.5	124.5	125.0	123.9	2.8	3.1	4.1	3.0	3.3
10.	VR 1130	92.0	87.5	93.5	89.0	90.5	124.5	118.0	126.0	120.0	122.1	2.2	3.7	3.8	2.6	3.1
11.	VR 1131	81.5	74.0	80.0	81.0	79.1	109.5	103.5	109.5	110.5	108.3	2.4	3.7	2.8	1.9	2.7
12.	VR 1132	81.0	75.5	81.5	79.0	79.3	111.0	105.5	110.5	108.0	108.8	2.9	3.4	3.3	3.5	3.3
13.	VR 1133	78.0	69.5	71.0	74.0	73.1	108.5	98.0	100.0	102.0	102.1	2.1	2.7	2.3	3.4	2.6
14.	VR 1134	93.0	87.0	93.0	89.5	90.6	124.5	117.5	123.0	119.5	121.1	2.8	4.2	3.2	3.6	3.5
15.	VR 1135	92.5	88.5	94.5	88.0	90.9	122.5	119.5	126.5	119.0	121.9	2.6	4.0	3.4	2.9	3.2
16.	VR 1136	90.5	83.0	89.0	87.0	87.4	122.5	113.5	119.0	117.5	118.1	2.6	2.9	4.0	2.2	2.9
17.	VR 1137	91.0	89.0	95.0	89.0	91.0	124.0	121.0	128.0	120.5	123.4	2.5	4.0	2.9	2.5	3.0
18.	VR 1138	84.5	78.5	84.5	84.5	83.0	116.0	108.5	115.5	115.0	113.8	2.7	4.0	4.1	3.9	3.7
19.	VR 1139	92.5	87.5	93.5	90.5	91.0	122.5	119.5	125.5	122.5	122.5	2.2	3.1	3.9	3.3	3.1
20.	VR 1140	97.5	91.5	95.0	94.5	94.6	129.0	123.0	128.0	126.5	126.6	2.9	4.1	3.3	2.8	3.3
21.	VR 1141	98.5	90.5	96.5	83.5	92.3	133.0	123.0	127.0	113.5	124.1	3.0	3.5	3.0	3.8	3.3
22.	VR 1142	94.0	91.0	97.0	88.0	92.5	126.0	124.0	129.5	119.5	124.8	2.6	3.0	3.5	3.6	3.2
23.	VR 1143	73.0	66.0	72.0	69.5	70.1	101.5	94.5	100.5	98.5	98.8	2.5	3.3	3.1	3.2	3.0
24.	VR 1144	93.5	89.5	95.5	90.0	92.1	126.5	120.5	125.5	121.0	123.4	2.3	4.3	2.5	2.4	2.9
25.	VR 847 ©	94.0	88.0	94.0	93.5	92.4	126.5	121.0	124.5	124.5	124.1	2.3	2.3	3.9	2.7	2.8
26.	VL 352 ©	78.0	73.5	79.5	74.5	76.4	106.5	102.5	108.5	104.0	105.4	2.3	3.6	3.3	2.8	3.0
27.	VR 762 ©	82.5	77.0	83.0	78.5	80.3	113.5	106.5	112.5	108.0	110.1	2.2	3.8	3.2	3.0	3.1
28.	PR 202 ©	92.0	86.0	92.0	90.0	90.0	124.0	118.0	123.5	121.0	121.6	2.7	3.5	3.0	3.0	3.1
29.	VR 708 ©	74.5	66.0	72.0	73.0	71.4	103.5	94.5	100.5	101.5	100.0	2.4	3.5	3.9	2.8	3.2
30.	GE 4999 ©	74.0	70.5	76.5	73.0	73.5	103.0	99.0	104.5	101.5	102.0	2.4	3.9	2.5	2.6	2.9
	Mean	88.0	82.6	88.1	85.1	85.9	119.0	113.2	118.7	115.6	116.6	2.6	3.6	3.4	3.0	3.1
	Min	73.0	66.0	71.0	69.5	70.1	101.5	94.5	100.0	98.5	98.8	2.1	2.3	2.3	1.9	2.6
	Max	98.5	95.5	97.5	96.0	95.0	133.0	127.5	130.5	129.5	127.8	3.3	4.4	4.7	4.4	4.1
	CD (5%)	2.86	6.17	7.33	6.18		4.93	6.41	7.74	6.18		0.71	1.18	1.05	0.88	
	CV (%)	1.59	3.66	4.07	3.55		2.03	2.77	3.19	2.61		13.50	16.11	15.29	14.18	

Table-6 : Number of fingers per ear, grain yield and fodder yield in finger millet varieties during kharif, 2017 to 2020.

S. No.	Entry	Number of fingers/ear				Grain yield (q/ha)				Fodder yield (q/ha)						
		2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean	2017	2018	2019	2020	Mean
1.	VR 1121	7.70	6.40	7.30	8.20	7.40	25.00	28.91	28.88	30.38	28.29	45.2	59.9	69.86	51.02	56.51
2.	VR 1122	8.50	8.00	9.90	8.80	8.80	23.33	27.75	25.82	30.01	26.73	47.6	54.8	67.19	55.56	56.30
3.	VR 1123	8.10	8.00	8.00	8.00	8.03	22.50	25.19	26.04	29.35	25.77	46.9	59.9	72.48	59.90	59.77
4.	VR 1124	8.00	7.20	8.10	7.15	7.61	20.74	23.85	21.01	26.41	23.00	45.0	67.4	66.74	54.77	58.48
5.	VR 1125	8.60	7.80	8.40	7.70	8.13	33.70	39.00	37.79	44.95	38.86	70.6	92.0	97.32	88.53	87.12
6.	VR 1126	8.10	8.90	8.30	8.50	8.45	21.20	26.29	25.37	27.66	25.13	43.5	72.0	69.78	56.41	60.41
7.	VR 1127	7.10	7.60	7.00	6.80	7.13	20.37	24.78	24.40	27.10	24.16	35.7	63.1	73.17	62.59	58.64
8.	VR 1128	8.40	8.30	7.60	7.80	8.03	26.11	30.36	36.07	33.35	31.47	51.1	79.3	69.67	69.10	67.27
9.	VR 1129	8.20	7.90	9.40	8.50	8.50	29.17	34.86	31.30	35.25	32.64	58.5	73.7	77.02	80.54	72.44
10.	VR 1130	5.70	4.90	5.40	5.30	5.33	26.39	29.93	34.70	31.14	30.54	52.6	80.5	84.60	75.03	73.19
11.	VR 1131	5.90	6.90	6.00	5.90	6.18	20.83	28.38	25.05	25.77	25.01	40.3	66.9	60.48	70.61	59.58
12.	VR 1132	7.10	7.00	6.70	6.40	6.80	24.17	27.35	25.73	29.07	26.58	51.5	64.9	73.77	59.37	62.39
13.	VR 1133	9.00	10.80	9.30	8.90	9.50	20.46	24.25	19.58	26.64	22.73	40.9	83.8	63.61	57.85	61.55
14.	VR 1134	7.80	8.10	7.00	7.90	7.70	28.15	34.74	30.93	34.13	31.99	68.0	78.8	84.64	79.55	77.75
15.	VR 1135	7.20	7.00	6.70	8.30	7.30	20.83	24.69	22.83	29.88	24.55	47.2	77.1	76.54	66.92	66.94
16.	VR 1136	7.00	6.80	7.20	6.10	6.78	27.96	37.71	44.81	30.32	35.20	59.0	79.4	78.50	79.48	74.07
17.	VR 1137	7.80	7.80	7.70	8.40	7.93	21.48	25.17	22.94	26.82	24.10	43.8	60.8	65.40	52.68	55.65
18.	VR 1138	8.90	8.50	8.20	8.00	8.40	26.67	30.97	40.90	32.80	32.83	55.2	72.8	79.51	57.95	66.37
19.	VR 1139	6.00	6.40	5.80	4.80	5.75	23.70	27.48	24.89	29.52	26.40	49.3	75.2	74.57	58.18	64.30
20.	VR 1140	6.20	5.70	5.80	5.60	5.83	24.81	30.42	26.17	30.72	28.03	51.2	79.9	75.97	69.10	69.03
21.	VR 1141	10.00	9.90	10.00	10.10	10.00	20.65	25.42	22.22	26.30	23.65	45.5	56.3	56.51	55.73	53.52
22.	VR 1142	7.90	8.00	8.10	8.00	8.00	19.35	22.73	23.15	26.76	23.00	38.1	61.5	71.65	55.96	56.79
23.	VR 1143	7.10	7.70	7.90	5.70	7.10	13.61	18.59	29.40	22.60	21.05	45.6	48.6	60.35	60.46	53.75
24.	VR 1144	7.90	7.80	8.10	8.80	8.15	30.46	34.56	36.58	33.24	33.71	42.6	62.9	67.11	68.23	60.20
25.	VR 847 ©	7.90	7.10	6.90	8.30	7.55	23.98	27.60	28.05	29.89	27.38	49.4	72.5	74.50	65.04	65.35
26.	VL 352 ©	7.40	7.40	8.00	7.20	7.50	20.00	25.71	19.34	26.98	23.01	45.2	61.2	62.53	57.75	56.67
27.	VR 762 ©	7.50	7.20	8.20	7.80	7.68	22.16	25.34	24.19	27.78	24.86	42.1	56.6	58.05	60.21	54.23
28.	PR 202 ©	7.80	8.00	8.30	7.50	7.90	26.89	31.79	32.98	32.21	30.96	62.2	86.5	90.60	85.04	81.08
29.	VR 708 ©	8.20	7.40	8.50	8.70	8.20	13.23	16.74	15.11	20.08	16.29	46.1	70.0	54.22	59.45	57.45
30.	GE 4999 ©	8.00	7.20	8.10	7.80	7.78	13.08	16.52	14.91	18.40	15.73	38.5	45.2	60.93	53.09	49.42
	Mean	7.70	7.59	7.73	7.57	7.65	23.03	27.57	27.37	29.18	26.79	48.61	68.78	71.24	64.20	63.21
	Min	5.70	4.90	5.40	4.80	5.33	13.08	16.52	14.91	18.40	15.73	35.70	45.15	54.22	51.02	49.42
	Max	10.00	10.80	10.00	10.10	10.00	33.70	39.00	44.81	44.95	38.86	70.62	92.00	97.32	88.53	87.12
	CD (5%)	1.22	1.69	2.05	1.47		6.98	6.78	7.46	9.23		14.25	17.74	16.43	17.41	
	CV (%)	7.76	10.91	12.95	9.50		14.82	12.04	13.29	15.47		14.41	12.66	11.32	13.34	

of the entries recorded resistant reaction. Entries, VR 1128, VR 1123, VR 1141, VR 1134, VR 1134 and VR 1136 recorded lower incidence of banded blight disease over the resistant check, GE 4999 during 2017, while VR 1141 recorded significantly lower incidence of banded blight over the resistant check, GE 4999 during 2018. During 2019, six entries, viz., VR 1135, VR 1141, VR 1128, VR 1125, VR 1144 and VR 1122 recorded significantly lower score of banded blight over the resistant check, GE 4999 while during 2020, three entries; VR 1141, VR 1136 and VR 1123 recorded significantly lower score of banded blight disease than the resistant check, GE 4999. It was observed that VR 1141, VR 1135, VR 1128, VR 1136, VR 1125, VR 1122 and VR 1133 recorded lesser score of banded blight than the resistant check, GE 4999 in the pooled mean.

Similar results for blast resistance were observed by Patro *et al.* (2013), Patro *et al.* (2016), Nagaraja *et al.* (2016), Neeraja *et al.* (2016), Divya *et al.* (2016), Patro *et al.* (2018a&b) and Patro and Anuradha (2019)

2. Agronomic traits: All the traits under study recorded significant differences among the test entries (ANOVA not given)

2.1 Ear length : The ear length ranged from 6.53 cm (VR 762) to 10.90 cm (VR 1137) during 2017 (Table-4) and it was from 5.97 cm (VR 1144) to 11.02 cm (VR 1137) during 2018, while it was from 6.06 cm (VR 1140) to 10.77 cm (VR 1121) during 2019, whereas it was from 5.00 cm (VR 1143) to 11.02 cm (VR 1123) during 2020. The pooled mean over four years ranged from 7.18 cm (VR 708) to 10.51 cm (VR 1137). Entries, VR 1137 and VR 1131 recorded significantly longer ear length over the check, VL 352 during 2017, while VR 1137 recorded significantly longer ear length over the check, VL 352 during 2018. During 2019, two entries, viz., VR 1121 and VR 1137 recorded longer ear length over the check, VL 352 while during 2020, four entries; VR 1123, VR 1128, VR 1142, VR and VR 1137 recorded longer ear length over the check, VL 352. It was observed that VR 1137 consistently recorded longer ear length over the check, VL 352.

2.2 Finger length : The finger length ranged from 5.58 cm (VR 1141) to 9.30 cm (VR 1137) during 2017 (Table-4) and it was from 5.40 cm (VR 1144) to 10.57 cm (VR 1137) during 2018, while it was from 5.58 cm (VR 1143) to 10.60 cm (VR 1121) during 2019, whereas it was from 4.65 cm (VR 1143) to 10.79 cm (VR 1123) during 2020. The pooled mean over four years ranged from 6.47 cm (VR 1144) to 9.97 cm (VR 1137).

Entry, VR 1137 recorded significantly longer finger length over the check, VL 352 during 2017, while VR 1137 and VR 1131 recorded significantly longer finger length over the check, VL 352 during 2018. During 2019, two entries, viz., VR 1121 and VR 1137 recorded longer finger length over the check, VL 352 while during 2020, four entries; VR 1123, VR 1128, VR 1137 and VR 1142 recorded significantly longer finger length over the check, VL 352. It was observed that VR 1137 consistently recorded longer finger length over the check, VL 352.

2.3 Finger width : The finger width ranged from 0.88 cm (VR 1139) to 1.20 cm (VR 1144) during 2017 (Table-4) and it was from 0.60 cm (VR 1123) to 1.48 cm (VR 1141) during 2018, while it was from 0.8 cm (VR 1127) to 1.45 cm (VR 1144) during 2019, whereas it was from 0.75 cm (VR 1143) to 1.28 cm (VR 1122) during 2020. The pooled mean over four years ranged from 1.24 cm (VR 1134) to 0.83 cm (VR 1123). Entries, VR 1141, VR 1126, VR 1142 recorded wider finger width over the check, VL 352 during 2017, while VR 1141 recorded significantly wider finger width over the check, VL 352 during 2018. During 2019, four entries, viz., VR 1144, VR 1124, VR 1121 and VR 1131 recorded wider finger width over the check, VL 352 whereas during 2020, VR 1123, VR 1122 recorded wider finger width over the check, VL 352. It was observed that there were no entries which consistently recorded wider finger width over the check, VL 352 during four consecutive years.

2.4 Days to 50% flowering : Days to 50% flowering ranged from 73 days (VR 1143) to 99 days (VR 1141) during 2017 (Table 5) and it was from 66 days (VR 1143) to 96 days (VR 1128) during 2018, while it was from 71 days (VR 1143) to 98 days (VR 1123) during 2019, whereas it was from 70 days (VR 1143) to 96 days (VR 1123) during 2020. The pooled mean over four years ranged from 70 (VR 1143) to 95 days (VR 1128).

Entries, VR 1143 and VR 1133 were significantly earlier in days to 50% flowering than the early check, VL 352 during 2017, while VR 1143 was significantly earlier in days to 50% flowering than the early check, VL 352 during 2018. During 2019, two entries, viz., VR 1131 and VR 1133 were significantly earlier in days to 50% flowering than the early check, VL 352 during 2020. It was observed that VR 1143 followed by VR 1133 consistently recorded earlier days to 50% flowering than the early check, VL 352 during all the four years.

2.5 Days to maturity : Days to maturity ranged from 102 days (VR 1143) to 133 days (VR 1141) during 2017 (Table-5) and it was from 95 days (VR 1143) to 128 days (VR 1128) during 2018, while it was from 100 days (VR

1133) to 131 days (VR 1123) during 2019, whereas it was from 99 days (VR 1143) to 130 days (VR 1123) during 2020. The pooled mean over four years ranged from 99 (VR 1143) to 128 days (VR 1123). The entry, VR 1143 was significantly earlier in maturity than the early check, VL 352 during 2017 and 2018 while VR 1143 and VR 1133 were significantly earlier in maturity than the early check, VL 352 during 2019. During 2020, two entries, viz., VR 1143 and VR 1133 were earlier than the early check, VL 352 during 2020. It was observed that VR 1143 followed by VR 1133 consistently recorded earlier maturity than the early check, VL 352 during all the four years.

2.6 Number of Productive tillers/plant : The range was very narrow and there is no much significant variation in number of productive tillers per plant compared to the best check during the evaluation period of four years (Table-5).

2.7 Number of fingers per ear : Number of fingers per ear ranged from 6 (VR 1130) to 10 (VR 1141) during 2017 (Table-6) and it was from 5 (VR 1144) to 11 (VR 1137) during 2018, while it was from 5 (VR 1140) to 10 (VR 1121) during 2019, whereas it was from 5 (VR 1143) to 10 (VR 1123) during 2020. The pooled mean over four years ranged from 5 (VR 708) to 10 (VR 1137). Entries, VR 1141 recorded significantly more number of fingers than the best check, VR 708 during 2017, while VR 1133 and VR 1141 recorded significantly more number of fingers than the best check, PR 202 during 2018. During 2019, two entries, viz., VR 1141 and VR 1122 recorded more number of fingers than the best check, VR 708 while during 2020, VR 1141 recorded more number of fingers than the best check, VR 708. It was observed that VR 1141 followed by VR 1131 recorded more number of fingers than the best check, VR 708 in the pooled mean.

2.8 Fodder Yield per Hectare : Fodder yield per hectare ranged from 35.7 q/ha (VR 1127) to 70.6 (VR 1125) during 2017 (Table 6) and it was from 45.0 (GE4999) to 92.0 (PR 202) during 2018, while it was from 54.2 (VR 708) to 97.3 (VR 1125) during 2019, whereas it was from 51.0 (VR 1121) to 88.5 (VR 1125) during 2020. The pooled mean over four years ranged from 49.4 (GE4999) to 87.1 (VR 1125). The entry, VR 1125 recorded high fodder yield than the best check, PR 202 during 2017, 2018, 2019 and 2020 and pooled mean data also indicate that VR 1125 recorded high fodder yield than the best check, PR 202.

2.9 Grain Yield per Hectare : It ranged from 13.08 q/ha (GE4999) to 33.7 q/ha (VR 1125) during 2017 (Table 6) and it was from 16.5 q/ha (GE4999) to 39.0 q/ha (VR 1125) during 2018, while it was from 14.9 q/ha (GE 4999) to 44.8 q/ha (VR 1136) during 2019, whereas it was from

18.4 q/ha (GE4999) to 445.0 q/ha (VR 1125) during 2020. The pooled mean over four years ranged from 15.7 q/ha (GE4999) to 38.8 q/ha (VR 1125). The entry, VR 1125 recorded significantly higher grain yield per hectare compared to the best check, PR 202 during 2017 and 2018. During 2019, VR 1136 and VR 1138 recorded significantly higher yield while VR 1125 recorded numerically higher yield compared to the best check, PR 202 whereas during 2020, VR 1125 recorded significantly higher grain yield per hectare compared to the best check, PR 202. It was observed that VR 1125 followed by VR 1136 recorded higher grain yields compared to the best check, PR 202.

Similar results of wide range of diversity for ear length, finger length, finger width, number of fingers per ear, days to 50% flowering, days to maturity, fodder and yield were observed in earlier studies (Anuradha *et al.*, 2013; 2017a&b, 2019a&b and 2020 a&b)

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WEB BASED SYSTEM FOR SOIL AMENDMENT IN ACIDIC SOILS

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Abstract

In India most of the acid regions soils are sedentary and are found in hilly terrains. Generally, these are common in on hill tops, hill slopes, terraced and unterraced uplands, medium lands or valley floors (Mandal, 1996). Further, acid and non-acid soils are present in many places in close proximity of each other. The acid soils in India occupies approximately 100 million ha of the geographical area. Acidic soils below pH 5.5 occupy around 25 million ha of arable land. Such type of problematic soils in India are mainly concentrated in north eastern region and western Ghats with sporadic distribution in Jharkhand, Himachal Pradesh, Orissa, Orissa, West Bengal, Chhatisgarh, etc. As such almost 84, 77, 76, 60, 57 and 47 percent soils of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura respectively have the soil pH below 5.5 and are considered strongly acidic. To solve the problems related to acid soils, their management and provide immediate information to solve the problem of the user an interactive web-based computer program has been developed to provide assistance on making decisions related to acidic soils and their management.

Key words : *Web, lime recommendation, acidic soils*

Introduction

Acid Soils Distribution : The acid soils are sedimentary in nature belonging to lateritic, ferruginous red and other red soil groups. They are developed mainly by the influence of relief, acidic parent material and wet climate. Under hot humid climate and heavy precipitation soils undergo drastic weathering of parent material and excess leaching of bases. In short, high rainfall with high temperature and heavy leaching is the main factor for the formation of acid soils. The toxicity of soil Al has been recognized one of the important factors limiting the productivity of crops on acid soils having pH below 5.5 in humid north eastern hills (NEH) region of India (Patiram, 2002). Improved sustainable-agricultural production systems for these soils could contribute to alleviate serious resource degradation and social equity concerns prevalent in these areas.

Soil acidity and fertility constraints : Acid soil infertility is a syndrome of problems that affect plant growth in soils with low pH. This complex of problems arises from toxicities and deficiencies in acid soils are related to :

1. Presence of the toxic concentration of Al and to a lesser extent Mn toxicity in many species,
2. Deficiency of bases (Ca, Mg, K) and their poor retention power,
3. High P fixation capacity of soil caused by highly active Al and Fe surfaces, rendering it unavailable to plants.

4. Deficiency of Mo, especially for the growth of legumes.

5. Reduction of soil biological activities.

6. Impairment of N₂-fixation by legumes caused by poor survival of microsymbiont and inhibition of nodulation, and

7. Fe and Mn toxicities in submerged rice.

Amendment of Soil Acidity for Crop Production :

Ninety five per cent of soils of NE states excepting Nagaland (77%) are acidic in reaction. Soil acidification is a major soil degradation issue in many parts of North eastern region of India. It is often an insidious soil degradation process, developing slowly although indicators such as falling yields, leaf discoloration in susceptible plants and lack of response to fertilizers can indicate that soil pH is falling to critical levels. If it is not corrected, acidification can continue until irreparable damage takes place in the soil. The vast areas are under slash and burn cultivation and these ancient and highly weathered soils and current systems of agricultural land use are particularly vulnerable to this process. Soils under jhums of North –Eastern Region are becoming increasingly infertile and acidic. Future changes in critical soil acidity can lead to catastrophic effect in soil quality and there is an urgent need to establish an accurate baseline for measuring future changes. Knowledge of soils/land management practices is needed to interpret soil acidity trends and to determine the effect of changes

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in management practice on the rate of soil acidification. The adverse effects of soil acidity can be solved either by addition of lime to counteracts the anomalies of such soils or to manipulate the agricultural practices to obtain optimum crops production. The liming of acid soils periodically, replenishes the calcium and magnesium, and neutralizes the soil acidity and other toxic nutrients to plants.

Liming of acid soils : The application of agricultural liming materials (referred to commonly as lime) to acidic soils, increases soil pH and decreases soil acidity and frequently alleviates the problems of soil infertility stresses without addition of harmful elements. Agricultural liming

materials contain compounds of carbonates, hydroxides, or oxides of calcium and magnesium. Liming materials include limestone, burned lime, marl, oyster shells, slag, cement plant flue dust, mining tailings, sugarcane press mud, wood ashes, and paper mill lime sludge (Table). It can be categorized into carbonates, oxides, hydroxides, and by-product materials.

Liming for Acid Soil Reclamation in Northeastern Hill region :

Any strategy for optimum land use in the North Eastern States is usually confronted with various constraints. There are different types of problem lands where the constraints for optimum production are either unfavorable

physico-chemical properties of the soil or some inherent land features and/or environmental conditions limiting optimum growth of crops. As such the productivity of these lands goes down to a considerable extent. Soil acidity is one such limiting factor affecting adversely crop production to a considerable extent mainly in high rainfall and light texture conditions over extensive areas of North Eastern states.

Soil acidity management

This part of the program allows users to enter soil test results and then it generates lime recommendations for major crops grown in Mizoram at the target pH of 6.5. To use the program, users should entered both pH and Soil clay.

To solve the problems related to acid soils, their management and provide immediate information to solve the problem of the user an interactive web-based computer program has been developed to provide assistance on making decisions related to acidic soils and their management.

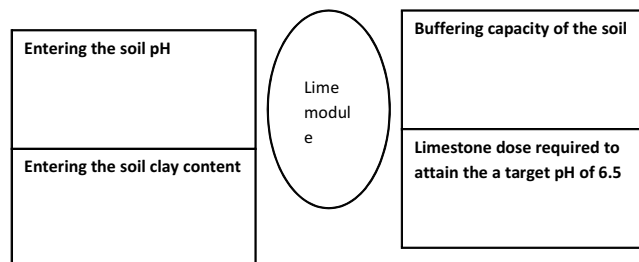
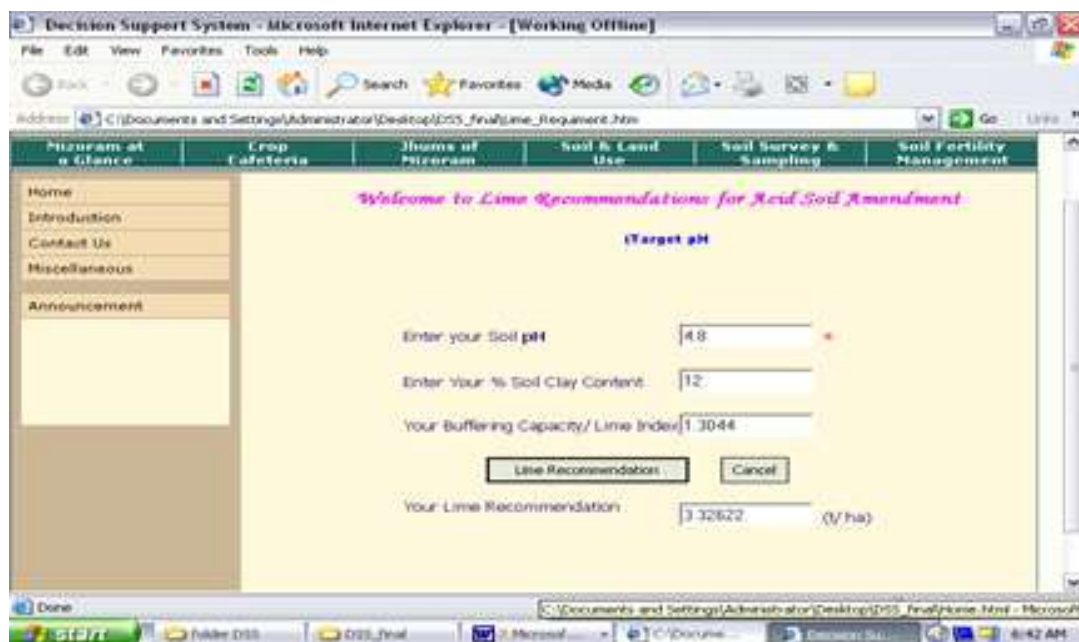


Fig. Flow diagram of Input-output relationship for lime module in DSSFMSM.

The Buffer pH (BpH) has a unique feature in that it automatically considers the different buffering capacities of soil textures. Example of 2 soils, one sand, one clay both with a pH of 5.5 can have different buffer pH values. The sand may have a BpH of 6.9 and the clay a BpH of 6.3. According to the table in Pub 296 the recommended rate of lime to achieve a target pH of 6.5 would be 2 and 5 tonnes per ha. The clay soil has a higher buffering capacity, caused by the higher exchange capacity, which holds more H and requires a greater amount of lime to raise the pH from 5.5 to 6.5. Whereas the sandy soil with a lower buffering capacity, and a lower exchange capacity requires less lime to move the pH from 5.5 to 6.5.

Conclusions

This decision support system allows users to obtain lime recommendation based on soil test results, to calculate the amount of lime required to bring the soil pH to a target pH of 6.5 which is suitable for cultivation of major crops in acidic soils of the region. To use the program, users should enter both pH and Soil clay content/buffer index for an accurate lime recommendation. Then, the system will automatically calculate the quantity of lime required to bring the soil to a target pH of 6.5 and will provide immediate solution in the respective column. It is hoped that the outcome of the programme will go long way in addressing one of the vital issue of this part of India and acid soils as a whole.



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Role of Different Organic Manures (Solid and liquid Organic Manures) on Agronomic Response 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, yield and quality of soybean. 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 highest plant height (26.92 cm) at 30 DAS in treatment T₁₁ Farmyard manure + Fish Amino Acid + Variety JS 95-60 and at 45 DAS highest plant height (39.80 cm) observed in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). There was progressive number of branches plant⁻¹ at 30 DAS significantly higher values (6.73) and at 45 DAS highest observed in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). There was progressive increase crop growth rate at 30 – 45 DAS, number of nodules plant⁻¹ at 45 DAS and dry weight significantly higher values (12.88, 16.00 and 41.33 g respectively) observed in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335), and at 83 DAS significantly higher Chlorophyll content was observed in treatment T₉ (Farmyard manure + Fish Amino Acid + Variety JS 335). The maximum biological yield (6191.66 kg ha⁻¹), net return (72925.66 Rs. ha⁻¹) and B: C ratio (2.66) observed in treatment T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335), highest oil content (20.00%) was observed in treatment T₁ (Vermicompost + Fish Amino Acid + Variety JS 335), and protein content (38.49) observed in T₆ (Poultry manure + *Panchgavya* + Variety JS 335).

Key words : Organic farming, farm yard manure, vermicompost, *panchgavya*, variety JS 335,

Introduction

Soybean (*Glycine max* L.) is considered as a wonder crop of 21st century which is the top oil seeds in the world production. Imkongtoshi and Gohain (2009). It contains 18 to 22% oil, highly desirable in diet and has 40 to 42% of good quality protein. Therefore, it is the best source of protein and oil and truly claims the title of the meat/oil on plants. Generally, it is used in the food industry for flour, oil, cookies, candy, milk, vegetable cheese, lecithin and many other products (Fatima *et al.*, 2006). 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 (Natarajan, 2002), 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). Soybean grown both as an oil seed and grain legume, fixes atmospheric nitrogen in soil and makes it available to partially fulfill the nitrogen requirement of succeeding crop (Jaybhay *et al.*, 2015). There is need to refining and standardized package of practice for important crop under organic farming system. Nutrient imbalance is one of the important constraints of soybean productivity and quality. Therefore in the present investigation effect of various of solid and liquid organic manure on (farmyard manure, Vermicompost, poultry manure, *Panchgavya* and Fish amino acid) 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. Use of 3% Panchgavya solution in field. Prepare 3% solution by 300 ml Panchgavya added with 10 liter water. 300 liter water require of one hectare. Three spray application in crop duration time, then one hectare require nine liter Panchgavya. 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. Chlorophyll content was measured by SPDA 502 handheld chlorophyll meter and the data was recorded in per cent. Measurements were taken Minolta SPDA Opti-Sciences CCM chlorophyll meter on leaves of a soybean crop. Plastic filter were used as leaf models because of their similarity to leaf spectra and their uniformity of colour (Richardson *et al.*, 2002). Oil content in kernels was estimated through 'Soxhlet's apparatus using petroleum ether as organic solvent (40-60°C) as per the methodology of Perry and Green, 1988.

$$\text{Oil content in kernels (\%)} = \frac{W_2 - W_1}{W_3} \times 100$$

Where, W_1 = Weight of flask (g)

W_2 = Weight of flask + oil (g)

W_3 = Weight of sample (g)

One g material was taken and it was homogenized with 10 ml buffer solution, after that the content was filtered and finally 10 ml filtrate was taken and it was mixed with 10 ml 10% TCA, after that it was kept for half an hour and then filtered. The residue was dissolved in 5 ml 0.1% N NaOH. Further, 1 ml filtrate was taken and 5 ml alkaline copper reagent was added. Solution was mixed well by centrifuge at 5000 rpm and kept for 10 minutes at room temperature. Half ml folin reagent was added and kept for 30 minutes. Finally the intensity was recorded at 660 nm (Lowry *et al.*, 1951)

It was calculated by the formula,

$$\text{Protein (\%)} = \frac{100 \text{ OD total volume made up}}{0.12 \text{ W } 10} \times 100$$

Where, OD = optical density

W = weight of sample

1. TCA Solution (10%) : 10 g TCA was dissolved in 100 ml water.

$$2. 0.1 \text{ N NaOH NEV} = \frac{0.1 \times 40 \times 100}{1000} \times 0.4$$

0.4 g was dissolved in 100 ml of distilled water.

3. Alkaline copper reagent

(i) 4% sodium carbonate in 0.1% N NaOH

(ii) 0.5% CuSO₄ in 1% sodium potassium tartarate

50 ml reagent (i) and 2 ml reagent (ii)

4. Folin reagent 1:1 ratio with distilled water

Pooled analysis of the data for four years was carried out using standard analysis of variance suggested by Gomez and Gomez (1984).

Variety and agronomic practices : Soybean variety JS-335 is a medium duration, high yielding variety, widely cultivated in India. The crop was sown in the first week of July and harvested at last week of October. Hand weeding was done once at 35 days after sowing.

Results and Discussion

There was progressive increase plant height, number of branches plant⁻¹ at 75 DAS, number of nodules plant⁻¹ at 60 DAS and dry weight at 45 DAS significantly higher values (55.33, 12.13, 30.33 and 12.00 g respectively) observed in treatment T₁₀ (Farmyard manure + Panchgavya + Variety JS 335), but chlorophyll content significantly higher values (49.53%) observed in treatment T₂ (Vermicompost + Panchgavya + Variety JS 335). However, plant height, number of branches plant⁻¹ and number of nodules plant⁻¹ in treatment T₂ (Vermicompost + Panchgavya + Variety JS 335), were found to be statistically at par with T₁₀ (Farmyard manure + Panchgavya + Variety JS 335). Further plant height, dry weight and chlorophyll content in treatment T₁ (Vermicompost + Fish Amino Acid + Variety JS 335) and number of branches, number of nodules and chlorophyll content in treatment T₉ (Farmyard manure + Fish amino acid + Variety JS 335), were found to be statistically at par with T₁₀ (Farmyard manure + Panchgavya + Variety JS 335).

Organic manure is most beneficial which effectively enhance growth of soyabean by improving the physical, chemical and biological properties of the soil. Application of organic manures such as Farmyard manure increases the availability of macro and micro nutrient, and promotes the activity of beneficial micro-organism under the organic farming system (Chaturvedi *et al.*, 2010). Increased plant height in the present investigation might be due to optimum nutrient uptake and reduced loss of N, *etc.*, which was evident in treatments with vermicompost application. Similar findings were reported by Grapelli *et al.* (1985).

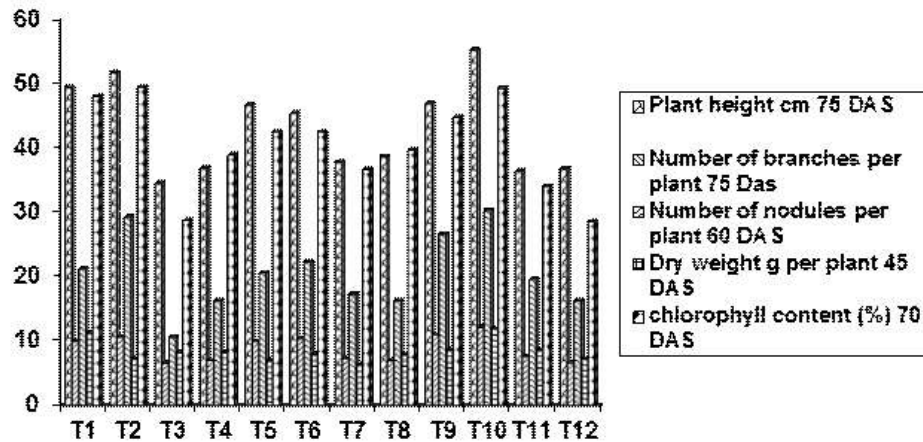


Fig.-1 : Role of different organic manures on growth of soybean.

Table-1 : Role of different organic manures on growth of soybean.

Treatments			Plant height cm		Number of Branches plant ⁻¹	
			30 DAS	45 DAS	30 DAS	45 DAS
Vermicompost	Fish Amino Acid	Variety JS 335	21.35	36.13	4.80	7.66
Vermicompost	<i>Panchgavya</i>	Variety JS 335	22.61	37.00	5.46	8.46
Vermicompost	Fish Amino Acid	Variety JS 95-60	26.45	32.06	4.93	6.13
Vermicompost	<i>Panchgavya</i>	Variety JS 95-60	25.99	34.33	5.20	6.93
Poultry manure	Fish Amino Acid	Variety JS 335	22.66	34.80	5.26	8.33
Poultry manure	<i>Panchgavya</i>	Variety JS 335	21.26	32.46	5.26	8.53
Poultry manure	Fish Amino Acid	Variety JS 95-60	25.90	34.06	4.86	6.66
Poultry manure	<i>Panchgavya</i>	Variety JS 95-60	26.83	36.83	4.73	7.46
Farmyard manure	Fish Amino Acid	Variety JS 335	23.68	33.80	5.40	7.40
Farmyard manure	<i>Panchgavya</i>	Variety JS 335	25.43	39.80	6.73	9.46
Farmyard manure	Fish Amino Acid	Variety JS 95-60	26.92	33.60	5.13	7.20
Farmyard manure	<i>Panchgavya</i>	Variety JS 95-60	25.33	34.80	4.80	5.93
SEd (±)			2.17	3.58	0.42	1.16
CD (P= 0.05)			NS	NS	0.87	NS
CV (%)			10.85	12.53	9.87	18.83

Vermicompost (2.6 t ha⁻¹), Farmyard manure (16 t ha⁻¹), Poultry manure (2.2 t ha⁻¹), *Panchgavya* (3%), Fish Amino Acid (3%)

Further, organic manures may have stimulated the functional activities of cells in roots of the plants (Rahman *et al.*, 2012). The application of organic manures decrease bulk density, improve the soil environment including physico-chemical (such as enhanced nitrogenase activity), biological condition, aeration and micro climate of rhizosphere resulting in maximum penetration of rhizobium in root hairs (Mishra *et al.*, 1990 and Yawalkar *et al.*, 1996). Additionally the significantly increased number of nodules plant⁻¹ might have been due to the ready availability of nutrients like phosphorus, through liquid organic formulations, *i.e.*, *Panchgavya* as foliar spray at critical stages, which would have triggered nodulation. Similar findings were reported by Ahlawat and Omprakash (1996).

The maximum oil content (20.00%) recorded in treatment T₁ (Vermicompost + Fish Amino Acid + Variety JS 335) and protein content (38.49%) observed in treatment T₆ (Poultry manure + *Panchgavya* + Variety JS

335). Further biological yield, net return and B: C ratio (6191.66 kg ha⁻¹, 72925.66 ha⁻¹ and 2.66 respectively) were recorded in T₁₀ (Farmyard manure + *Panchgavya* + Variety JS 335). The data of economics revealed that foliar application of *Panchgavya*, farm yard manure along with Variety JS 335 increased net returns and B: C ratio compared to other organic manure, being highest net return and B: C ratio. The optimum dose of nutrient through organic sources, which play an important role in increasing the output of soybean crop and sustain the fertility and productivity of the soil (Behera *et al.*, 2007) has shown itself to be economically promising.

Application of FYM and vermicompost produced maximum oil content. It may be due to higher rate of availability of sulphur from FYM and vermicompost (Behra, 2002). Vermicompost is most beneficial which effectively enhance growth of soybean by improving the physical, chemical and biological properties of soil (Sheikh *et al.*). The protein synthesis increased in seed

Table-2 : Role of different organic manures on growth of soybean at different stages.

Treatments			30-45 DAS CGR (g m ⁻² day ⁻¹) ⁻¹	30-45 DAS RGR (g g ⁻¹ day ⁻¹)	45 DAS Number of Nodules plant ⁻¹)	75 DAS Dry weight (g plant ⁻¹)	83 DAS Chlorophyll content (%)
Vermicompost	Fish Amino Acid	Variety JS 335	23.78	0.20	7.33	24.66	40.32
Vermicompost	<i>Panchgavya</i>	Variety JS 335	14.65	0.15	10.66	29.33	40.32
Vermicompost	Fish Amino Acid	Variety JS 95-60	16.69	0.17	4.66	20.33	8.73
Vermicompost	<i>Panchgavya</i>	Variety JS 95-60	17.31	0.18	7.33	18.33	12.10
Poultry manure	Fish Amino Acid	Variety JS 335	14.21	0.16	5.33	26.33	39.67
Poultry manure	<i>Panchgavya</i>	Variety JS 335	16.48	0.18	5.33	21.66	38.05
Poultry manure	Fish Amino Acid	Variety JS 95-60	12.57	0.15	9.33	19.33	13.40
Poultry manure	<i>Panchgavya</i>	Variety JS 95-60	15.88	0.15	6.33	21.33	13.17
Farmyard manure	Fish Amino Acid	Variety JS 335	17.06	0.17	15.66	27.66	40.66
Farmyard manure	<i>Panchgavya</i>	Variety JS 335	25.88	0.20	16.00	41.33	39.59
Farmyard manure	Fish Amino Acid	Variety JS 95-60	17.30	0.15	7.33	21.66	14.47
Farmyard manure	<i>Panchgavya</i>	Variety JS 95-60	14.87	0.16	7.33	20.66	13.96
SEd (±)			2.18	0.03	2.95	2.44	3.04
CD (P= 0.05)			4.51	NS	6.11	5.07	6.30
CV (%)			15.48	22.02	42.16	12.27	14.20

Table-3 : Role of different organic manures on quality, yield and economics of soybean.

Treatments				*Oil content (%)	*Protein content (%)	Biological Yield (kg ha ⁻¹)	*Net return (Rs. ha ⁻¹)	*B:C ratio
T ₁	Vermicompost	Fish Amino Acid	Variety JS 335	20.00	37.32	3819.00	36840.35	1.94
T ₂	Vermicompost	<i>Panchgavya</i>	Variety JS 335	18.00	37.54	4918.33	45732.35	2.17
T ₃	Vermicompost	Fish Amino Acid	Variety JS 95-60	17.33	36.82	3182.66	16263.66	1.41
T ₄	Vermicompost	<i>Panchgavya</i>	Variety JS 95-60	18.33	37.33	3414.00	22239.00	1.57
T ₅	Poultry manure	Fish Amino Acid	Variety JS 335	18.66	38.28	4803.00	51869.66	2.34
T ₆	Poultry manure	<i>Panchgavya</i>	Variety JS 335	17.66	38.49	3992.33	52013.66	2.35
T ₇	Poultry manure	Fish Amino Acid	Variety JS 95-60	17.33	37.65	3529.66	34209.66	1.88
T ₈	Poultry manure	<i>Panchgavya</i>	Variety JS 95-60	18.66	37.92	3993.00	57685.00	2.49
T ₉	Farmyard manure	Fish Amino Acid	Variety JS 335	17.66	37.41	4574.66	49450.35	2.12
T ₁₀	Farmyard manure	<i>Panchgavya</i>	Variety JS 335	19.33	37.53	6191.66	72925.66	2.66
T ₁₁	Farmyard manure	Fish Amino Acid	Variety JS 95-60	18.66	36.93	3703.33	25057.00	1.55
T ₁₂	Farmyard manure	<i>Panchgavya</i>	Variety JS 95-60	18.33	37.23	3934.66	34849.00	1.79
SEd (±)				-	-	728.95	-	-
CD (P= 0.05)				-	-	NS	-	-
CV (%)				-	-	21.40	-	-

Vermicompost (2.6 t ha⁻¹), Farmyard manure (16 t ha⁻¹), Poultry manure (2.2 t ha⁻¹), Fish Amino Acid (3%), *Panchgavya* (3%),

due to elevated contribution of nitrogen through organic manures that finally lead to increased protein content. Similar findings were reported by Evans and Sarger (1996). The better performance of organic manures (Farmyard manure, *Panchgavya*, etc) might be associated with sustained nutrient supply, increased root nodulation, which amplified the photosynthetic activity (Pakhale *et al.*, 2009) and good translocation efficiency (Tandaie *et al.*, 2009).

One liter *Panchgavya* cost of ₹ 63.25. One hectare require nine liter *Panchgavya*, nine liter cost of *Panchgavya* ₹ 1707. *Panchgavya* spray requires one labour for one hectare, then three sprays of *Panchgavya* three labour needs. One labour charge ₹ 165, then three

spray labour charge ₹ 495. Total charge spray of *Panchgavya* ₹ 2202. It is possible to apply to in field for low cost spray of *Panchgavya* under organic farming. The usage of fermented organic formulations with supportive beneficial microorganisms as foliar nourishment has been come into the picture of modern agriculture for giving rise to good quality non residue protected food (Galindo *et al.*, 2007). Consequences of *Panchgavya* application are superior growth, yield and quality of crops. This liquid organic solution is prepared from cow dung, urine, milk, curd, ghee, six ripe bananas. It provides macro nutrients, essential micro nutrients, many vitamins, required amino acids, growth promoting substances and beneficial microorganisms for plants well growth.(T.sivakumar, 2014).

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Efficacy of Certain Chemicals and Neem Products against Tobacco Caterpillar (*Spodoptera litura* Fab.) on Soybean (*Glycine max* L.) in Allahabad

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Abstract

A field experiment was conducted to study the efficacy of certain chemicals and Neem products against tobacco caterpillar (*Spodoptera litura*) on Soybean in Allahabad during *kharif* season of 2012-2013. The experiment was conducted in the research field of department of plant protection Sam Higginbottom Institute of Agriculture Technology and Science, Deemed-to-be-University Allahabad. Total two sprays were applied to protect the crop from *Spodoptera litura* using randomized block design with three replications. Chlorpyrifos 20 EC @ 0.05%, Cypermethrin 25 EC @ 0.006%, Quinalphos 25 EC @ 0.05%, Profenophos 50 EC @ 0.1%, Spinosad 45 SC @ 0.1%, NSKE 5%, Neem oil @ 1.0% were evaluated for their efficacy against *Spodoptera litura* damage Soybean. The observations of larvae of *Spodoptera litura* 24 hours before (Pre-treatment) and 3rd, 7th, 10th and 15th day after spraying (Post-treatment) were recorded for computing the percent larvae reduction. The data were subjected to statistical analysis after appropriate transformation for interpretation. The treatment with recommended insecticide spinosad 45% sc @ 0.1% was of the most effective treatment followed with and profenophos 50% EC @ 0.1%, Quinalphos 25 EC @ 0.05%, Cypermethrin 25 EC @ 0.006%, Chlorpyrifos 20 EC @ 0.05% and NSKE @ 5%. Neem oil @ 1%. The treatments with Quinalphos 25 EC @ 0.05% and Cypermethrin 25 EC @ 0.006%, Conc. also performed well against this pest Chlorpyrifos 20 EC @ 0.05%, NSKE @ 5% and Neem oil @ 1.0% were found less effective against *Spodoptera litura*. Spinosad (1:3.02) gave maximum cost benefit ratio followed by Quinalphos (1:2.83) Profenophos (1:2.81), Cypermethrin (1:2.80), Chlorpyrifos (1:2.74) and Neem oil (1:2.38) and NSKE (1:2.33) untreated control (1:1.60). Among the treatments the highest cost benefit ratio (C: B) of 1:3.02 was obtained with of Spinosad 45% SC @ 0.1%.

Key words : Efficacy, chemicals, neem product, *Spodoptera litura*, *Glycine max* L., cost benefit ratio.

Introduction

Soybean (*Glycine max* L. merill) is an important oil seed crop and food, in which most of the cereals are deficient. The 4 percent mineral salts of soybeans are fairly good grain legume. India is the second largest producer of Soybean after U.S.A. Soybean is known as the "GOLDEN BEAN" of the 20th Century (Gahukar, 1997). Though, Soybean is a legume crop, yet it is widely used as oilseed. Soybean has great potential as an exceptionally nutritive and very rich protein food. It can supply the much needed protein to human diets, because it contains 20% oil and 40% high-quality protein. Soybean protein is rich in the valuable amino acid, lysine 5% rich in phosphorous and calcium (Abhilash and Patil, 2006). Asian armyworm [*Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)] is a highly polyphagous, economically important pest in Southeast Asia, India, China, and Japan. It infests nearly 150 host plant species including cotton, bendhi, tomato, soybean and sunflower (Rao *et al.*, 1993). In India, 40 species of cultivated crops, wild plants and 11 flowering plants are affected by this pest. *Spodoptera litura* has developed resistance against many synthetic insecticides (Kranthi *et al.*, 2002).

Materials and Methods

The experiment was conducted to evaluate the selected insecticides and Neem products on *Spodoptera litura* during the *kharif* season of 2012-2013 at the central crop research Farm Dept. of plant protection of Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-to-be-University) Allahabad, Uttar Pradesh under partial irrigation condition. The experiment was laid out in Randomized block design with 8 treatment replicated three in 2x2 plot size. The soybean (JS-335 Variety) was raised as per the recommended package of practices except plant protection measures. The treatment were imposed by using knapsack sprayer @ 500-600 litre of spray solution/ha. The crop received two sprays, the first being given at 45 days after sowing when the population crossed Economics Threshold Level (1-2 Larva/plant) while the second spray was imposed 15 days after first spray. The number of *S. litura* larvae was counted on 5 randomly selected plants in each plot. The pre-treatment count was made a day before the first and second spray whereas, the post-treatment counts were made on 3rd, 7th, 10th and 15th days after each spray. The data obtained were subjected for arcsine transformation and statically analyzed. The yield was recorded for net plot area and then converted to q/ha. and analyzed

Table-1 : Efficacy of selected insecticides and Neem products against tobacco caterpillar (*Spodoptera litura* Fab.) on soybean (*Glycine max* L.) in Allahabad during kharif season 2012-2013 (1st spray).

Treatments		% Reduction over control					Overall Mean
		1 st Days after spraying					
		Before	3 DAS	7 DAS	10 DAS	15 DAS	
T ₁	Chlorpyriphos	2.27(8.66)	60.10(50.82)	57.32(49.20)	55.12(47.93)	47.23(43.46)	54.94(47.83)
T ₂	Cypermethrin	2.13(8.39)	62.87(52.45)	59.84(50.67)	60.68(51.16)	48.88(44.35)	58.07(49.64)
T ₃	Quinalphos	2.13(8.39)	68.68(55.96)	60.10(50.82)	57.90(49.54)	55.12(47.93)	60.45(51.03)
T ₄	Profenophos	2.27(8.66)	50.91(45.52)	68.68(55.96)	65.81(54.21)	55.34(48.04)	60.19(50.87)
T ₅	Spinosad	2.07(8.27)	82.82(65.51)	74.24(59.49)	71.15(57.51)	65.81(54.21)	73.51(59.02)
T ₆	Neem oil	2.07(8.27)	51.26(45.72)	42.67(40.78)	42.09(40.44)	39.53(38.95)	43.89(41.49)
T ₇	NSKE	2.00(8.13)	51.51(45.46)	45.70(42.53)	42.09(40.44)	42.09(40.44)	45.35(42.33)
T ₀	Control	2.13(8.39)	0.00	0.00	0.00	0.00	0.00
Overall Mean		2.13	53.52	51.07	49.36	44.25	56.62
F-test		NS	S	S	S	S	S
S. Ed. (±)		0.101	11.716	4.067	3.618	3.824	3.256
C.D. (P = 0.05)		0.214	24.837	8.622	7.671	8.106	6.903

Table-2 : Efficacy of selected insecticides and Neem products against tobacco caterpillar (*Spodoptera litura* Fab.) on soybean (*Glycine max* L.) in Allahabad during kharif season 2012-2013 (2nd spray).

Treatments		% Reduction over control					Overall Mean
		Days after spraying					
		Before	3 DAS	7 DAS	10 DAS	15 DAS	
T ₁	Chlorpyrifos	1.33(6.62)	76.28(60.85)	65.81(54.21)	59.52(50.48)	48.72(44.26)	62.58(52.58)
T ₂	Cypermethrin	1.33(6.62)	78.84(62.61)	68.37(55.77)	57.32(49.20)	53.66(47.09)	64.55(53.45)
T ₃	Quinalphos	1.13(6.10)	83.97(66.39)	63.03(52.55)	58.60(49.95)	47.62(43.63)	63.31(52.71)
T ₄	Profenophos	1.13(6.10)	83.97(66.39)	63.03(52.55)	60.80(51.23)	51.10(45.63)	64.73(53.56)
T ₅	Spinosad	0.87(5.35)	89.31(70.91)	78.84(62.61)	60.98(51.34)	58.42(49.84)	71.89(57.98)
T ₆	Neem oil	1.53(7.10)	65.60(45.08)	49.78(44.87)	36.63(37.24)	38.09(38.10)	47.53(43.58)
T ₇	NSKE	1.47(6.96)	68.16(55.64)	55.12(47.93)	47.51(43.57)	43.95(41.52)	53.69(47.11)
T ₀	Control	2.53(9.15)	0.00	0.00	0.00	0.00	0.00
Overall Mean		2.13	1.42	68.27	55.50	47.67	42.69
F-test		NS	NS	S	S	S	S
S. Ed. (±)		0.101	0.440	3.916	4.595	3.482	3.206
C.D. (P = 0.05)		0.214	0.933	8.302	9.742	7.381	6.797

statically for variance to compare the treatment larvae reduction per cent.

Results and Discussion

The data (Table-1 and 2) indicated that all the insecticidal treatment were significantly superior over control in reducing the *Spodoptera litura* recording at 3th, 7th, 10th and 15th days after insecticidal application. The treatment with Spinosad 0.01% was found significantly superior as compared to other insecticides. The highest reducing of 86.06, 76.54, 66.05 and 62.11% was recorded at 3th, 7th, 10th and 15th days after application. As regards grain yield, the yield of 17.50q/ha. was obtained in this treatment. The next promising treatment was Profenophos 0.1% which recorded larvae reduction of 67.44, 65.85, 63.30 and 53.22% the grain yield was 16.02q/ha. Both these treatment were found to de par with each other as regards to larvae reduction and grain yield.

Further, the treatment with Profenophos 0.1% and Quinalphos 0.05% were equally effective in reducing larval 62.45 and 61.87% up to two weeks after application and yield recorded was 16.02 and 15.93 q/ha. Respectively, (Gupta 2008) also reported effectiveness of various chemicals against major insect pests of soybean indicated highest larval reduction per cent in the treatment with Spinosad (86.06, 76.54, 66.06 and 62.21). In the treatment Neem oil consistently lower larval reduction was reported 3th, 7th, 10th and 15th after spraying (58.43, 46.22, 39.36 and 38.81%).

Conclusions

In this study, it was concluded that the treatment, Spinosad 0.01% showed maximum reduction of *Spodoptera litura*. The grain yield obtained was also highest (17.50q/ha) in this treatment. The treatment with Cypermethrin was also on par with Profenophos.

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Combining Ability for Earliness and Yield Related Traits in Wheat [*Triticum aestivum* (L.)] Over the Environments

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Abstract

The present study was conducted to assess the general combining ability effects of parents and specific combining ability effects of crosses for traits viz., days to 50 per cent flowering, number of effective tillers per plant, number of spikelets per plant, biological yield per plant, total protein content in grains, heat injury, proline content and total chlorophyll content. 42 F₁s developed by line x tester were evaluated. The pooled analysis for above characters revealed that mean squares due to environments, GCA lines, GCA testers and SCA crosses significant for all the above eight characters. The ratio of sca/gca variance revealed that there was preponderance of additive gene action of all the traits. The maximum desirable significant GCA effects were exhibited by parent HPW 360 for biological yield per plant (3.74), days to 50 per cent flowering (-0.92) and heat injury (-6.48) while maximum SCA effects (3.52) were depicted by cross DBW129 x RAJ 4120 for biological yield per plant over the environment.

Key words : general combining ability, specific combining ability, bread wheat.

Introduction

Bread wheat is considered as a staple food source for a large human population of the world and provides required carbohydrates and proteins in the diet (Kumar and Rai, 2014). The protein found in wheat is called gluten which is a primary protein source for world's inhabitants. Wheat (*T. aestivum* and *T. durum*) is the world's most important cultivated cereal crop and worldwide staple food, provides 20% of total food calories to about 35% of the world population (Debasis and Khurana, 2001). Wheat is cultivated as spring and winter crop and found best adapted to cool growing condition in different agro-ecological situations. Plant breeders are always interested in production of superior wheat varieties by using good general combining genotypes in crossing programme and selecting promising transgressive segregants from resulting crosses for grain yield and its related traits (Akbar *et al.*, 2009). Line x Tester analysis, is an important mating design for envisaging the general combining ability (GCA) of parental lines and choosing the appropriate parents and their subsequent F₁ crosses with high specific combining ability (SCA).

Materials and Methods

The experimental material comprised of seventeen wheat genotypes (14 lines and 3 testers) and two check varieties viz., MP 3288 and HI 1544. These genotypes were crossed in Line x Tester design to develop a total forty two crosses during *rabi* 2016-17. All the 61 genotypes (17

parents, 42 crosses and 2 checks) were evaluated in a RBD with three replications in three different environments during *rabi* 2017-18 at department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur. Each genotype was accommodated in one row plot of 3 meter length with spacing 22.5 x 10 cm. Heterobeltiosis and economic heterosis, expressed as per cent deviation toward desirable direction over better parent and standard check, respectively. To determine the general and specific combining ability effects using line x tester mating design was performed as per method suggested by Kempthorne (1957).

Results and Discussion

The pooled analysis for above characters revealed that mean squares due to environments, GCA lines, GCA testers and SCA crosses significant for all the above eight characters which indicated differences between lines for GCA, testers for GCA and crosses for SCA. Similarly, mean squares due to GCA lines x E were significant for biological yield per plant, heat injury, proline content and total chlorophyll content while mean squares due to GCA testers x E were significant for number of effective tillers per plant, heat injury, proline content and total chlorophyll content. Mean squares due to SCA x E was significant for all the above seven characters except biological yield per plant (Table-1). The sum of squares due to GCA were higher than sum of squares due to SCA for all the above eight characters indicated that additive type of gene action

Table-1 : Pooled mean squares for combining ability.

S. No.	Source	Df	Days to 50 per cent flowering	Number of effective tillers per plant	Number of spikelets per plant	Biological yield per plant (g)	Total protein content in grains (%)	Heat injury (%)	Proline content (µg per 100 mg)	Total Chlorophyll content (mg/g)
1.	Environment	2	2170.86**	557.36**	241116.02**	712.50**	7.94**	1200.76**	2589.19**	3.23**
2.	Rep./Env	6	1.33	0.64	308.47	1.67	0.06	5.86	0.60	0.01
3.	Genotype	60	12.29**	9.47**	4612.91**	69.96**	2.62**	158.61**	59.75**	0.96**
	GCA Tester	2	30.51**	22.87**	10124.18**	15.25**	2.00**	17.12**	58.96**	1.39**
	GCA Line	13	14.12**	11.61**	5592.02**	179.49**	7.55**	349.09**	99.66**	1.27**
	SCA L x T	26	8.70**	9.14**	3708.29**	29.37**	0.61**	74.39**	44.35**	0.73**
4.	G x E	120	4.46**	1.93**	548.74**	5.39*	0.11**	6.04**	4.08**	0.02**
	GCA T x E	4	11.04**	5.61**	1904.47**	5.52	0.11	5.01	3.63**	0.02*
	GCA L x E	26	5.09*	1.65	547.59	4.83	0.12*	6.43	3.90**	0.01**
	SCA L x T x E	52	5.24**	1.52	484.76	4.76	0.13**	6.38*	3.96**	0.02**
5.	Pooled Error	360	2.85	1.24	385.74	4.24	0.08	4.31	0.38	0.01

played major role in the expression of all these traits. Similar finding have been reported by Desale and Mehta, 2013, Dholariya *et al.* 2014, Lohithaswa *et al.* 2014, Jat *et al.* 2016, Jatav *et al.* 2017 and Rajput and Kandalkar (2018).

GCA and SCA effects for pooled environments for all characters were showed in Table-2. GCA effects were significantly negative for line HS-595 (-1.29), HPW 360 (-0.92) and tester RAJ 4037 (-0.49) for days to 50 per cent flowering while significant SCA effects for this trait were observed in 2 crosses *viz.*, DBW 179 x RAJ 4079 (-1.78) and HS-547 x RAJ 4037 (-1.47). Among 17 parents, 4 parents exhibited significant GCA effects for number of effective tillers per plant. Out of these 4 parents, line KBRL 82-2 showed maximum GCA effects (1.78) for this trait. Among crosses, 6 crosses exhibited significant positive SCA effect for number of effective tillers per plant. Further, cross DBW-93 x RAJ 4120 showed maximum significant and positive SCA effect (1.65). The maximum positive significant GCA effects for number of spikelets per plant were observed for line KBRL 82-2 (40.07) and for tester RAJ 4120 (6.18). The GCA effects were significant and positive for 4 parents. The SCA effects were positive and significant for 7 crosses, out of these maximum SCA effect was observed in cross PBW-701 x RAJ 4120 (40.93) for number of spikelets per plant. The significant positive GCA effects were exhibited by 6 parents over the environments for biological yield per plant. Out of them, line HPW 360 had maximum significant positive GCA effects (3.74). Significant positive SCA effects were exhibited in 4 crosses over the environments. The maximum SCA effects (3.52) were

depicted by cross DBW-129 x RAJ 4120 for biological yield per plant over the environments. Five parents exhibited significant positive GCA effects for total protein content in grain over the environments. Out of these parents, line PBW-701 (1.13) exhibited maximum significant positive GCA effect. The 4 crosses showed significant positive magnitude of SCA effects, among them maximum SCA effects were observed for cross GW-463 x RAJ 4120 (0.44) for total protein content in grain. 5 parents exhibited significant negative GCA effects for heat injury, out of these, line HPW-360 (-6.48) showed maximum negative GCA effect for heat injury. Among the crosses, 7 crosses exhibited significant and negative SCA effects on pooled basis. Among these, maximum negative significant SCA effect was expressed by cross HPW-368 x RAJ 4079 (-7.24). 10 parents exhibited significant positive GCA effects, among them line HS-595 (3.36) showed maximum GCA effect for proline content. 17 crosses exhibited significant and positive SCA effects. The maximum SCA effect was recorded for cross HPW-368 x RAJ 4037 (2.92) for proline content. 7 parents exhibited significant positive GCA effects for total chlorophyll content. Parent HUW-677 (0.35) expressed maximum GCA effects for this trait. While 17 crosses showed significant positive magnitude of SCA effects, out of them maximum SCA effects were recorded for cross HS-595 x RAJ 4037 (0.53) for chlorophyll content. Similar findings were also reported by Dholariya *et al.* 2014, Lohithaswa *et al.* 2014, Ismail and Samier 2015, Kalhoro *et al.* 2015, Kandil *et al.* 2016, Verma *et al.* 2016, Kumar *et al.* 2017, Tiwari *et al.* 2017, Choudhary *et al.* 2018, Ingle *et al.* 2018 and Rajput and Kandalkar 2018.

Table-2 : GCA and SCA effects for pooled environments.

S. No.	Genotype	Days to 50 percent flowering	Number of effective tillers per plant	Number of spikelets per plant	Biological yield per plant	Total protein content in grains	Heat injury	Proline content	Total Chlorophyll content
1.	RAJ 4120	0.49**	0.32**	6.18**	-0.17	0.04	0.13	0.45**	0.12**
2.	RAJ 4037	-0.49**	0.17	4.10*	0.40	0.10**	-0.41	0.33**	-0.07**
3.	RAJ 4079	0.00	-0.48**	-10.28**	-0.23	-0.14**	0.29	-0.79**	-0.05**
4.	DBW-129	0.12	0.45*	6.89	2.77**	-0.59**	-3.62**	0.24*	0.09**
5.	DBW-17	0.34	0.56*	5.18	2.30**	-0.38**	0.60	-1.35**	-0.24**
6.	DBW-93	0.93**	0.34	9.84*	-2.87**	0.68**	0.21	0.36**	-0.00
7.	DBW-71	0.93**	-0.44*	-14.74**	-2.92**	0.18**	4.76**	-2.55**	-0.26**
8.	HPW-368	0.23	0.01	-0.16	1.26**	-0.15**	0.39	-2.91**	-0.23**
9.	DBW-179	0.41	-0.03	0.77	3.57**	-0.49**	-3.08**	1.56**	-0.09**
10.	KBRL 82-2	0.60	1.78**	40.07**	1.99**	-0.31**	3.32**	-2.23**	-0.22**
11.	GW-463	-0.66	-0.74**	-12.47**	-2.89**	0.82**	2.01**	-1.87**	-0.04*
12.	HS-547	-0.62	-0.25	0.18	-2.17**	0.11	-1.47**	1.29**	-0.22**
13.	HS-595	-1.29**	-0.81**	-16.60**	-0.41	-0.49**	-6.48**	3.36**	0.32**
14.	HUW-677	-0.66	-0.48*	-12.30**	-0.67	-0.18**	1.23**	1.40**	0.35**
15.	VL-1003	-0.14	0.01	-10.41**	-0.46	-0.17**	2.26**	-0.38**	0.17**
16.	HPW-360	-0.92**	-0.29	2.15	3.74**	-0.16**	-5.38**	1.17**	0.21**
17.	PBW-701	0.75*	-0.11	1.60	-3.25**	1.13**	5.25**	1.90**	0.14**
18.	DBW-129 x RAJ 4120	0.14	-0.58	3.05	3.52**	0.17	-0.10	0.88**	0.09**
19.	DBW-17 x RAJ 4120	0.25	0.65	16.54*	0.39	-0.18	0.61	-1.95**	-0.11**
20.	DBW-93 x RAJ 4120	-0.46	1.65**	29.41**	1.02	0.22	-4.44**	1.87**	0.21**
21.	DBW-71 x RAJ 4120	-0.01	0.20	-2.42	0.92	0.44**	0.00	-0.75**	0.11**
23.	DBW-179 x RAJ 4120	0.51	-0.98*	-16.43*	-1.93*	-0.30**	0.38	0.18	0.24**
24.	KBRL 82-2 x RAJ 4120	-0.46	0.31	4.11	-1.55	0.15	1.88*	-0.27	0.13**
25.	GW-463 x RAJ 4120	-0.97	-0.06	9.60	-2.02*	0.17	-0.63	-0.38	0.16**
26.	HS-547 x RAJ 4120	0.99	0.13	1.37	-0.31	0.24*	-0.66	0.72**	-0.06
27.	HS-595 x RAJ 4120	-0.79	-0.76	-16.61*	1.39	-0.24*	-0.66	1.55**	-0.18**
29.	VL-1003 x RAJ 4120	-0.83	1.09*	-4.23	0.45	-0.22	2.38**	-1.55**	-0.50**
30.	HPW-360 x RAJ 4120	-0.05	-0.72	-12.99	-0.97	-0.41**	-3.10**	0.95**	0.14**
31.	PBW-701 x RAJ 4120	0.73	1.53**	40.93**	-0.62	-0.23*	-0.00	2.50**	0.47**
32.	DBW-129 x RAJ 4037	-0.43	0.57	-0.70	-3.63**	-0.14	-2.74**	1.38**	-0.06
33.	DBW-17 x RAJ 4037	0.01	0.35	-0.26	-1.52	0.18	-0.11	2.56**	0.03
36.	HPW-368 x RAJ 4037	0.34	-0.09	-3.71	-1.19	-0.08	2.41**	2.92**	0.10**
37.	DBW-179 x RAJ 4037	1.27	0.06	-4.52	2.63**	0.20	-1.93*	-1.57**	-0.30**
38.	KBRL 82-2 x RAJ 4037	1.08	0.91*	22.87**	-1.09	-0.17	-0.94	-2.46**	-0.15**
39.	GW-463 x RAJ 4037	0.46	-0.35	-6.76	1.55	-0.24*	0.30	2.76**	-0.11**
40.	HS-547 x RAJ 4037	-1.47*	-0.17	-4.89	1.39	-0.09	-2.58**	-0.84**	-0.08*
41.	HS-595 x RAJ 4037	-0.36	0.28	2.05	0.56	0.07	-1.40	0.40	0.53**
42.	HUW-677 x RAJ 4037	-1.32	1.50**	28.41**	0.42	-0.33**	1.19	2.83**	0.36**
43.	VL-1003 x RAJ 4037	-0.17	-0.65	1.94	-0.11	0.04	-1.53	1.08**	0.31**
44.	HPW-360 x RAJ 4037	-0.62	-0.13	-1.35	1.01	0.31**	4.98**	-2.01**	-0.15**
47.	DBW-17 x RAJ 4079	-0.26	-1.00*	-16.28*	1.13	-0.01	-0.49	-0.60*	0.07*
48.	DBW-93 x RAJ 4079	-0.30	-0.11	-3.16	-0.56	-0.31**	2.41**	1.07**	0.12**
49.	DBW-71 x RAJ 4079	-1.07	-0.11	-6.69	-0.38	-0.45**	-0.89	2.19**	-0.14**
50.	HPW-368 x RAJ 4079	0.19	0.56	21.82**	2.38**	-0.04	-7.24**	-1.54**	0.23**
51.	DBW-179 x RAJ 4079	-1.78**	0.93*	20.95**	-0.70	0.10	1.55	1.38**	0.06
52..	KBRL 82-2 x RAJ 4079	-0.63	-1.22**	-26.98**	2.65**	0.03	-0.94	2.73**	0.02
54.	HS-547 x RAJ 4079	0.48	0.04	3.52	-1.08	-0.16	3.24**	0.12	0.14**
56.	HUW-677 x RAJ 4079	-0.15	0.48	5.81	-1.32	0.26*	-0.70	-0.46	0.01
57.	VL-1003 x RAJ 4079	1.00	-0.44	2.29	-0.34	0.18	-0.84	0.46	0.18**
58.	HPW-360 x RAJ 4079	0.67	0.85	14.34	-0.04	0.10	-1.88*	1.06**	0.01

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

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Performance of Wheat in Rice-Wheat Cropping System under Zero Tillage : Experience from Farmers' Field

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Abstract

Krishi Vigyan Kendra, Bhatapara, Chhattisgarh conducted frontline demonstrations (30 Nos.) on sowing of wheat by zero tillage method at farmers' field (12 hectare) during years 2018-19 to 2020-21 in NICRA villages viz. Bakulahi and Gudeliya. The data on productivity and economics in demonstrated plots were calculated and compared with the corresponding farmer's practice. It was observed that yield of demonstrated plots was 28.7 per cent higher than farmer's practices. The extension gap and technology gap were 5.3 q/ha and 3.2 per cent respectively. Due to reduced cost of cultivation and higher crop yield, the gross and net return was also higher in zero tillage as compared to the farmer's practice. The BCR was 2.19, 2.21 and 2.41 in zero tillage, which was higher than in conventional sowing 1.45, 1.48 and 1.63, respectively. Higher yield and returns due to reduced cost of cultivation and water saving in the front line demonstrations over the farmer's practice created greater awareness and motivated the other farmers to adopt this latest wheat sowing technology.

Key words : Front line demonstration, zero tillage, wheat and NICRA.

Introduction

India is the second largest producer of wheat in the world with an average annual production of 107 MT (million tonnes) in 2019-20 (1). The seventeen-fold increase in wheat production (6.46 million tonnes in 1950-51 to 107.59 million tonnes in 2019-20) during the last seven decades has been a remarkable and unparalleled achievement (1). Chhattisgarh produces 115.30 million tonnes wheat with a yield level of 1050 q/ha in 2019-2020. The district Baloda Bazar-Bhatapara is located in central part of Chhattisgarh. Cropping intensity is low (121%) with rice grow in *Kharif* season and wheat, gram and lathyrus in *Rabi* season. About 37% of cultivated area is irrigated, mostly through canals. Looking to the agro-climatic situation and demand of *Poha* mills, many farmers grow late-maturing, bold-seeded varieties of rice, causing late sowing of wheat in *Rabi* season. The delay of every successive day in planting beyond November third week decreases the grain yield. Therefore, to avoid delay in planting and reduce the cost of production, KVK Bhatapara introduced the zero tillage seeding concepts to reduce the turnaround time between rice and wheat crop (2). Savings in input cost, fuel consumption and irrigation water-use have been reported due to the adoption of zero tillage in wheat cultivation (3, 4).

As the main aim of Krishi Vigyan Kendra is to reduce the time lag between generation of technology at the research institution and its transfer to the farmers for increasing productivity and income from the agriculture and allied sectors on a sustained basis. The KVKs are

grass root level organizations meant for application of technology through assessment, refinement and demonstration of proven technologies under different 'micro farming' situation in a district (5). Despite the documented positive agronomic, economic and environmental impacts, zero tillage under wheat has not yet become popular in the district. For its horizontal expansion, we planned to conduct front line demonstration of this innovative sowing method.

Materials and Methods

The soils of the demonstration fields are generally vertisol in texture which is low to medium in organic carbon (0.4 to 0.75%), medium to high in available phosphorus (10-25 kg/ha) and low to medium in potash (100-200 kg/ha). The area is characterized by sub-tropical, semi-arid climate with dry summers (March-June) and winters (November-January) with an average annual rainfall of 1039 mm (75-80% of which is received during July to September), minimum temperature of 13°C in December, the maximum temperature of 45°C in May. The conventional rice-wheat rotation was being followed on the field from last 15 years. The front line demonstration on zero tillage wheat sowing in NICRA villages was conducted from the year 2018-19 to the year 2020-21. Each demonstration was of 0.4 ha area and wheat seed and zero tillage seed drill was supplied as critical input for partial fulfilment and other inputs were applied as per the recommendation at their fields. The sowing of wheat was done during 20th to 30th November in zero tillage, whereas it was sown from 1st to 15th December in conventional tillage (farmer

Table-1 : Details of wheat grown under FLD and farmer practice.

S. No.	Particulars	Frontline demonstration	Farmer practice
1.	Variety	Ratan	Ratan
2.	Seed rate	100	125
3.	Seed treatment	Raxil-2 D.S. 2 gm/kg seed	No
4.	Sowing method	Zero tillage	Broadcasting
5.	Fertilizer application (N:P:K kg/ha)	120:60:40	150:24:0
6.	Weed control	Less emergence and easy to control through single application of herbicide.	More emergence and difficult to control even with higher doses of herbicides.
7.	Plant protection measures	Need based spray of insecticides and fungicides.	Over dose/unrecommended brands of insecticides and Fungicides.

Table-2 : Grain yield and gap analysis of FLDs and farmers' practice.

Year	No. of Demons	Area (ha)	Yield (q/ha)		Extension gap (q/ha)	Technology gap (q/ha)
			Demo	Farmer Practice		
2020-21	10	4.0	20.1	14.4	5.7	1.9
2019-20	10	4.0	18.7	13.2	5.5	3.3
2018-19	10	4.0	17.5	12.7	4.8	4.5
Average	10	4.0	18.8	13.4	5.3	3.2

Table-3 : Economic analysis in demonstrated plots and farmers' practice.

Year	Cost of cultivation (Rs./ha)		Gross returns (Rs./ha)		Net return (Rs/ha)		B:C ratio	
	Demo	Farmer Practice	Demo	Farmer Practice	Demo	Farmer Practice	Demo	Farmer Practice
2020-21	16500	17500	39698	28440	23198	10940	2.41	1.63
2019-20	16300	17200	35998	25410	19698	8210	2.21	1.48
2018-19	15931	17165	34853	24970	18922	7805	2.19	1.45
Average	16244	17288	36850	26273	20606	8985	2.27	1.52

practice). Farmers were generally adopting broadcast method for wheat sowing. The total of 30 frontline demonstrations in 12 hectares was conducted at farmers' field in NICRA villages. Along with frontline demonstrations (FLD), practicing farmer training on calibration, operation and maintenance of zero tillage seed drill was also imparted. All fertilizers were drilled at the time of sowing in demonstrated fields, whereas, it was broadcast in farmers' practice. Three irrigation is given to crop in zero tillage, while in addition to this two irrigation in conventional tillage fields, one pre-sowing irrigation was also given. Details of wheat grown under FLD and farmer practice were given in Table-1.

Results and Discussion

Grain Yield : The crop from all the plots was harvested under the supervision of the KVK officials. The yield from both the plots, *i.e.* demonstration and farmers' practices were compared and it is evident from the data in Table-2 that an average yield of demonstrated plots was 28.7 per cent higher than that of farmer's practices. The grain yield under demonstrated plots were 20.1, 18.7 and 17.5 q/ha with an average of 18.8 q/ha from the year 2018 to 2021. However, it was 14.4, 13.2 and 12.7 q/ha with an average of 13.4 q/ha under farmer's practice. The highest increase in grain yield (54.2%) was observed in the year 2020-21.

The reasons behind the increase of yield under demonstrated plots might be due to timely sowing and adoption of other recommended technologies about which the farmers were ignorant. The higher wheat yield in zero tillage as ZT wheat farmers could sow the crop much earlier than conventional counterpart and early sowing is associated with higher yield, a significant and positive yield impact observed in the study area also observed by (6).

Extension Gap : An extension gap between demonstrated technology and farmers practices was also calculated and it ranged from 4.8 to 5.7 q/ha during different three years and on an average basis, the extension gap of 5.3 q/ha was calculated (Table-2). This gap might be attributed to the adoption of improved technology practices such as proper seed rate, use of seed treatment material, nutrient management, pest management etc. in demonstrated plots which resulted in higher grain yield than the traditional farmers practices. On the basis of the extension gap, the farmers were motivated to adopt the recommended package of practices to reduce the extension gap and to increase their grain yield.

Technology Gap : The technology gap was calculated by deducting the demonstrated plot yield from the potential

yield of the wheat crop. The recorded technology gap was 1.9, 3.3 and 4.5 q/ha during the study period. The average technology gap was found 3.2 q/ha. The difference in technology gap during three years could be due to more feasibility of recommended technologies like sowing time, seed rate, seed treatment, nutrient management and plant protection measures especially IPM. Higher technology index reflected the inadequate proven technology for transferring to farmers and insufficient extension services for transfer of technology.

Economic Analysis : The cost of cultivation (Rs/ha) during the year 2018-19 to 2020-21 was 15931, 16300 and 16500 respectively in zero tillage sown wheat. While it was 17165, 17200 and 17500 in conventionally sown fields (Table-3). Particularly in conventional sowing due to more number of tillage operations, the average higher cost of cultivation in conventional sown field was 1044 (Rs/ha). Due to reduced cost of cultivation and higher crop yield, the gross and net return was also higher in zero tillage as compared to the conventional sowing. The BCR was 2.19, 2.21 and 2.41 in zero tillage, which was higher than in conventional sowing 1.45, 1.48 and 1.63, respectively.

Conclusions

In the present scenario of rising inputs cost and labour shortage in agriculture, farmers need input saving alternative technologies to sustain crop production. In zero tillage wheat cultivation, both yield and net returns were higher than conventional wheat sowing. The increase in yield of wheat to the extent of FLDs over the conventional sowing created greater awareness and

motivated the other farmers to adopt this latest wheat sowing technology. The beneficiary farmers of FLDs also play an important role as a source of information. The concept of frontline demonstrations 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.

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Effect of N P Level and Zinc Nutrition on Yield Attributes and Economics of Barley (*Hordeum vulgare* L.)

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Abstract

A field experiment was conducted during Rabi 2017-18 at Instructional Farm, Rajasthan College of Agriculture, Udaipur to find out the effect of nitrogen, phosphorus level and zinc nutrition on growth attributes and yield of Barley (*Hordeum vulgare* L.) in southern Rajasthan. The experiment consisted of 12 treatments combinations comprising 4 N P levels (75, 100, 125 and 150% RDF) and 3 zinc levels (2.5 and 5.0 kg ha⁻¹). The experiment was laid out in factorial randomized block design with three replications. The experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.8), medium in available nitrogen (295.30 kg ha⁻¹) and phosphorus (24.5 kg ha⁻¹), medium in potassium (292.70 kg ha⁻¹) and low in available zinc status (0.58 ppm). Application of 125% RDF significantly affected the days to maturity, effective tillers, length of ear, grains ear⁻¹, 1000-grain weight and weight of grains ear⁻¹. Application of 125% RDF statistically increased grain and straw yield over its preceding lower levels while biological yield was significantly enhanced up to 150% compared to remaining treatments under test. The per cent increase in grain and straw yield by 125% RDF was 43.08 & 44.89 over 75% RDF. Successive increment in zinc nutrition significantly enhanced effective tillers, length of ear, grains ear⁻¹, 1000-grain weight and weight of grains ear⁻¹. The grain, straw and biological yields were increased by zinc nutrition due to application of 5.0 and 2.5 kg zinc ha⁻¹ compared to control.

Key words : Barley, yield attributes, yield, zinc, maize.

Introduction

Barley (*Hordeum vulgare* L.) has the widest ecological range amongst cereals and is widely grown in Rajasthan. Barley crop is frequently being described as the most cosmopolitan of the crops and also considered as poor man's crop because of the low input requirement and better adaptability to drought, salinity, alkalinity and marginal land (FAO, 2002). During 2017-18, at global level the crop was cultivated on nearly 49.00 million hectares area with production of 137.47 million tons with the productivity of 2805 kg ha⁻¹. In India, during the same reference period, the crop occupied nearly 0.68 lakh hectares area producing nearly 17.88 lakh tons grain with a productivity of 2641 kg ha⁻¹. While in Rajasthan, during 2017-18 the crop was cultivated on 2.81 lakh hectares with 8.56 lakh tons of production with the productivity of 3046 kg ha⁻¹. Its cultivation in India was suffered during green revolution period due to replacement of barley from marginal land and rainfed areas by more remunerative oilseed and pulses.

Nitrogen is a major nutrient which provide lush green plant colour on account of increase in chlorophyll. Being

an essential element it plays an important role in crop development and yield. The deficiency of this element has been found as one of the major yield limiting factors for barley production. Application of nitrogen at lower rates adversely affects growth and grain yield of this crop. Yield and protein content in barley seeds increase with increase in nitrogen rate which is indispensable for increasing crop production. It is an important constituent of molecules, enzymes, coenzymes and cytochromes. It is also an important constituent of protoplasm and chlorophyll and associated with the activity of living cells. Therefore, for full exploitation of the higher yield potential of high yielding barley varieties, increase rate of nitrogen fertilization is of prime importance.

In addition to nitrogen, phosphorous is of paramount importance for energy transfer in living cells by means of high energy phosphate bonds of ATP. Thus, it plays a pivotal role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. 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.

Table-1 : Effect of N P level and zinc nutrition on yield attributes and yields of barley.

Treatment	Effective tillers (m ⁻¹ row length)	Length of ear (cm)	Grains ear ⁻¹	1000-grain weight (g)	Weight of grain ear ⁻¹ (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)	Net Return (ha ⁻¹)	B : C ratio
N P levels											
75% RDF	62.80	4.97	40.87	32.33	1.40	2530	3754	6284	40.40	21992	0.89
100% RDF	72.00	5.27	45.35	35.69	1.60	3070	4584	7654	40.20	31612	1.26
125% RDF	80.92	5.60	49.15	37.22	1.75	3620	5438	9058	40.19	41446	1.62
150% RDF	83.34	5.81	51.14	37.81	1.82	3868	5835	9703	39.57	45676	1.75
SEm±	0.92	0.08	0.68	0.43	0.03	107	160	200	1.06	1613	0.06
CD (P=0.05)	2.69	0.25	2.00	1.27	0.09	315	470	589	NS	4729	0.18
Zinc levels (kg ha⁻¹)											
0	69.83	5.24	42.44	33.71	1.49	2931	4327	7257	40.54	29173	1.17
2.5	75.84	5.42	47.69	36.19	1.68	3304	4929	8232	40.25	35701	1.40
5.0	78.63	5.58	49.75	37.38	1.75	3582	5454	9035	39.48	40670	1.57
SEm±	0.79	0.07	0.59	0.37	0.03	93	139	173	0.92	1396	0.05
CD (P=0.05)	2.33	0.21	1.73	1.10	0.08	272	407	507	NS	4096	0.16

According to FAO, about 30% of the cultivated soils in the world are deficient in zinc.

Materials and Methods

The experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur which is situated at 24° 35' N latitude, 72° 42' E longitude and at an altitude of 579.5 m above mean sea level. It falls under agroclimatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. This zone falls under sub-tropical climatic conditions characterized by mild winters and moderate summers associated with high relative humidity during the months of July to September. The mean annual rainfall of the region is 637 mm, most of which is contributed by South-West monsoon from July to September. Rainfall received during crop season was only 4.20 mm.

The experimental field was clay loam in texture, slightly alkaline in reaction (pH 7.8), medium in available nitrogen (295.30 kg ha⁻¹) and phosphorus (24.5 kg ha⁻¹), medium in potassium (292.70 kg ha⁻¹) and low in available zinc status (0.58 ppm). The experiment consisted of 12 treatments combinations comprising 4 N P levels and 3 zinc levels with three replication. The gross plot area of each plot was 5.0 m × 3.15 m and net plot area was 4.0 m × 1.80 m. The treatment details are as follows:

(A) N P levels : 75% RDF, 100% RDF, 125% RDF and 150% RDF means.

(B) Zinc levels (kg ha⁻¹) : 1.0 kg ha⁻¹, 2.5 kg ha⁻¹ and 5 kg ha⁻¹. The recommended dose of fertilizer is 60 kg N and 20 kg P₂O₅ ha⁻¹.

The barley variety 'RD 2035' was sown on 14th November 2017 in furrows opened at 22.5 cm apart and seeds were placed at a depth of 3-4 cm after pre sowing irrigation using seed rate of 100 kg ha⁻¹. The recommended dose of N and P was 60 and 20 kg ha⁻¹. Nitrogen, phosphorus and zinc were applied as per treatment through urea, DAP and zinc sulphate as source of nitrogen, phosphorus and zinc, respectively. The total quantity of phosphorus and zinc and half of nitrogen were drilled in furrows at sowing. The remaining half nitrogen was applied in two equal splits *i.e.*, at first and second irrigations. Three irrigation was given during whole crop growth period on 09th Dec. 2017, 14th January 2018 and 13th Feb. 2018. Urea was top dressed in two split doses as per treatment. The crop was harvested on 18th March 2018.

The number of effective tillers (m⁻¹ row length) was counted from three randomly selected 1 m row length in each plot at physiological maturity of crop. Random sampling of five productive ears from each of the plot was carried out at physiological maturity and length of each ear was measured from base to tip of uppermost spikelet and average ear length was computed in cm. For number of grains ear⁻¹ and Weight of grain ear⁻¹, five productive ears were randomly selected. Grain yields and straw yield was recorded in as kg plot⁻¹, thereafter, it was converted into kg ha⁻¹. The economics of treatment is the most important consideration making any recommendation to the farmers for its wide adoption. To find out economic viability of treatment, net monetary returns (ha⁻¹) and B C ratio was worked out.

Results and Discussion

Yield and Yield Attributes :

Effect of N P levels : A perusal of data presented in Table-1 revealed that application of 125% RDF significantly increased all the yield attributing characters viz., effective tillers m^{-1} row length, length of ear (cm), number of grains ear^{-1} , 1000-grain weight and grains weight ear^{-1} of barley as compared to 75% and 100% RDF. Better plant growth and higher dry matter production in turn resulted into better development of reproductive structures and sink. It might be due to the increasing N P levels enhanced the availability of the nutrients in the soil and led to higher nutrient uptake and plant growth. These findings are in close conformity with the findings Pervez *et al.*, 2009, Efe and Yarpuz, 2011 and Gebreslassie and Demoz, 2016.

Application of N, P @ 125% RDF significantly increased grain and straw yield of barley. The per cent increase in grain and straw yield by 125% RDF was 43.08 and 44.89 over 75% RDF. Increasing the N P levels from 75 to 100% RDF and 100 to 125% RDF tended to increase grain yield by 21.34 and 17.92 per cent, 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. The higher level of N P favorably 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. Higher grain yield at higher N P levels may also be attributed due to higher nutrient availability and uptake by the crop. These results are in accordance with the findings of Singh *et al.*, 2009; Meena *et al.*, 2011 and Shafi *et al.*, 2011.

Effect of Zinc levels : Application of 5.0 kg zinc ha^{-1} increased effective tillers m^{-1} row length by 12.60 per cent over control and while 3.68 per cent increase over 2.5 kg zinc ha^{-1} . Similarly, length of ear significantly influenced by application of 5 kg zinc ha^{-1} to the tune of 6.49 per cent (Table-1). It is evident from the data that application of 5 kg zinc ha^{-1} significantly increased grains ear^{-1} by 12.37 and 4.32 per cent compared to their corresponding lower levels. Whereas, 1000-grain weight to the tune of 36.19 and 37.38 g as against the lowest of 33.71 g recorded under control. Successive increase in zinc level recorded a significant enhancement in weight of grains ear^{-1} .

Application of significantly increased in grain yield of barley to the tune of 22.21 per cent over control (Table-1). Straw yield, biological yield and harvest index was also

significantly influenced with the application of 5 kg zinc ha^{-1} . 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. The results of present investigation were supported by Hossain *et al.* (2011), Babaeian *et al.* (2012) and Dhaliwal *et al.* (2012).

Economics

Effect of N P levels : Data presented in Table-1 indicates that net return and B: C ratio significantly increased with 125% RDF as compared to their respective lower levels and recorded 19454 and 9834 ha^{-1} over 75 % and 100% respectively. This could be primarily due to significantly higher grain and straw yields resulting into maximum net returns and comparatively less treatment cost of N P fertilization.

Effect of Zinc levels : The results of the field experiment clearly indicated that application of 5.0 kg zinc ha^{-1} significantly enhanced the net returns (Table-1) and B C ratio of barley crop. This could be primarily due to higher grain and straw yields with comparatively less additional cost of zinc under other treatments.

Conclusions

Application of 125% RDF (75 kg N and 25 kg P_2O_5 ha^{-1}) along with 5.0 kg zinc ha^{-1} through commercial zinc sulphate enhanced the yield of barley crop with maximum net returns and B C ratio.

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Genetic Variability and Heritability Studies for Grain Yield and its Yield Attributes in Finger Millet (*Eleusine coracana*)

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Abstract

Finger millet (*Eleusinecoracana*) is one of the nutri-cereal which serves as food and nutritional security. The experiment material for the present study comprised of 18 finger millet genotypes including four check varieties (VL 352, Vakula, VR 847, VR 929) which were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during kharif, 2020. All these genotypes were planted in a randomized complete block design (RCBD) with three replications. Observations were recorded for 15 quantitative characters and the data were analyzed for biometric characters viz., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as per cent of mean (GAM). High PCV (24.67) and GCV (21.74) were recorded for grain yield. Whereas high PCV (20.75) with moderate GCV (14.72) was recorded for number of productive tillers per plant. High heritability (77.67, 62.59) coupled with high genetic advance as percent of mean (39.47, 20.71) was observed for grain yield and number of fingers respectively indicated that this characters is largely governed by additive genes and selection for improvement of such characters could be effective.

Key words : Finger millet, variability, heritability and genetic advance.

Introduction

Finger millet (*Eleusine coracana* (L.) Gaertn.) is an annual herb belongs to the family poaceae, sub-family, chloridoideae with chromosome number $2n=4x=36$. Finger millet, an allotetraploid cereal, is widely cultivated in the arid and semi-arid regions of the world. Being rich in protein and calcium, it serves as 'nutritious millet' for rural populations in developing countries. This crop not only gives us food security because of its hardiness and excellent storage value, but also is a crop of nutritional security as it is endowed with many nutritive values like fair quantity of protein, dietary fiber, minerals especially calcium and vitamins India is the major producer of finger millet in the world. It is cultivated in more than 25 countries of Asian African sub-continent for human consumption. In India, it occupies sixth position after wheat, rice, maize, sorghum and bajra. India is the largest producer with an area, production and productivity of 1.19 million hectares, 1.98 million ton and 1661 kg per ha, respectively (Sood *et al.*, 2019). Whereas in Andhra Pradesh finger millet grown in 48.8 million hectares with 52.8 million tonnes production and 1128 kg/ha productivity (Shukla *et al.*, 2015). Finger millet is highly nutritious as its grain contain 65-75% carbohydrates, 5-8% protein, 15-20% dietary fibre and 2.5-3.5% minerals (Chetan and Malleshi, 2007).

Materials and Methods

The experiment was conducted with 18 finger millet

genotypes including four check varieties (VL 352, Vakula, VR 847 and VR 929). All genotypes were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2020. Genotypes were planted in a randomized complete block design (RCBD) with three replications and a spacing of 30 × 10 cm. per each entry. Every genotype was grown in 10 lines each of 3 m length. Fertilizers, DAP (87 kg/ha), MOP (42 kg/ha) and Urea (22 kg/ha) were applied basally at the time of land preparation and remaining 22 kg/ha Urea was applied three weeks after sowing. Standard management practices were followed to maintain a healthy crop. Observations were recorded on five plants for plant height (cm), number of productive tillers per plant, ear length (cm), finger length (cm), finger width (cm), leaf junction node (cm), number of fingers per main tiller, number of leaves per main tiller, leaf length (cm), peduncle length (cm) and leaf width (cm). Days to 50% flowering, days were recorded by visualizing the entire plot. Fodder yield and grain yield were recorded on per plot basis and then converted into per hectare.

Analysis of variance and summary statistics was calculated as per Panse and Sukathme (1967). Phenotypic and genotypic coefficients of variation (PCV and GCV) were computed as per Burton and Devane (1953). Heritability in broad sense was computed as per Allard (1960). Genotypic and phenotypic correlations were calculated according to Falconer (1981). Heritability and genetic advancement were categorized into low, medium and high as per Johnson *et al.*, (1955).

Table-1 : ANOVA of 16 finger millet genotypes.

Source of variation	df	Mean sum of Squares														
		DFF	DM	PH	NPT	EL	FL	FW	NL	NFE	NLJ	PDL	LL	LW	GY	FY
Treatments	17	107.1	113.1	127.2	0.8	2.3	1.9	0.0	3.4	4.0	2.6	5.2	5.0	0.0	1320783.8	3022903.9
Replications	2	3.7	6.7	98.4	2.1	1.4	1.5	0.1	16.8	1.1	0.7	14.6	13.5	0.1	688.2	476332.9
Error	34	4.7	8.0	52.9	0.2	0.6	0.3	0.0	1.5	0.7	0.9	4.6	1.7	0.0	115481.2	1337688.5

Note : DFF: Days to 50% flowering; DM: Days to maturity; Plant height (cm); NPT: No. of productive tillers per plant; NFE: No. of finger per ear; EL: Ear length (cm); FL: Finger length (cm); Finger width (cm); PDL: peduncle length (cm); NLJ: length from the top node to leaf sheath junction (cm); NL: No. of leaves/main tiller ; FLL: Flag leaf length (cm); FLW: Flag leaf width (cm); GY: Grain yield (kg/ha); FY: Fodder yield (kg/ha).

Table-2 : Performance of 18 finger millet genotypes.

S. No.	Entry	DFF	DM	PH	NPT	EL	FL	FW	NL	NFE	NLJ	PDL	LL	LW	GY	FY
1.	VR 1159	76	105	91.0	3.8	6.7	5.6	0.8	12.1	8.6	10.7	9.2	38.6	1.0	3485.2	8037.0
2.	VR 1152	83	114	98.5	3.4	7.6	6.1	0.7	11.5	7.1	10.3	9.5	38.6	0.8	3874.1	8470.4
3.	VR 1146	79	110	92.4	3.7	8.6	7.0	0.7	10.1	9.4	11.5	8.0	36.1	0.9	2496.3	7292.6
4.	VR 1149	82	112	100.8	2.9	8.9	8.0	0.6	11.6	8.0	10.5	12.0	37.6	0.8	3770.4	7896.3
5.	VR 1130	72	102	95.6	2.3	6.9	6.2	0.6	10.4	11.1	9.2	11.4	40.1	0.8	3029.6	5903.7
6.	VR 1147	75	106	107.8	2.2	7.7	6.9	0.6	11.9	10.2	8.8	10.2	37.0	0.7	3333.3	6581.5
7.	VR 1157	83	114	96.7	3.6	6.6	5.9	0.7	11.7	7.4	9.5	11.1	37.1	0.7	1777.8	7670.4
8.	VR 1154	78	109	97.0	2.8	7.9	6.9	0.6	11.8	7.9	11.4	10.3	38.0	0.9	3288.9	7751.9
9.	VR 1150	77	107	89.7	2.5	8.8	7.9	0.8	9.6	8.3	8.8	9.1	38.5	0.9	2407.4	6303.7
10.	VR 1138	71	107	89.6	2.8	7.7	6.9	0.7	11.2	8.6	8.3	12.3	41.4	0.7	3637.0	6448.1
11.	VR 1144	87	118	104.4	3.9	6.7	6.1	0.7	11.8	7.7	9.4	11.8	40.0	0.8	2940.7	8407.4
12.	VR 1130	87	118	109.1	2.6	6.7	5.8	0.7	13.2	7.0	8.7	11.9	39.0	0.8	2055.6	8929.6
13.	VR 1131	78	107	91.6	2.9	9.2	8.0	0.7	10.8	9.6	9.9	11.4	39.1	0.9	2485.2	5581.5
14.	VR 1134	83	114	100.2	3.2	6.4	5.8	0.7	11.2	7.4	8.9	11.3	38.3	0.7	3063.0	6392.6
15.	VR 1125	66	96	88.7	3.6	7.0	6.4	0.7	11.7	8.5	9.5	13.0	38.8	0.6	2174.1	5670.4
16.	Vakula	72	101	93.9	2.5	6.7	6.0	0.6	11.0	8.0	9.5	10.8	37.8	0.9	1907.4	6759.3
17.	VR 847	86	116	104.2	3.1	7.3	6.3	0.6	13.2	6.7	10.5	12.3	39.7	0.7	3355.6	6937.0
18.	VR 929	84	115	104.2	3.0	7.2	5.7	0.7	13.8	8.3	9.3	10.4	37.4	0.7	3392.6	7518.5
	Mean	78.83	109.43	97.52	3.06	7.48	6.54	0.67	11.59	8.32	9.70	10.89	38.50	0.79	2915.23	7141.77
	CD (1%)	4.82	6.31	16.19	1.00	1.66	1.15	0.20	2.75	1.82	2.15	4.76	2.94	0.33	756.92	2576.16
	CD (5%)	3.59	4.70	12.06	0.74	1.23	0.86	0.15	2.05	1.36	1.60	3.54	2.19	0.24	563.79	1918.86
	CV (%)	2.75	2.59	7.46	14.61	9.95	7.89	13.63	10.66	9.82	9.96	19.61	3.43	18.53	11.66	16.19

Note : DFF: Days to 50% flowering; DM: Days to maturity; Plant height (cm); NPT: No. of productive tillers per plant; NFE: No. of finger per ear; EL: Ear length (cm); FL: Finger length (cm); Finger width (cm); PDL: peduncle length (cm); NLJ: length from the top node to leaf sheath junction (cm); NL: No. of leaves/main tiller ; FLL: Flag leaf length (cm); FLW: Flag leaf width (cm); GY: Grain yield (kg/ha); FY: Fodder yield (kg/ha).

Results and Discussion

Analysis of Variance components (Table-1) revealed significant differences for all the traits studied except for finger width, leaf width and peduncle length indicating presence of adequate amount of variability among different genotypes for all those traits. Similar results were reported earlier (Anuradha *et al.*, 2013, 2017a; 2017b; 2019a and 2019b)

In the present study, VR 1152 (3874.07 kg/ha) had significantly out yielded all the check varieties for grain yield (Table-2). VR 1125 was the earliest with 96 days of maturity. This genotype can be used for breeding earliness in finger millet. VR 1125 can be used for breeding non-lodging genotypes since it was observed to be the shortest (88.67 cm) among all 18 genotypes studied. More number of productive tillers is shown by VR 1144 (3.87) which is an indicative for getting more grain yield. Longer ear length ear shown by VR 1131(9.19) which is an indicative for getting higher yield. More

number of fingers were observed by VR 1130 (11.13). No. of leaves/main tiller were more in VR 929(13.78) while longest leaf (41.36) was observed in VR 1138 indicating more photosynthetic ability of these genotypes.

High Phenotypic Coefficient of Variation and Genotypic Coefficient of Variation were observed by grain yield per plant (Table 3). High PCV was observed by other characters like number of productive tillers per plant (20.75), peduncle length (20.01) and leaf width (20.01). Whereas moderate GCV were observed by number of productive tillers per plant (14.72), number of fingers (12.71), finger length (11.35), fodder yield (10.49) and ear length (10.24) and all other characters showed narrow range of variation indicating less amount of variability of these characters. Presence of variability implies possibility of selections. For reliable selection on has to depend on heritability studies

Heritability which is the heritable portion of phenotypic variance is a good index of transmission of characters from parents to offspring (Falconer, 1981).

Table-3 : Genetic parameters of 18 finger millet lines.

S. No.	Para-meter	DFF	DM	PH	NPT	EL	FL	FW	NL	NFE	NLJ	PDL	LL	LW	GY	FY
1.	Mean	78.83	109.43	97.52	3.06	7.48	6.54	0.67	11.59	8.32	9.70	10.89	38.50	0.79	2915.23	7141.77
2.	Minimum	66.00	96.00	88.67	3.06	6.44	5.62	0.57	9.65	6.69	8.29	8.04	36.11	0.55	1777.78	5581.48
3.	Maximum	87.00	118.00	109.07	3.87	9.19	8.04	0.82	13.78	11.13	11.47	12.99	41.36	0.99	3874.07	8929.63
4.	GCV	7.4	5.4	5.1	14.7	10.2	11.4	5.2	6.9	12.7	7.7	4.3	2.7	7.6	21.7	10.5
5.	PCV	7.9	6.0	9.0	20.7	14.3	13.8	14.6	12.7	16.1	12.6	20.1	4.4	20.0	24.7	19.3
6.	ECV	2.7	2.6	7.5	14.6	10.0	7.9	13.6	10.7	9.8	10.0	19.6	3.4	18.5	11.7	16.2
7.	H ² (B)	87.9	81.3	31.9	50.4	51.4	67.4	12.8	29.2	62.6	37.4	4.6	38.0	14.3	77.7	29.6
8.	Genetic Advance	11.3	11.0	5.8	0.7	1.1	1.3	0.0	0.9	1.7	0.9	0.2	1.3	0.0	1150.8	839.6
9.	GAM	14.3	10.0	5.9	21.5	15.1	19.2	3.8	7.6	20.7	9.7	1.9	3.4	5.9	39.5	11.8

Note : DFF: Days to 50% flowering; DM: Days to maturity; Plant height (cm); NPT: No. of productive tillers per plant; NFE: No. of finger per ear; EL: Ear length (cm); FL: Finger length (cm); Finger width (cm); PDL: peduncle length (cm); NLJ: length from the top node to leaf sheath junction (cm); NL: No. of leaves/main tiller; FLL: Flag leaf length (cm); FLW: Flag leaf width (cm); GY: Grain yield (kg/ha); FY: Fodder yield (kg/ha).

The estimates of heritability and genetic advance can be utilized for the prediction of genetic gain, which indicates the genetic improvement that would result from the selection of best individuals. High broad sense heritability coupled with high genetic advance as percent of mean for traits. High heritability was shown by days to 50% flowering (87.94) followed by days to maturity (81.34). Similar results were reported by Reddy *et al.*, (2013), Manoj Kumar *et al.*, (2015), Ezeaku *et al.*, (2015), Suryanarayana *et al.*, (2014), Jyothsna *et al.*, (2016). High heritability (77.67, 62.59) coupled with high genetic advance as percent of mean (39.47, 20.71) is observed for grain yield and number of fingers respectively indicating preponderance of additive gene action and additive gene action is very much selection responsive. These traits can be improved by simple direct selection.

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Characterization of Finger Millet (*Eleusine coracana* L.) Genotypes through Principal Component Analysis for Yield and Other Secondary Characters

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Abstract

The present investigation, 56 finger millet germplasm had been evaluated for their variability and diversity for 14 characters including yield and yield attributors. The trial was conducted in Agricultural Research Station located at Vizianagaram, India during main season of 2019. The experimental material planted in randomized block design with three replications. The analysis of variance showed highly significant differences ($p < 0.01$) among the genotypes for all the studied characters studied. High heritability recorded for all the studied traits except plant height, indicating the possibility of improvement for respective trait through simple selection. Character association studies showed that grain yield recorded significant ($p < 0.05$) positive association with the traits viz., number of productive tillers, ear length, finger length, finger width, days to 50% flowering, days to maturity and fodder yield. Principal component analysis showed that first five principal components (PCs) with more than one eigen value and those contributing almost 80% of the total variation. Among five PCs, first PC (PC1) contributed 29.7% of total variation followed by PC2 (20.4%), PC3 (12.8%), PC4 (10.3%) and PC5 (7.2%). Consequently, the entire genotypes were successfully grouped into two, early and late maturing varieties with high yielding characteristics.

Key words : Principal component analysis, heritability, correlation, variability, finger millet.

Introduction

Finger millet is the third most important among millet crops grown in many states of India under diverse climatic conditions. Finger millet is one of the most important minor millet crops grown in vast areas of the developing world especially in Africa and Asia. It is an important staple food after rice, wheat, pearl millet and sorghum in India. It provides food for millions of people residing in arid and semi-arid tropics. It has the ability to produce higher yield than other crops under multiple stresses such as drought, soil acidity and land marginality (Barbeau and Hilu, 1993; Upadhyaya *et al.*, 2006). Finger millet is a climate resilient, nutri-rich small millet which provides triple security in terms of food, fodder and nutrition to the growers and consumers as well. It can withstand extremes of temperature and can come up well with scanty water sources. The availability of the diverse material and the amount of genetic variability present in the available germplasm plays major role in genetic enhancement through conventional breeding approaches. Moreover, it has a great nutritional value and excellent grain storage qualities due to multiple layered seed coat (Dida *et al.*, 2007). In India, it is cultivated in approximately 1.14 million hectares with a production of almost two million tons with an average productivity of 1600 kg per hectares (Anonymous, 2018).

The usefulness of multivariate analysis for the study

of morphologically complex individual and for measuring the degree of divergence between biological populations has been shown in different fields of research. Multivariate statistical techniques which simultaneously analyze multiple measurements on each individual under investigation are widely used in analysis of genetic diversity irrespective of whether it is morphological, biochemical or molecular marker-based and subsequently, classification of germplasm collections. Principal component analysis (PCA) and cluster analysis among the multivariate techniques, had been shown to be very useful in selecting genotypes for breeding program that meet the prime objective of a plant breeder (Mohammadi and Prasanna, 2003). Among these, PCA may be used to reveal patterns and eliminate redundancy in data sets as morphological and physiological variations routinely occur in crop species (Adams, 1995). The present study was carried out to undertake a classification analysis on the finger millet germplasm by means of descriptive statistic and to understand the association of various characters and PCA which would enable breeders to classify test germplasm into distinct groups on the basis of their genetic diversity. The objective of this study is to find out relative contribution of various traits for total variability of finger millet genotypes using PCA.

Materials and Methods

A set of 56 pre-released genotypes (Table-1) obtained

Table-1 : List of finger millet genotypes evaluated at Agricultural Research Station, Vizianagaram during kharif 2019.

Genotype code	Name of the genotype	Genotype code	Name of the genotype	Genotype code	Name of the genotype	Genotype code	Name of the genotype
1.	VR 1115	15	VR 1146	29	VR 1161	43	VR 1175
2.	VR 1117	16	VR 1147	30	VR 1162	44	VR 1176
3.	VR 1118	17	VR 1149	31	VR 1163	45	VR 1177
4.	VR 1121	18	VR 1150	32	VR 1164	46	VR 1178
5.	VR 1122	19	VR 1151	33	VR 1165	47	VR 1179
6.	VR 1125	20	VR 1152	34	VR 1166	48	VR 1180
7.	VR 1129	21	VR 1153	35	VR 1167	49	VR 1181
8.	VR 1130	22	VR 1154	36	VR 1168	50	VR 1182
9.	VR 1131	23	VR 1155	37	VR 1169	51	VR 1183
10.	VR 1132	24	VR 1156	38	VR 1170	52	VR 1184
11.	VR 1134	25	VR 1157	39	VR 1171	53	VR 1185
12.	VR 1138	26	VR 1158	40	VR 1172	54	SriChaitanyaC
13.	VR 1143	27	VR 1159	41	VR 1173	55	VakulaC
14.	VR 1144	28	VR 1160	42	VR 1174	56	VL 352C

C, indicated the local checks included.

Table-2 : Analysis of variance for characters including grain yield and yield components in 56 finger millet entries.

Character	Mean	TrMSS (df=55)	RepMSS (df=2)	ErrorMSS (df=110)	CV %	h ² bs
Plant height (cm)	118	77.3**	0.843	42	5.49	45.7
No. of productive tillers	2.97	0.757**	1.08	0.213	15.6	71.8
No. of fingers	7.69	1.27**	1.7	0.386	8.08	69.5
Ear length (cm)	9.51	5.74**	1.34	0.73	8.99	87.3
Finger length (cm)	8.02	11.1**	1.56	0.73	10.7	93.4
Finger width (cm)	1.1	0.0536**	0.0509	0.0124	10.1	76.9
Days to 50% flowering	74.7	287**	13	8.33	3.86	97.1
Days to maturity	106	303**	8.29	15	3.65	95.1
Grain yield (q/ha)	34.3	61.6**	3.8	167	11.9	72.8
Fodder yield (q/ha)	74.8	218**	30.4	113	14.2	68.2

**, significant at 1% probability (p=0.01)

Table-3 : Correlation coefficients among yield and yield components in finger millet genotypes studied.

Traits	PH	NPT	NoFin	EL	FinL	FinW	DFF	DM	GY	FY	LB	NB	FB	BB
PH	1.000													
NPT	-0.023	1.000												
NoFin	-0.165	-0.112	1.000											
EL	-0.104	0.159	0.002	1.000										
FinL	-0.070	0.157	-0.242	0.690	1.000									
FinW	-0.008	0.200	-0.140	0.013	0.317	1.000								
DFF	0.412	0.292	-0.351	0.289	0.396	0.152	1.000							
DM	0.455	0.281	-0.330	0.264	0.387	0.185	0.991	1.000						
GY	0.007	0.239	-0.094	0.102	0.274	0.255	0.385	0.376	1.000					
FY	0.137	-0.156	0.019	-0.086	-0.047	-0.041	0.377	0.393	0.382	1.000				
LB	0.095	-0.114	-0.138	-0.178	-0.243	0.036	-0.152	-0.148	-0.683	-0.306	1.000			
NB	0.024	-0.052	-0.161	-0.292	0.091	0.362	-0.070	-0.054	-0.404	-0.296	0.734	1.000		
FB	0.026	-0.045	-0.173	-0.296	0.094	0.361	-0.060	-0.045	-0.389	-0.283	0.732	0.999	1.000	
BB	0.118	-0.108	0.033	-0.131	-0.367	-0.187	-0.243	-0.241	-0.835	-0.221	0.690	0.338	0.328	1.000

from All India Coordinated Research Project (AICRP) on Small millets, ICAR-Indian Institute of Millet Research (IIMR), Hyderabad were evaluated in a Randomized Block Design with three replications during *Kharif* 2020 at Agricultural Research Station, Vizianagaram. Each plot consisted of 8 rows of 3 meters length with a spacing of

22.5 × 10 cm. The fertilizer dose of 60:40:30kg NPK/ha (50% N in + Full P and K at the time of sowing) was applied at the time of sowing seed and seeds were sown by hand dibbling. The remaining 50% N was applied after three weeks of sowing. Standard pest management measures were taken during the crop growth period as and when

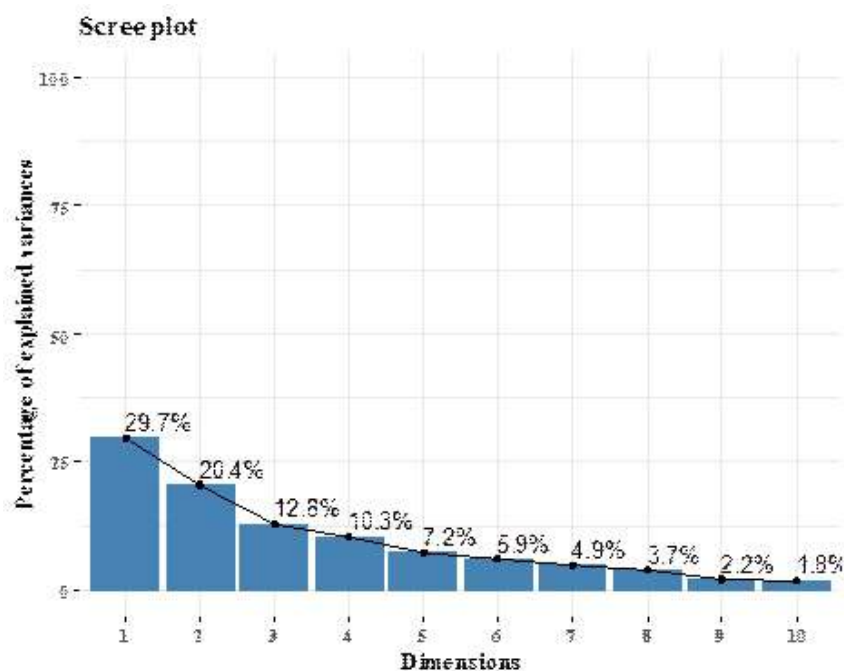


Figure-1 : Scree plot showing percentage of explained variance and dimensions (Principal components, PCs).

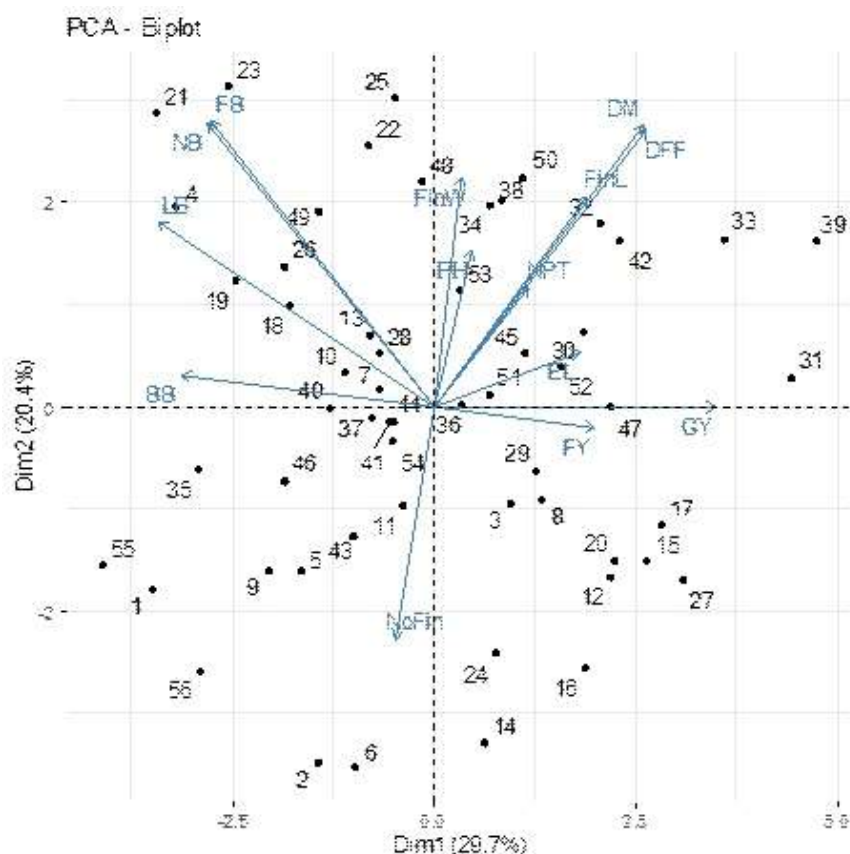


Figure-2 : PCA biplot of 56 finger millet genotypes and 14 morphological characters including yield and yield contributing characters.

required. Observations were recorded for fourteen quantitative characters viz., plant height (PH, in cm), number of tillers per plant (NPT), number of fingers per ear

(NoFin), main ear length (EL, in cm), finger length (FinL, in cm), finger width (FinW, in cm), day to 50% flowering (DFF), days to maturity (DM), leaf blast (LB, in

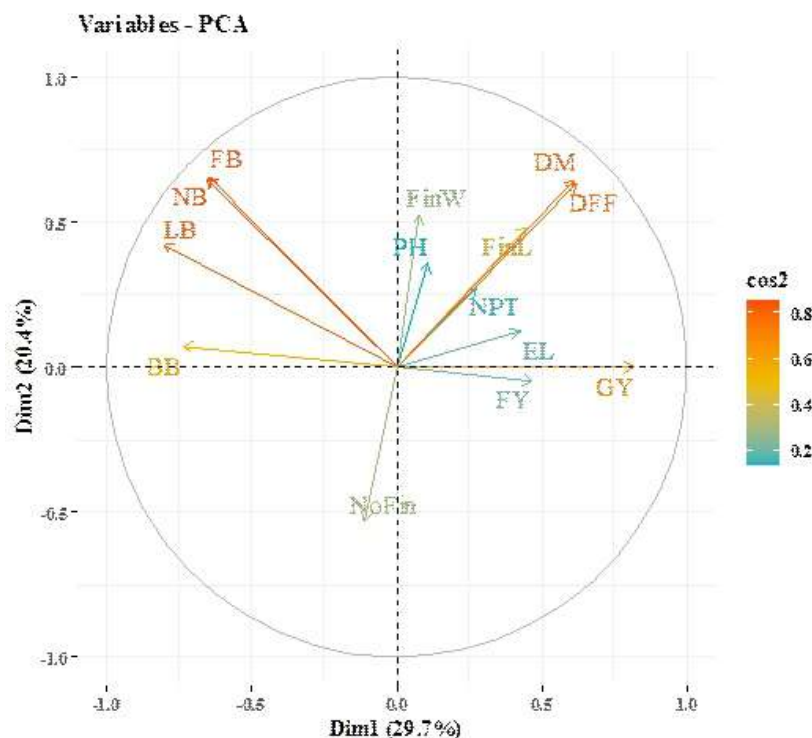


Figure-3 : PCA biplot showing contribution of variables studied towards total variation.

percentage), neck blast (NB, in percentage), finger blast (FB, in percentage), fodder yield (FY, in q/ha) and grain yield (GY, in q/ha).

The data was subjected to statistical analysis and estimates of correlation coefficients were worked out as per Snedecor and Cochran (1967) and Johnson *et al.* (1955). Principal component analysis was carried out according to procedure described by Banfield (1978). PCA can be performed on two types of data matrices viz., variance–covariance matrix and correlation matrix. With characters of different scale, a correlation matrix standardizing the original dataset is preferred. If the characters are of same scale, a variance–covariance matrix can be used. In the present study, PCA was performed on the correlation matrix of traits, thereby removing the effects of scale (Jackson, 1991). A data matrix of all 56 genotypes over fourteen variables of each genotype was prepared and used for analysis by 'agricole' in RStudio (de Mendiburu and Yaseen, 2020). A covariance matrix derived from the data matrix is converted to correlation matrix. The eigen value and eigen vector pairs created from data matrix were utilized to identify the principal components. Principal component analysis was performed to detect the diversity of the genotypes and the contribution of traits to the total divergence respectively.

Results and Discussion

The analysis of variance showed highly significant differences ($p < 0.01$) among the genotypes for all the fourteen characters studied (Table-2). High heritability recorded for most of the studied traits, except plant height, indicating the possibility of improvement for respective trait through simple selection. The results were in accordance with earlier studies by Ashok *et al.* (2016) and Anuradha *et al.* (2020) in finger millet. Character association studies showed that grain yield recorded significant ($p < 0.05$) positive association with most of the traits viz., no. of productive tillers, ear length, finger length, finger width, days to 50% flowering, days to maturity and fodder yield (Table 3). Grain yield showed significant and strong negative correlation with leaf blast, neck blast, finger blast and banded blight.

Principal component analysis (PCA) showed that first five principal components (PC) with more than one eigen value and those contributing almost 80% of the total variation (Figure-1). Among five PCs, first PC (PC1) contributed 29.7% of total variation followed by PC2 (20.4%), PC3 (12.8%), PC4 (10.3%) and PC5 (7.2%) (Figure-1). All the genotypes were successfully grouped into two, early and late maturing varieties with high yielding characteristics based on the position of the

genotypes on the biplot area. The angle between the genotypes and traits on the biplot area (Figure-2 and 3) showed the association between the respective trait and genotype. Association between the traits can be easily assessed by the angle present them. Acute angle indicates the strong positive correlation and obtuse angle between traits indicates negative correlation between them. A right angle between the traits indicates there is no correlation or zero correlation. Similar findings were reported by Sinha and Mishra (2015), Patil *et al.* (2017), Patil *et al.* (2019), Salini *et al.* (2010), Shoba *et al.* (2017) and Jyothsna *et al.* (2016).

Acknowledgements

The authors are highly thankful to Acharya N.G. Ranga Agricultural University, Guntur and All India Coordinated Research Project on Small Millets, ICAR- Indian Institute of Millet Research (IIMR), Hyderabad for providing necessary facilities, plant material and financial support by which the manuscript was prepared.

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Genetic Variability Studies in Little Millet (*Panicum sumatrense* L.) for Yield and its Related Traits

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Abstract

Little millet (*Panicum sumatrense* L.) is one of the small millets which is known for its nutritional value. The amount of genetic variability present in any population is most important for the success of breeding programme. Greater the variation in the material, better is the chance for selecting promising and desired types. 16 genotypes of little millet were evaluated at Agricultural Research Station, Vizianagaram to assess genetic variability, heritability and genetic advance for ten yield contributing traits. The characters included under study are days to 50 % flowering, days to maturity, plant height, number of productive tillers per plant, panicle length, grain yield and fodder yield per plant. Analysis of Variance revealed significant differences observed for all the traits studied except for number of productive tillers per plant and panicle length which are more influenced by environment. High PCV with moderate GCV was recorded for days to 50% flowering indicating large variability for this trait among little millet genotypes. High heritability coupled with high genetic advance as percent of mean is observed for days to 50 % flowering (71.86, 33.75), days to maturity (69.75, 24.24) and grain yield (63.93, 26.44) indicating predominance of additive genes which responds well to simple selection.

Key words : Little millet, variability, heritability and genetic advance.

Introduction

Little millet (*Panicum sumatrense*) locally known as samalu, samai, kutki, mejhari, medois one of the hardest minor cereal crop belonging to the family Poaceae (Gramineae) and is indigenous to Indian sub-continent. It is a drought tolerant crop and requires less amount of water to complete its life cycle. Hence, it can provide us with food security in unfavourable climatic conditions. In addition, it is rich in vitamin B, minerals like potassium, phosphorus, iron, zinc and magnesium and also rich source of antioxidants. Now a days the role of antioxidants in human health is gaining more importance. Free radicals are produced in human body constantly and are capable of attacking the healthy cells of the body causing them to lose their structure and functions. Therefore it can address nutritional sensitive agriculture, which aims at nutritional enhancement to combat the present scenario of micronutrient malnutrition (Arunachalam *et al.*, 2005, Kundgol *et al.*, 2014, Selvi *et al.*, 2015).

It is one of the important minor millets grown extensively in the tropics and a staple food for the low income groups in some countries of the world. The crop is cultivated by tribal and poor farmers in low fertile soils with low or no cash input for food and feed. It has an excellent rejuvenating capacity compared to other cereal crops. In India, the crop is cultivated in an area of 291 thousand hectares with annual production of 102 thousand tones

and productivity of 349 kg per hectare which is very less as compared to other cereal crops. Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Odisha, Tamil Nadu, Karnataka, Jharkhand and Gujarat are major little millet growing states in the country.

Materials and Methods

In the present study, 16 little millet genotypes including one local check varieties, viz., BL 6 were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2019. Genotypes were sown in a randomized complete block design (RCBD) in three replications with a spacing of 22.5 × 7.5 cm per each entry. Each genotype was grown in 10 lines of 3 m length. All the recommended practices were followed to raise a healthy crop. Observations were recorded on days to 50% flowering, maturity, plant height (cm), panicle length (cm), productive tillers per plant, fodder yield (t/ha) and grain yield (q/ha).

Analysis of variance and summary statistics was calculated as per Panse and Sukathme (1967). Phenotypic and genotypic coefficients of variation (PCV and GCV) were computed as per Burton and Devane (1953). Heritability in broad sense was computed as per Allard (1960). Genotypic and phenotypic correlations were calculated according to Falconer (1981). Heritability and genetic advancement were categorized into low, medium and high as per Johnson *et al.*, (1955).

Table-1 : ANOVA of 16 little millet genotypes.

Source of Variations	Df	Mean Sum of Squares						
		DFF	DM	PH	NPT	PL	GY	FY
Treatments	15	430.87	550.66	415.87	4.68	55.89	14.16	245.87
Replications	2	28.31	56.44	424.44	2.01	50.03	1.59	17.92
Error	30	49.76	69.55	67.41	2.42	33.38	2.24	58.12

Note : DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NPT: No. of productive tillers per plant; PL: Panicle length (cm GY: Grain yield (q/ha); FY: Fodder yield (q/ha).

Table-2 : Performance of 16 little millet genotypes.

S. No.	Entry	DFF	DM	PH	NPT	PL	GY	FY
1.	DHLM 36-3	65.67	163.27	98.67	11.80	43.31	11.97	69.51
2.	OLM 203	79.67	159.67	114.67	11.67	32.51	13.96	71.36
3.	BL 6	52.67	154.53	84.00	12.00	40.85	11.77	55.89
4.	VS-25	47.00	143.73	77.33	11.73	35.76	13.69	62.50
5.	GPUL-8	57.00	125.67	88.67	12.33	32.97	13.36	68.52
6.	GPUL-9	49.00	153.07	78.00	12.80	37.34	12.50	46.03
7.	LMNDL-2	58.33	150.53	88.33	11.13	34.50	11.64	67.86
8.	LMNDL-3	52.67	151.33	84.67	12.93	40.48	9.26	65.01
9.	TNP _{su} 223	54.00	162.00	84.67	12.00	38.79	12.83	64.68
10.	TNP _{su} 224	51.33	154.87	83.67	11.67	45.11	8.99	66.40
11.	IIMR-R18-5004	50.33	132.87	81.33	13.80	38.64	9.33	56.68
12.	IIMR-R18-5003	56.33	144.87	86.33	11.33	35.91	12.17	64.68
13.	DPLV-1	89.67	130.33	125.00	9.47	48.33	17.59	86.57
14.	DLM-5	67.67	147.47	100.00	13.20	40.42	14.95	75.26
15.	VS-6	46.00	153.20	75.67	14.07	36.16	12.24	57.54
16.	Local Check	55.67	166.07	87.00	14.47	38.85	12.43	63.82
	Mean	58.31	149.59	89.88	12.28	38.75	12.42	65.15
	CD (1%)	15.84	18.43	18.72	3.49	12.97	3.36	17.11
	CD (5%)	11.76	13.69	13.90	2.59	9.63	2.50	12.71
	CV (%)	12.10	5.49	9.28	12.67	14.91	12.06	11.70

Table-3 : Genetic parameters of 16 little millet genotypes.

S. No.	Parameter	DFF	DM	PH	NPT	PL	GY	FY
1.	Mean	58.31	149.59	89.88	12.28	38.75	12.42	65.15
2.	Minimum	46.00	125.67	75.67	9.47	32.51	8.99	46.03
3.	Maximum	89.67	166.07	125.00	14.47	48.33	17.59	86.57
4.	GCV	19.33	7.20	14.09	7.07	7.07	16.05	12.14
5.	PCV	22.80	9.06	16.87	14.51	16.50	20.07	16.86
6.	ECV	12.10	5.49	9.28	12.67	14.91	12.06	11.70
7.	H ² (B)	71.86	63.27	69.75	23.75	18.36	63.93	51.85
8.	Genetic Advance	19.68	17.66	21.79	0.87	2.42	3.28	11.74
9.	GAM	33.75	11.81	24.24	7.10	6.24	26.44	18.01

Note : DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NPT: No. of productive tillers per plant; PL: Panicle length(cm); GY: Grain yield (q/ha); FY: Fodder yield (q/ha)

Results and Discussion

The genotypic differences were highly significant for all the characters studied except for number of productive tillers per plant and panicle length indicating considerable amount of genetic variability among the genotypes tested in the present study, suggesting ample scope for improvement of yield and various yield attributing characters (Table-1). The results were similar with the earlier reports of Sasamala *et al.*, 2015, Selvi *et al.*, 2015 and Jyothsna *et al.*, 2016 .

Mean values of all 16 little millet genotypes were given in (Table-2). Early maturity was observed for VS 6 (76 days) and DPLV-1 (125 days) was late maturing genotype. Short plant height was recorded for GPUL-8 (126 cm) followed by DPLV-1 (130 cm), whereas tall plant height was observed for local check (166 cm). More number of tillers were observed for local check (14.47) followed by VS 6 (14.07) whereas more panicle length was recorded for DPLV -1 (48.3) followed by TNP_{su} 224 (45.11). Highest grain yield was recorded for late duration genotype DPLV-1 (17.59 q/ha) whereas for early duration

genotypes VS 6 and GPUL 9 recorded 12.24 and 12.50 q/ha grain yield respectively. Little millet is also valued for fodder yield. So fodder yield of all 16 genotypes were taken where more fodder yield is recorded by DPLV 1(86.57 q/ha).

PCV of all the traits was higher than GCV (Table-3). PCV ranged from low to high (9.06 to 22.80) whereas GCV ranged from (7.07 to 19.33). High PCV with moderate GCV was recorded for days to 50% flowering indicating large variability of these trait among little millet genotypes. Similar results were reported by (Anuradha et al., 2017). GCV and PCV are low for plant height indicating lesser variability of this trait in the population. High heritability was recorded by days to 50% flowering (71.86) followed by days to maturity (69.75).

Presence of variability indicates possibility of selections. For reliable selection one has to depend on heritability studies. Highly heritable traits are governed by genotypic variances rather than with environmental variance. Hence, there is more chance for success in selection of genotypes based on heritability. However, heritability informs whether the variation is genetic or non genetic while Genetic Advance as Percent Mean (GAM) enlightens the aspect of gene action. Hence heritability along with GAM studies are meaningful. High heritability coupled with high genetic advance as percent of mean is observed for days to 50 % flowering (71.86, 33.75), days to maturity (69.75, 24.24) and grain yield (63.93, 26.44) indicating predominance of additive genes which responds well to simple selection. Hence, direct selection for these traits is rewarding. Similar results were reported earlier by Patil et al., (2013) and Sasamala et al., (2015).

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Estimation of Genetic Variability and Inter-Trait Associations among Foxtail Millet (*Setaria italica* (L.) P. Beauv.) Genotypes

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Abstract

The present investigation was carried out at Agricultural Research station, Vizianagaram during kharif, 2020 to evaluate twelve foxtail millet genotypes for grain yield and other agronomic traits. Highest grain yield was recorded in SiA 3085 (35.1 q/ha) and on par yields were observed in IIMR FXM-2(33.1 q/ha) and LFM 001 (32.8 q/ha). Similarly high fodder yield was recorded in SiA 4203 (78.2q/ha) followed by LFM 004 (70.4 q/ha). Days to 50% blooming, days to maturity, panicle length, and grain yield had strong heritability, whereas GAM was high for just grain yield, with the other traits having low to moderate GAM. This suggests that additive gene activity dominates grain yield, which can be exploited through simple selection. Grain yield had a substantial positive association with panicle length, but fodder yield had a significant positive correlation with days to maturity. Since both grain yield and panicle length have high heritability values, they can be improved by selecting for one of them.

Introduction

Among the seven small millets, foxtail millet (*Setaria italica* (L.) P. Beauv), generally known as Italian millet, is an important crop. Giant setaria, German millet, Chinese millet, and Hungarian millet are some of the other names for it. It has chromosomal number $2n=18$ and belongs to the Poaceae family (Vavilov, 1926). It is farmed for grain, which is consumed by humans as well as animals, poultry, and cage birds, and its straw is used as fodder. It's a self-pollinated, healthy food crop that grows every year.

Drought tolerance is observed for foxtail millet, but it can't withstand standing water. It is a potential crop that feeds millions of people and is produced largely on poor or marginal soils in southern Europe and temperate, subtropical, and tropical Asia. It may even grow at a height of 2000 metres above sea level. Foxtail millet is the world's second-largest production of millets. It is grown on 5 lakh hectares in India, with a production of 2.9 million tonnes and a yield of 600 kg per hectare (Anonymous, 2016). Foxtail millet is currently grown in the Indian states of Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Rajasthan, Madhya Pradesh, Uttar Pradesh, and the north-eastern provinces.

Crop improvement is only possible when there is variation in the population, and it is also dependent on the trait's inheritance pattern. As a result, genetic variability and heritability research is crucial in plant breeding. Quantitative characteristics such as grain yield and micronutrient content are controlled by the surrounding environment in which they are grown and are governed by numerous minor genes with a collective effect.

Knowledge of the relationship between easily heritable qualities and quantitative traits aids in the selection of low heritable traits in an indirect manner. (Basavaraj et al., 2017).

Materials and Methods

The experiment was conducted with 12 foxtail millet lines including one check variety (SiA 3222) which were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2020. Genotypes were planted in a randomized complete block design (RCBD) with three replications and a spacing of 30 × 10 cm. per each entry. Every genotype was grown in 10 lines each of 3 m length. Standard management practices were followed to maintain a healthy crop. Observations were recorded on five plants for plant height (cm), number of productive tillers per plant, panicle length (cm), flag leaf length (cm) and flag leaf width (cm). Days to 50% flowering, days to maturity was recorded by visualizing the entire plot. Fodder yield and grain yield were recorded on per plot basis and then converted into per hectare.

Although analysis of variance may not reveal absolute variability, the coefficients of variability can be obtained by normalising the phenotypic and genotypic variances. As a result, Burton and Devane's components of variation, such as genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV), were computed (1953). Separating the environmental influence from total variability is also critical for selection. This refers to the precision with which a genotype may be recognised based on its phenotypic performance, and so heritability in the broad sense was calculated according to

Table-1 : List of foxtail millet genotypes evaluated during kharif 2020 at Agricultural Research Station, Vizianagaram.

Sl. No.	Entry name	Sl No.	Entry name
1.	LFM 001	7.	SiA 4148
2.	Suryanandi	8.	SiA 4203
3.	SiA 4201	9.	SiA 3085
4.	SiA 4210	10.	SiA 3156
5.	LFM 004	11.	IIMR FXM-2
6.	SiA 4213	12.	SiA 3222 (LC)

LC, local check

Table-2 : Mean sum of squares from analysis of variance (ANOVA) for grain yield and yield component traits in foxtail millet

Source of variation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	Grain yield (q/ha)	Fodder yield (q/ha)
Treatments (df=11)	33.78**	46.17**	68.03**	1.27**	15.75**	4.13	0.13**	73.23**	251.26**
Replications (df=2)	4.69	25.69	3.17	1.43	6.05	4.16	0.05	1.34	7.14
Error (df=22)	0.48	5.18	55.94	0.44	2.09	6.77	0.09	13.53	96.58

**, significant at 1% probability (p=0.01)

Table-3 : Mean performance of nine characters including grain yield and yield component traits for twelve foxtail millet genotypes evaluated.

Sl No.	Entry	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	Grain yield (q/ha)	Fodder yield (q/ha)
1.	LFM 001	41.0	70.3	134.4	4.0	23.9	33.9	2.3	32.8	51.1
2.	Suryanandi ©	38.7	67.3	125.4	4.8	23.0	32.2	1.7	26.3	52.4
3.	SiA 4201	42.7	72.7	139.4	3.1	20.0	35.3	2.5	23.9	63.2
4.	SiA 4210	44.3	72.7	140.0	3.2	17.8	31.7	2.2	20.7	47.8
5.	LFM 004	47.7	78.0	141.0	3.0	17.1	34.1	2.1	22.4	70.4
6.	SiA 4213	41.0	70.3	140.8	3.8	21.6	34.4	2.1	27.7	57.6
7.	SiA 4148	38.0	66.7	133.0	4.3	19.3	34.1	2.0	24.6	55.1
8.	SiA 4203	42.0	71.3	133.6	4.3	19.6	33.3	2.1	26.0	78.2
9.	SiA 3085 ©	42.0	71.3	132.0	3.9	22.6	34.9	2.1	35.1	56.2
10.	SiA 3156 ©	40.7	70.7	134.0	2.8	23.8	31.8	1.8	31.1	58.2
11.	IIMR FXM- 2	41.3	70.3	136.2	4.0	22.0	33.2	1.9	33.1	58.3
12.	SiA 3222 (LC)	34.0	61.7	129.9	4.6	19.3	33.4	1.9	20.9	46.4
	MEAN	41.1	70.3	135.0	3.8	20.8	33.5	2.1	27.0	57.9
	CD (5%)	1.18	3.85	12.66	1.12	2.45	4.41	0.50	6.229	16.64
	CD (1%)	1.60	5.24	17.21	1.52	3.32	5.99	0.68	8.466	22.62
	CV (%)	1.69	3.24	5.54	17.37	6.94	7.76	14.46	13.602	16.97

CD: Critical difference, CV: Coefficient of variation

Allard (1960). The heritability estimates alone are insufficient to predict the response to selection. As a result, when heritability estimates were combined with estimates of genetic progress, the heritability estimates looked to be more relevant. Hence the genetic advances as per cent mean (GAM) was also estimated. Heritability and genetic advancement were categorized into low, medium and high as per Johnson *et al.*, (1955). Because selection is based on a complex web of interconnections, phenotypic correlations were determined using Falconer's method (1981).

Results and Discussion

The Analysis of variance (Table-1) indicated significant variations among different foxtail entries for all traits studied except leaf length. These results are in consonance with that of Nirmalakumari, 2008; Nirmalakumari and Vetriventhan, 2010; Prasanna *et al.*, 2013; Brunda *et al.*, 2017, Anuradha and Patro, 2020. Among all the entries evaluated, the local check, SiA 3222 (34 days) was the earliest (Table 2) and none of the entries were on par. It was followed by SiA4148 (38 days)

Table-4 : Genetic variability parameters for studied traits in twelve foxtail millet genotypes.

Variability parameter	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	Grain yield (q/ha)	Fodder yield (q/ha)
Range (Min.)	34.0	61.7	125.4	2.8	17.1	31.7	1.7	20.7	46.4
Range (Max.)	47.7	78	141.0	4.8	23.9	35.3	2.5	32.8	78.2
GCV	8.10	5.26	1.49	13.84	10.25		5.49	16.493	12.40
PCV	8.28	6.18	5.74	22.21	12.38		15.46	21.379	21.02
ECV	1.69	3.24	5.54	17.37	6.94		14.46	13.602	16.97
h^2 (bs)	95.84	72.51	6.72	38.82	68.59		12.61	59.517	34.80
GA	6.72	6.48	1.07	0.68	3.64		0.08	7.089	8.73
GAM	16.34	9.23	0.79	17.76	17.49		4.02	26.211	15.07

Table-5 : Pearson's correlation values (r) for studied characters including yield and yield components in twelve foxtail millet genotypes.

S. No.	Traits	Days to 50% flowering	Days to maturity	Plant height	Number of productive tillers	Panicle length	Leaf length	Leaf width	Grain yield	Fodder yield
1.	Days to 50% flowering	1.000	0.991**	0.706*	-0.703*	-0.308	0.108	0.459	0.012	0.532
2.	Days to maturity	0.991**	1.000	0.700*	-0.735**	-0.243	0.155	0.46	0.066	0.581*
3.	Plant height	0.706*	0.700*	1.000	-0.741**	-0.446	0.274	0.630*	-0.19	0.301
4.	No. of productive tillers	-0.703*	-0.735**	-0.741**	1.000	0.182	0.002	-0.406	0.040	-0.233
5.	Panicle length	-0.308	-0.243	-0.446	0.182	1.000	-0.089	-0.28	.829**	-0.252
6.	Leaf length	0.108	0.155	0.274	0.002	-0.089	1.000	.600*	0.139	0.272
7.	Leaf width	0.459	0.46	0.630*	-0.406	-0.28	0.600*	1.000	-0.117	0.198
8.	Grain yield	0.012	0.066	-0.19	0.04	0.829**	0.139	-0.117	1.000	0.001
9.	Fodder yield	0.532	0.581*	0.301	-0.233	-0.252	0.272	0.198	0.001	1.000

**, Correlation is significant at 1% probability ($p=0.01$), *, Correlation is significant at 1% probability ($p=0.05$)

and Suryanandi (39 days). Highest grain yield was recorded in the check, SiA 3085 (35.1 q/ha) and on par yields were observed in IIMR FXM-2(33.1 q/ha) and LFM 001 (32.8 q/ha). Similarly fodder yield was highest in SiA 4203 (78.2q/ha) followed by LFM 004 (70.4 q/ha). Plant height ranged from 125.4 cm (Suryanandi) to 141.0 cm (LFM 004) while broad range in the panicle length was observed, it ranged from 17.1 cm (LFM 004) to 23.9 cm(LFM 001) (Table-3 and 4).

For all variables investigated, PCV values were higher than GCV, which is consistent with previous findings (Nirmalakumari, 2008; Nirmalakumari and Vetriventhan, 2010; Prasanna *et al.*, 2013; Brunda *et al.*, 2017, Anuradha and Patro, 2020) (Table 4). GCV ranged from 1.49 (Plant height) to 16.5 (Grain yield) while PCV ranged from 5.74 (Plant height) to 22.21 (No. of productive tillers/plant). The range of heritability was from 6.7 (Plant height) to 95.8 (Days to 50% flowering) while that of GAM was from 0.79 (Plant height) to 26.21 (Grain yield).

GCV, PCV, heritability and GAM were low for plant height followed by leaf width. GCV and PCV were low and heritability was high for days to 50% flowering and days to maturity indicating that though very little variation exists in the population, it is heritable variation. Moderate variation was recorded for number of productive tillers/plant, grain yield and fodder yield and none of the traits recorded high

variation indicating that the genotypes under consideration were derived from the common pool and hence much variation was observed. Heritability was high for days to 50% flowering, days to maturity, panicle length and grain yield while GAM was high for only grain yield, the other traits recorded low to moderate GAM. This indicates that grain yield have preponderance of additive gene action which can be utilized through simple selection. Similar result was reported earlier by Anuradha and Patro (2020). On contrary, many earlier workers recorded low to moderate GAM (Nirmalakumari and Vetriventhan, 2010; Prasanna *et al.*, 2013; Brunda *et al.*, 2017). Fodder yield recorded moderate heritability along with moderate GAM indicating the presence of both additive and non additive gene action.

Correlations help to choose superior genotypes based on phenotypic selection of easily heritable characteristics. Days to 50% flowering was positively and significantly correlated with days to maturity and plant height while with No. of productive tillers/plant it was negatively correlated. Similarly, days to maturity was significantly correlated in positive direction with days to 50% flowering as well as with fodder yield while similar negative correlation was observed with No. of productive tillers/plant like days to 50% flowering. No. of productive tillers/plant recorded significant negative correlation also with plant height. Leaf length and leaf width were highly and positively correlated. Grain yield had significant

positive correlation with panicle length while fodder with days to maturity. On contrary, Anuradha and Patro (2020) recorded significant association of grain yield with plant height and maturity. Since, panicle length and grain yield were positively correlated and both have high heritability values, both the traits can be improved by selecting for either of the traits.

Acknowledgements

Authors are high thankful to Acharya NG Ranga Agricultural University for providing opportunity to do the research on foxtail millet.

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Organic Production Package for Little Millet (*Panicum sumatrense*) in Red Sandy Loam Soils

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Abstract

The possible differences between organic and inorganic (conventional) plant products are examined from the view of possible effects on human health. However, there can be considerable risk that the avoidance of chemical inputs in organic farming will result in poor food production. Organic farming is a system aimed at producing food with minimal harm to ecosystems, animals or humans which is often proposed as a solution. Keeping in view of sustained crop yields as well as soil health a long-term experiment is being conducted at Agricultural Research Station, Vizianagaram, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, from Kharif, 2015-16 to study the effect of organic manures in comparison with inorganic fertilizers on soil available nutrients, yield and quality of little millet crop. The organic inputs were supplied in the form of *in-situ* incorporation of green manures (Sunhemp), application of farmyard manure, neem cake and biofertilizers (Azospirillum and Phosphorus Solubilising Bacteria), whereas the inorganic fertilizers were applied as Recommended Dose of fertilizers (20-20-20 kg NPK/ha). The results revealed that significantly highest plant height (143.7 cm), grain yield (858 kg/ha), straw yield (6801 kg/ha) were recorded when compared to the organic plot (140.5 cm, 730kg/ha and 6039 kg/ha respectively). But the soil available nitrogen, potassium, zinc and manganese were found significantly high in the organic plot (235 kg/ha, 326 kg/ha, 1.16 ppm and 8.57 ppm respectively) when compared to inorganic plot (224 kg/ha, 309 kg/ha, 0.99ppm and 6.98ppm respectively). Moreover, when we compare the grain quality the N content, Zn and Fe contents along with the antioxidants, phenols and tannins were also found significantly high in the organic plot.

Key words : Little millet, organic, conventional, yield, soil fertility and nutrient uptake.

Introduction

Millet is tiny in size and round in shape and can be white, grey, yellow to red hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. Minor millets are claimed to be the future foods for better health and nutritional security. Small millets comprising finger millet, foxtail millet, barnyard millet, little millet, proso millet and kodo millet are considered to be soothing, least allergic and most digestive grains available. Among all the small millets, little millet commonly called as sama is one of the reliable catch crop in view of its earliness and resistance to adverse agroclimatic conditions of high drought as well as water logging. In order to increase the crop productivity, nutrient management may be achieved by the integration of organic sources, biofertilizers and micronutrients.

Millets are better adapted to dry infertile soils than most other crops and are therefore often cultivated under extremely harsh conditions. Introduction of high yielding varieties and intensive rice farming had led to increased use of chemical fertilizers and pesticides. Continuous, increased and discriminate use of sole chemical fertilizers lead to several harmful effects on the soil environment, ground and surface water and even atmospheric pollution, reducing the productivity of soil by affecting soil

health in terms of physical, chemical and biological properties.

Continuous monoculture of a particular crop over a period of time has clearly indicated a long term degradation of soil resource base. Growing of high yielding varieties with indiscriminate use of fertilizers, poor water management practices and inefficient plant-protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce (Pradhan and Mondal, 1997). Hence enhancement and maintenance of system productivity and resource quality is essential for sustainable agriculture. Maintaining and improving the soil quality is thus crucial if agricultural productivity and environmental quality are to be sustained for generations (Reeves, 1997). Thus, organic matter inputs through organic amendments in addition to supplying nutrients, stimulate microbial diversity and activity and improved soil aggregation, which had positive effects on soil water content, temperature, aeration and mechanical impedance (Ferrerias *et al.*, 2006).

In recent years the use of chemical fertilizers has increased many folds to derive higher yield but its hazardous effect on soil and human health cannot be ruled out. There is a demanding need to find out

Table-1 : Effect of organic and inorganic manures on growth, yield of Little millet.

S. No.	Particulars	Organic plot	Inorganic plot	T Value	P Value
1.	Plant height (cm)	140.5	143.7	4.09*	0.04*
2.	No. of Productive tillers/plant	8.9	8.5	1.05	0.40
3.	Leaf length (cm)	31.0	31.6	0.43	0.71
4.	Leaf width (cm)	0.93	1.10	0.89	0.47
5.	Inflorescence length (cm)	35.0	38.0	0.06	0.12
6.	Straw yield (q ha ⁻¹)	6039	6801	4.67	0.04
7.	Grain yield (q ha ⁻¹)	730	858	24.23**	0.001**

*Significant at P=0.05 level

** Significant at P= 0.01 level

Table-2 : Effect of organic and inorganic manures on soil health at harvest.

S. No.	Particulars	Initial Values	Organic plot	Conventional plot	T value	P value
1.	pH	6.94	7.01	6.87	7.31	0.018
2.	EC	0.24	0.23	0.24	3.92	0.059
3.	Organic carbon (%)	0.43	0.46	0.43	1.78	0.216
4.	Available N (kg ha ⁻¹)	240	235	224	5.56*	0.030*
5.	Available P ₂ O ₅ (kg ha ⁻¹)	59	65	62	1.05	0.403
6.	Available K ₂ O (kg ha ⁻¹)	315	326	309	4.33*	0.049*
7.	Available Fe (ppm)	9.6	10.80	9.34	2.02	0.181
8.	Available Mn (ppm)	6.03	8.57	6.98	19.30**	0.003**
9.	Available Zn (ppm)	1.22	1.16	0.99	6.31*	0.024*
10.	Available Cu (ppm)	2.35	2.48	2.19	0.77	0.523

*Significant at P=0.05 level

**Significant at P= 0.01 level

alternative sources of nutrients in terms of its economy, non-hazardous and ecofriendly nature. Therefore there is a need to go for the use of organic sources of nutrients which are cheaper and ecofriendly. Phosphate solubilizing bacteria have the ability to solubilize phosphate compound, present in the organic manures and soils. Azospirillum inoculation saves the addition of nitrogenous fertilizers by 10-20%. The present investigation was undertaken to study the effect of organic sources of nutrients on growth characters, yield and quality of little millet along with the soil health.

Materials and Methods

The long term field experiment was being conducted for the past 5 years since *kharif*, 2015 at Agricultural Research Station, Vizianagaram, ANGRAU, to study the effect of organic method of farming using organic inputs in comparison with conventional method of farming using inorganic fertilizers on growth parameters, yield, soil fertility status grain quality and nutrient uptake at harvest in little millet. The soil was sandy loam in texture, neutral in reaction with low soluble salts, low in organic carbon (0.43%) and available nitrogen (240 kg/ha) and medium in available phosphorus (59 kg/ha) and potassium (315 kg/ha). The experiment was laid out with two treatments i.e. organic treated plot and inorganic treated plot (conventional plot). The Recommended Dose of Fertilizer (20:20:20 kg NPK ha⁻¹) was applied to the inorganic treated plot. Recommended dose of nitrogen, phosphorus and potassium were applied in the form of urea, single

super phosphate and murate of potash as basal dose. While, *in-situ* incorporation of green manure (sunhemp), application of FYM @ 5t ha⁻¹ along with neem cake @ 0.5 t ha⁻¹ as top dressing were applied to organic treated plot. Moreover, green manure (sunhemp) was grown *in-situ*, incorporated and biofertilizers in the form of *Azospirillum* and Phosphorus Solubilizing Bacteria @ 5 kg ha⁻¹ were applied in organic plot. The biomass of the green manure crop incorporated was quantified and the total nutrients supplied to the organic plot in the form of FYM and neem cake. The crop was harvested at maturity stage and growth characters viz., plant height, no. of productive tillers/plant, inflorescence length and yield attributes viz., grain yield, straw yield were recorded. The initial soil samples were collected before sowing of the crop at 0-15 cm depth in 2015 and the final soil samples were collected after harvest of the crop during all the five years using standard procedures.

Results and Discussion

While observing the pooled data, among the two treatments, significantly high grain and straw yields were recorded in inorganic plot (858 kg/ha and 6801 kg/ha) compared to the organic plot (730 kg/ha and 6039 kg/ha, respectively). Among both the treatments even after five years (Table-1) significantly higher grain yields were recorded in inorganic plot compared to the organic plot. Initially the difference in the grain yield between the two plots was 33% which after five years reduced to 17%. The increase in the yields can be owned to the fact that

inorganic plot recorded higher growth and yield attributing characters when compared to the organic plot. Among the plant growth characters, plant height was found significantly high in the inorganic plot (143.7 cm) compared to the organic plot. The number of productive tillers, leaf length and leaf width are statistically on par with each other but the inflorescence length was found numerically high in the inorganic treatment (38.0 cm), but statistically it is nonsignificant. These results are in accordance with Pawar *et al.*, (2013).

After completion of the fifth year of the experiment it is noted that pH and EC of soil were unchanged over their initial status in both the treatments (Table-2) which was in accordance with Rajiv *et al.*, (2014). The Organic Carbon % has shown a increased trend in the organic plot (0.46%) by 0.3% compared to the initial value (0.43%) which was not statistically significant. These results are in accordance with Antara *et al.*, 2017. The soil available macronutrients N, P₂O₅ and K₂O showed an increasing trend over their parental status in both the organic and inorganic treatments. The pooled data of the soil available nitrogen and potassium was found significantly high in organic plot (235 kg/ha and 326 kg/ha, respectively) compared to the inorganic plot (224 kg/ha and 309 kg/ha, respectively), whereas the soil available phosphorus did not show any significant difference between the two treatments. The soil available Zn and Mn was found significantly high in the treatment of organic plot (1.16 ppm and 8.57 ppm) compared to the inorganic plot (0.99 ppm and 6.98 ppm) and no significant difference was found in soil available Fe and Cu among both the treatments. Hence, the use of manures may not increase the grain and straw yields in a very short period but will

certainly help to enhance the organic matter content of the soil which improves the physical, chemical and biological properties of the soil along with the quality of the crop yield.

Conclusion

Antara Seal, Ranjan Bera, Anupam Datta, Susmita Saha, Rupkatha Roy Chowdhury, Kajal sengupta, Arun Kumar Barik and Ashis Kumar Chatterjee, 2017. Evaluation of an organic package of practice towards integrated management and its comparison with conventional farming in terms of yield, quality, energy efficiency and economics. *Acta Agriculturae Slovenica*. 3: 109-200.

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Resistant Source Identification in Finger Millet under Natural Field Conditions against Blast Incited by *Pyricularia grisea* and Banded Blight Incited by *Rhizoctonia solani* Kuhn.

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Abstract

A total of 29 finger millet (*Eleusine coracana*) genotypes were evaluated for identification of resistant source against blast caused by *Pyricularia grisea* and banded blight incited by *Rhizoctonia solani* at Agricultural Research Station, Vizianagaram, Andhra Pradesh, India, during kharif, 2021 under natural disease pressure. None of the genotypes were found free from disease incidence. Minimum percentage of neck and finger blast severity was recorded in OEB 610 (22.0% and 22.0%) and the maximum percentage of disease severity was observed in GPU 67 (59.3% and 55.0%) whereas it was 69.6% and 65.1% in Udurumallige (check) respectively. Minimum percentage of banded blight was recorded in VR1130 (21.87%) and maximum was recorded in PPR 1096 (54.13%) whereas, it was 18.2% in resistant check (GE4449) and 71.8% in susceptible check Udurumalliga.

Key words : Banded blight, blast, finger millet, resistant, screening, susceptible.

Introduction

Finger millet (*Eleusine coracana*), is an important small millet grown extensively in diverse regions of India and Africa. Among small millets, finger millet ranks first in area and production. Among cereals and millets its position in production is sixth after wheat, rice, maize, sorghum and bajra. Finger millet consumption has wide range of advantages because of its high nutritive values. Finger millet is highly nutritious as its grains contain 65-75% Carbohydrates, 5-8% protein, 15 -20% dietary fiber and 2.5-3.5% minerals. It contains 5-8% good quality protein, eleusinins which our body can easily absorb. It also has key essential amino acids, tryptophan, methionine, threonine, valine, isoleucine and cystine which are required for good health. It is lower in fat content (1.3%) and majority is unsaturated fat. It is the richest source of calcium (344 mg/100 g), iron (3.9 mg/100 g) and other minerals. It is also rich in phosphorus (283 mg/100 g) and potassium (408 mg/100 g). It is highly valued as a reserve food in the times of famine.

Finger millet is affected by several diseases viz., blast, brown leaf spot, foot rot and viral diseases. Among the various diseases that affect finger millet, blast disease affects adversely the crop from economic point of view, whenever it occurs. In fact the impact of the disease on growth and grain yield of the crop is so high. Under favourable environmental conditions yield reduction upto 100 per cent was recorded at Rampur, Nepal (Batsa and Tamang, 1983 and Getachew *et al.*, 2003). The leaf and neck blast severity varies within the season and also from

one season to other. Mc Rae (1922) reported this disease for the first time from India and gave an estimate of loss due to the impact of the disease. Blast disease is considered as number one in the form of yield loss in Andhra Pradesh, Haryana, Madhya Pradesh, Maharashtra and Mysore. The ultimate loss in grain yield is due to the cumulative effect of reduction in grain number and weight as well as enhanced spikelet sterility (Nagaraja *et al.*, 2007). Banded blight disease was observed in severe form at the university farms in Vizianagaram, Andhra Pradesh and Berhampur (Anil kumar *et al.*, 2003). The disease is characterized by oval to irregular light grey to dark brown lesions on the lower leaf sheath. The central portion of the lesions subsequently turns white to straw with narrow reddish brown border. Symptoms produced on every part of the plant thus gives a characteristic banded appearance, due to which the disease has been named as banded blight (Dubey, 1995). *Rhizoctonia solani* is a very common soil borne pathogen with a great diversity of host plants.

Hence the diseases caused by this fungus are more serious and is of major importance throughout the world. Limited information is available on resistant genotypes/varieties of these diseases for this region. In the present study, 29 entries of finger millet were evaluated against finger millet diseases under natural epiphytotic conditions during kharif, 2021.

Materials and Methods

A total of 29 finger millet entries were screened against blast caused by *Pyricularia grisea* and banded blight

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Standard Evaluation System (SES) scale for sheath blight disease.

Score	Description	Reaction
0	No lesions/symptoms on leaves	Immune
1	Small brown specks of pinhead to slightly elongate, necrotic grey spots with a brown margin, less than 1% area affected	HR
2	A typical blast lesion elliptical, 5-10 mm long, 1-5% of leaf area affected	R
3	A typical blast region elliptical, 1-2 cm long, 6-25% of leaf area affected	MR/MS
4	26-50% leaf area affected	S
5	More than 50% of leaf area affected with coalescing lesions	HS

Table-3 : Evaluation of finger millet varieties for resistance against blast and banded blight diseases.

S. No.	Entry	Leaf Blast (Grade)	Neck Blast (%)	Finger Blast (%)	Banded Blight (%)
1.	IIMR-FM-3002	2.20	24.67	21.00	32.00
2.	BR-14-1	4.23	46.00	41.00	27.00
3.	VL 408	2.03	27.00	23.67	36.57
4.	TNEc 1326	1.57	23.33	21.00	31.00
5.	IIMR-FM-3126	3.47	41.00	36.33	46.00
6.	OEB 610	1.33	22.00	22.00	30.00
7.	RAUF 25	2.97	29.00	25.33	26.00
8.	GPU 103	3.87	41.00	36.00	43.00
9.	IIMR-FM-3003	2.10	20.00	17.33	25.53
10.	BR-IAR 6	1.40	27.00	23.33	38.00
11.	BR-IAR 5	2.90	29.33	25.67	43.57
12.	PPR 1096	2.57	25.67	22.00	54.13
13.	VR 1131	4.80	53.00	50.67	34.00
14.	VR 1130	1.47	24.53	21.53	21.87
15.	TNEc 1323	2.00	44.00	39.00	38.67
16.	PR 1731	1.73	26.53	23.67	49.00
17.	VL 407	2.47	33.00	29.33	28.63
18.	KMR 656	2.27	34.00	31.00	29.00
19.	PR 1433	5.67	49.00	44.33	37.07
20.	IIMR-FM-3001	1.97	23.00	20.67	32.00
21.	OEB 633	2.47	26.33	22.00	27.00
22.	GPU 104	3.93	55.00	45.00	33.00
23.	KMR 702	1.93	23.33	21.00	30.00
24.	GPU 67	2.27	59.33	55.00	35.00
25.	VL 376	3.53	36.33	32.00	44.00
26.	PR 202	1.87	32.33	29.20	42.23
27.	GPU 45	2.27	35.00	31.33	38.63
28.	GE4449 (R)	0.63	17.13	9.20	18.20
29.	UM (S)	8.17	69.67	65.13	71.80
	Mean	2.7	34.4	30.3	36.0
	C.D. (5%)	0.6	3.5	3.3	4.0
	C.V. (%)	13.8	7.1	7.1	7.9

incited by *Rhizoctonia solani* during *kharif*, 2021 at Agricultural Research Station, Vizianagaram. The experiment was laid on a plot in Randomized Block Design (RBD) and the entries were replicated three times which was sown in two rows of 3 m length with a spacing of 22.5 x 10 m. The recommended agronomic practices and other standard packages of practices were adopted at

the time of crop growth period. Five randomly selected plants were selected from each genotype/replication for recording the observations. The genotypes of finger millet were screened under natural epiphytotic conditions and no artificial inoculation was made. Infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5

scale (Anon, 1995) (Table 1). Neck blast (%) and finger blast (%) was calculated by using the following formula :

$$\text{Neck blast (\%)} = \frac{\text{No. of infected panicles}}{\text{Total no. of panicles}} \times 100$$

Neck blast (%)

$$= \frac{\text{No. of infected fingers}}{\text{Averages no. of fingers} \times \text{Total no. of panicles}} \times 100$$

For banded blight disease severity data, infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5 scale (Anon, 1996) (Table-2).

Percent Disease Index (PDI) was calculated by using the formula

PDI for severity

$$= \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Results and Discussion

Symptoms of blast and banded blight were observed and per cent disease severity was recorded (Table-3). A total of 29 finger millet genotypes were evaluated against blast and banded blight disease, out of which none of the genotype could exhibit immune reaction. None of the genotypes were found free from disease incidence. Minimum percentage of neck and finger blast severity was recorded in OEB 610 (22.0% and 22.0%) and the maximum percentage of disease severity was observed in GPU 67 (59.3% and 55.0%) whereas it was 69.6% and 65.1% in Udurumallige (check) respectively. Minimum percentage of banded blight was recorded in VR1130 (21.87%) and maximum was recorded in PPR 1096 (54.13%) whereas, it was 18.2% in resistant check (GE4449) and 71.8% in susceptible check Udurumallige.

Patro and Madhuri (2014) evaluated 32 finger millet genotypes and among them, two were susceptible to neck blast and moderately resistant to finger blast, 14 were moderately resistant and 13 were susceptible to both neck and finger blast. Patro *et al.* (2013) evaluated 16 pre-released and released varieties of finger millet and reported that GPU28 as immune to blast pathogen and nine varieties were resistant to all three forms of blast disease. Patro *et al.* (2016) and Nagaraja *et al.* (2016) screened 12 elite finger millet cultivars among them, GE 4449 and GPU 28 were reported to be resistance to leaf blast and GE 4440, GE 4449 and GPU 28 were moderate resistance/susceptible to neck and finger blast. Neeraja *et al.* (2016) screened 25 finger millet varieties and reported that nine varieties were resistant to moderately resistant to leaf blast and three were moderately resistance to both

neck and finger blast. Nineteen entries of finger millet were screened for major diseases by Patro *et al.* (2019) and reported that VR 1101 was found to be moderately susceptible to neck and finger blast. Patro *et al.* (2020) screened 29 entries against blast and banded blight and revealed, none of the genotypes was found free from disease incidence. Minimum percentage of neck and finger blast severity was recorded in VL 399 (19.0% and 15.0%) and the maximum percentage of disease severity was observed in PR 1643 (69.3% and 62.3%) whereas it was 73.5% and 74.0% in Udurumallige (check) respectively. Minimum percentage of banded blight was recorded in check GE 4449 (20.0%) and all the varieties showed high susceptibility. Maximum percentage of banded blight was recorded in check Udurumallige (98.0%).

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Resistant Source Identification in Foxtail Millet Varieties against Banded Blight Disease Incited by *Rhizoctonia solani* Kuhn. under Natural Field Conditions

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Abstract

Sixteen genotypes of foxtail millet were screened for sheath blight disease resistance incited by *Rhizoctonia solani* during kharif, 2021 under natural field conditions at Agricultural Research Station, Vizianagaram, Andhra Pradesh. Among the entries screened, none of the entries or varieties were immune or highly resistant. However, four entries (SiA 1827, TNSi 416, TNSi 418, GS 02236) were found to be resistant. GS 2137 (53.00%) was recorded as susceptible. Percent disease severity ranged from 23.93% (SiA 1827) to 53.00% (GS 2137) whereas, 80.47% was recorded in susceptible check (SiA 3367).

Key words : Banded blight, foxtail millet, resistant, screening.

Introduction

Small millets grown in India mainly constitute Finger millet, Foxtail millet, Kodo millet, Little millet, Proso millet and Barnyard millet. Among the six small millets, Italian millet (*Setaria italica* (L.) P. Beauv.) is an important crop next only to finger millet. Foxtail millet is fairly tolerant to drought; it cannot tolerate water logging. It is one of the world's oldest cultivated millet in the Poaceae family, distributed widely among the millets. Foxtail millet is also known as Italian millet and its other colloquial names kangni, navane, tenai, korra and rala. China is regarded as the centre of origin of foxtail millet (Vavilov, 1926). In India it is cultivated in an area of 5 lakh hectares and the production of 2.9 million tons with productivity of 600 kg per hectare (Anon., 2016). At present, foxtail millet (*Setaria italica*) is cultivated on a limited area in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Rajasthan, Madhya Pradesh, Uttar Pradesh and north eastern states. Foxtail millet grains are rich in protein, fibre, -carotene, minerals viz., calcium, iron, potassium, magnesium, zinc, antioxidants and vitamins (Rai, 2002). The grains with husk intact have long shelf life which is a preferable attribute (Ravi et al., 2010).

Foxtail millet has been affected with many diseases like blast, rust, smut, brown spot, downy mildew and udbatta have been reported on this crop, blast, rust and downy mildew diseases are the yield limiting biotic constraints (Nakayama *et al.*, 2005) and banded blight has been emerged as a deadly disease in this crop which hinders the yield. Under water logging conditions, found infected with sheath blight disease caused by a soil borne necrotrophic fungi *Rhizoctonia solani* kuhn. causing considerable loss in grain yield under favorable

environmental conditions. The disease is characterized by oval to irregular light grey to dark brown lesions on the lower leaf sheath. A temperature of around 28-30 °C and a relative humidity of 70 per cent or above favors the rapid disease development where these lesions enlarge rapidly and coalesce to cover larger portions of the sheath and leaf lamina. At this stage, the disease symptom is characterized by a series of copper or brown color bands across the leaves giving a very characteristic banded appearance.

Materials and Methods

A field experiment was conducted against sheath blight disease caused by *Rhizoctonia solani* during kharif, 2021 at Agricultural Research Station, Vizianagaram. The experiment was laid on a plot in Randomized Block Design (RBD), with 16 varieties, replicated three times which was sown in two rows of 3 m length with a spacing of 22.5 x 10 m. The recommended agronomic practices and other standard package of practices were adopted at the time of crop growth period. Five randomly selected plants were selected from each genotype/replication for recording the observations. The genotypes of foxtail millet were screened under natural epiphytotic conditions and no artificial inoculation was made. Infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5 scale (Anon, 1996).

Percent Disease Index (PDI) was calculated by using the formula :

PDI for severity

$$= \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Evaluation of foxtail millet genotypes against sheath blight.

S. No.	Entry	Banded blight (%)	Reaction
1.	SiA 2566	38.23	MS
2.	SiA 2667	30.37	MS
3.	SiA 1827	23.93	R
4.	TNSi 416	26.13	R
5.	TNSi 417	40.27	MS
6.	TNSi 418	26.47	R
7.	TNSi 419	48.13	MS
8.	TNSi 421	44.07	MS
9.	TNSi 422	31.47	MS
10.	GS 702	41.40	MS
11.	GS 1204	45.67	MS
12.	GS 2137	53.00	S
13.	GS 02236	24.73	R
14.	SiA 2755	33.33	MS
15.	SiA 3367	8.03	HR
16.	SiA 326	80.47	HS
	MEAN	37.23	
	C.D. (5%)	8.6	
	C.D. (1%)	11.6	
	C.V. (%)	13.9	

Results and Discussion

16 entries were evaluated during *kharif* 2021 in foxtail millet against banded blight disease. The screening revealed that none of the test lines or varieties were immune or highly resistant. However, four entries (SiA 1827, TNSi 416, TNSi 418, GS 02236) were found to be resistant. GS 2137 (53.00%) was recorded as susceptible. Percent disease severity ranged from 23.93% (SiA 1827) to 53.00% (GS 2137) whereas 80.47% was recorded in susceptible check SiA 3367 (Table-2).

Patro *et al.*, 2018 screened 11 varieties and reported that two varieties SiA 2863 (24.00) and ISC 74A (32.00) were found to be resistant. Four varieties were moderately resistant to moderately susceptible. Whereas, SiA 3208 (local check) was recorded 70.67%. Patro and Madhuri (2014) screened 16 foxtail millet genotypes and reported that minimum percentage of disease severity was recorded in VFMC-391. However, eight genotypes were evaluated as resistant. Patro *et al.* (2014) and

Nagaraja *et al.* (2016) reported that all the small millet crops were found infected with *R. solani*. Similar research was also done in other small millet crops by Neeraja *et al.*, 2016, Patro *et al.*, 2013 and Patro *et al.*, 2016. These genotypes would be of immense value to the breeders involved in developing high yielding resistant genotypes of little millet. Patro *et al.*, 2019 reported that SiA 3159 (35.5%) and SiA 3274 (38.2%) was recorded as moderately resistant when screened 18 foxtail millet entries against *R. solani*. Patro *et al.*, 2020 screened Sixteen genotypes of foxtail millet for identification of resistance source against *Rhizoctonia solani* and revealed that none of the test lines or varieties were immune or highly resistant.

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Performance Evaluation of Tractor Operated Raised Bed Planter for Chickpea

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Abstract

This study was undertaken for comparative performance of raised bed furrow Irrigation technique for sowing of chickpea crop over the conventional flatbed system in vertisols of Malwa region of MP. The field experiments were conducted by Krishi Vigyan Kendra, RVSKVV, Dewas at different villages of district during the rabi season of the year 2015-16, 2016-17 and 2017-18 to evaluate the performance of Furrow Irrigated raised Bed (FIRB) on flat bed sowing of Kabuli Gram. Total 33 demonstrations were conducted in 10 villages of 3 blocks. Each demonstration of 0.40 ha was laid out by raised bed machine with pair row of crop at 40 cm spacing on one bed and 50 cm furrow width was kept. Data indicated that use of furrow irrigated raised bed planter resulted in 40% reduction in seed rate; 20% saving in nitrogen; 20% saving in phosphorous and 40% saving in potassium were observed as compared to flat bed sowing. The effect of furrow irrigated raised bed cultivation over flatbed cultivation for chickpea was found to be significant for traits like plant height (49.5 cm and 43.8 cm), plant population per m² (32.5 and 37.3), primary branching (3.62 and 2.65), secondary branching (6.83 and 5.63), No. of pods per plant (51.1 and 41.9) and grain yield (17.12 and 14.35 q.ha⁻¹) The incremental benefit-cost ratio was favorable, and the entire investment made on acquiring of new equipment can be recovered in less than a year.

Key Words : FIRBS, Raised Bed, Kabuli Gram.

Introduction

Diminishing natural resources and increasing cost of cultivation has put tremendous pressure on agriculture sector to sustainably produce more output with lesser amount of input. Mechanization and intensification of traditional tillage-based system has aggravated major environmental and soil problems. Hence, conservation agriculture technology can be utilized for sustaining productivity, maintenance of natural resources and economic growth of peasants.

Chickpea (*Cicer arietinum* L.) being a major rabi pulse crop of India, occupies 31 per cent of total area under pulses and contributes about 37.9 per cent of total pulse production In India, chickpea is cultivated on an area of 7.29 million hectare with a production of 5.77 million tonnes as against the world area and production of 12.03 million ha and 9.24 million tones, respectively. Chickpea in central India are grown on flatbed either under rainfed condition or through application of flood irrigation, resulting in low productivity. In several chickpea producing state Andhra Pradesh registered highest productivity 1559 kg/ha followed by Bihar 894 kg/ha, Gujarat 850 kg/ha and Madhya Pradesh 711.8 kg/ha (Anonymous 2011). While district Dewas (Madhya Pradesh) have more productivity of Chickpea 1511 kg/ha as compared to M.P. State and national level. Although the yield potential of chickpea varieties is about 2500 kg

ha⁻¹. The cultivation of chickpea in clay soil on flat beds faces the problem of water logging and poor aeration and adversely affects the productivity. Water logging results in heavy plant mortality under over irrigated conditions. Further, the moisture stress at some of the critical stages of growth often leads to its lower productivity. Under these situations, crops should be grown on the top of bed and irrigation is to be applied in the furrows. Additionally, these furrows can also be used for drainage in vertisols, where water stagnation is a major problem.

Furrow irrigated Raised Bed planting (FIRB) is a technique, which leads to soil and water conservation along with efficient use of limited natural resources and energy. FIRB offer the opportunity of reducing field compaction and restoring physically degraded soil structure (McHugh *et al.*, 2009), reduce irrigation water use (Govaerts *et al.*, 2009), facilitate crop residue management, increase crop yield (Akbar *et al.*, 2007), reducing the risk of water logging (Hamilton *et al.*, 2005) and enhance field access leading to timely field operations (Govaerts *et al.*, 2006), provide good aeration and seed bed (Shaikh and Mungse, 1998). Lumpkin and Sayre (2009) estimated that use of furrow irrigation in raised bed provides a striking increase in irrigation use-efficiency. This led to 16% saving in water in raised beds as compared to flat bed. Hence, cultivation of chickpea can be more efficient by introduction of suitable sowing machinery on raised bed furrow irrigation system.

Table-1 : Performance of raised bed furrow Irrigation System for sowing of Chickpea.

S. No.	Parameter	FIRBS	Flat Bed
1.	Bed Size	Bottom Width x Top Width x Height 60 cm x 50 cm x 20 cm	Bed width 200 cm
2.	No of Rows	2	5
3.	Depth of Seed (cm)	5-6 cm	3-4 cm
4.	Speed of Operation (km/hr)	2.5-3.0	4.0 to 5.0
5.	Field capacity (ha/hr)	0.25 to 0.3	0.5 to 0.6
6.	Fuel consumption (l/hr)	5.0	3.5

Table-2 : Resource assessment of Raised Bed and Flat Bed system of chickpea cultivation.

S. No.	Parameter	FIRBS	Flat Bed
1.	Seed rate (kg/ha)	100	140
2.	Saving of seed over flat bed (%)	40	
3.	Fertilizer Applied (kg/ha)		
	DAP	125	150
	Murate of Potash	35	50
4.	Saving of Nitrogen over flat bed (%)	20	
5.	Saving of Phosphorus over flat bed (%)	20	
6.	Saving of Nitrogen over flat bed (%)	43	
7.	Grain Yield (q/ha)	17.18	14.43
8.	Increased in Yield (%)	19.10%	

Table-3 : Growth parameters of chickpea as influenced by planting Methods.

Treatment	Plant Height (cm)	Primary Branching per plant	Secondary Branching per plant	No of plants per sq m	No of pods per plant	Yield (q/ha)
Flat Bed	43.8	2.65	5.63	37.3	41.9	14.35
Raised Bed	49.5	3.62	6.83	32.5	51.1	17.12

Even though raised bed planting technology has several advantages, but one of the limiting factor affecting its wide adoption has been the lack of awareness about appropriate implement for conducting sowing operations. Hence, this study was undertaken for comparative performance of raised bed furrow Irrigation technique for sowing of chickpea crop over the conventional flatbed system in vertisols of Malwa region of MP.

Materials and Methods

The field experiments were conducted by Krishi Vigyan Kendra, RVSKVV, Dewas at different villages of district viz. Narana, Nanadharakhedi, Dakachya, Gorba, Amlawati, Nipaniya, Rajoda, Binjayana, Khatmba and Chhoticurlai during the rabi season of the year 2015-16, 2016-17 and 2017-18 to evaluate the performance of Furrow Irrigated raised Bed (FIRB) on flat bed sowing of Kabuli Gram. The village Narana, Dakachya, Rajoda and Nanadharakhedi situated in the block Sonkutch, Khatmba, Amlawati, Nipaniya, Binjayana and Chhoti churlai, comes in the block Dewas, while Gorba in Tonkchurd block of the Dewas district. Total 33 demonstrations were conducted in 10 villages of 3 blocks. The climate of the region is tropical sub-humid receiving an annual rainfall of 1067 mm with maximum and minimum temperature of 45°C and 5°C, respectively. The soils of experiment sites were medium black soil with pH 7.5 to 7.8, organic carbon (0.28 to 0.40%) at the time of

initiation of field experiment. On soil fertility account, it was low in available N (178 kg/ha), medium in P (17.2 kg/ha) and K (340 kg/ha) and S (13.8 kg/ha).

The each demonstration of 0.40 ha was laid out by raised bed machine with pair row of crop at 40 cm spacing on one bed and 50 cm furrow width was kept. Fertilizer was applied as per recommended dose of N, P and K; 20, 60 and 20 kg.ha⁻¹ for chickpea. The field was prepared and trapezoidal shape raised beds were made mechanically by tractor driven furrow irrigated raised bed planter. The experiments were conducted at 33 farmers' field and area of each field was kept 4000 sq m. The width of bed was adjusted to 50 cm with two rows of chickpea on 40 cm at each raised bed was kept. Recommended seed rate 80 kg/h of improved variety of chickpea Phule G -517 (Kripa) was used for sowing in demonstration with recommended package of practices including use of fertilizers (N:P:K; 20:60:20 kg/ha) and appropriate Rhizobium inoculation. First irrigation was applied at the time of branching (35-40 day after sowing) and second irrigation was at the stage of pod formation (90-95 day after sowing) through the furrow. Required plant protection measures were taken as and when found necessary. Where in farmers practices a tractor mounted seed drill machine was used for the for sowing of non-descriptive variety like dollar with imbalance use of fertilizer, no weeding and indiscriminate use of plant protection measures.

Table-4 : Cost of Operation of Sowing chickpea crop on Raised bed and Flat Bed.

S. No.	Prameter	FIRBS	Flat Bed
1.	Initial Cost (Rs)	80000	60000
2.	Fixed Cost (Rs/ha)	207	155
3.	Labour Wages (Rs/ha)	265	160
4.	Repair and maintenance (Rs/ha)	45	25
5.	Fuel and Lubricant (Rs/ha)	1300	900
6.	Overhead Charges (Rs/ha)	350	200
7.	Total Cost of Operation (Rs/ha)	2167	1440

Table-5 : Comparative Economics of Sowing of Chickpea on Raised Bed and Flat Bed.

S. No.	Prameter	FIRBS	Flat Bed
1.	Net Income (Rs/ha)	94580	81067
2.	Income from Seed Saving (Rs/ha)	3000	
3.	Income from fertilizer saving (Rs/ha)	875	
4.	Total Income	98455	
5.	Additional return over flatbed (Rs/ha)	17388	
6.	Additional Cost of Operation (Rs/ha)	727	
7.	Incremental benefit-cost ratio	23.92	



Data pertaining to crop growth, yield attributes and yield were collected at harvest and analyzed statistically. For economic analysis of the performance of raised bed cultivation of chickpea crops was calculated as in field capacity and fuel consumption in relation to crops grown and implements used were also taken into consideration. The additional incomes obtained from increase in grain yield and saving of inputs were compared with additional cost of operation to work out the incremental standard procedure. The B:C ratio was also calculated based on the net return and cost of cultivation in each demonstration.

Results and Discussion

Performance of raised bed planter for sowing of chickpea is presented in table-1. Speed of tractor during the operation kept low in raised bed sowing as compare to flat bed sowing for proper shaping of bed and proper placing

of seed. Higher fuel consumption (43%) was observed in furrow irrigated raised bed planter as compare to seed drill used in flat bed sowing.

Data presented in Table-2 indicated that use of furrow irrigated raised bed planter resulted in 40% reduction in seed rate; 20% saving in nitrogen; 20% saving in phosphorous and 40% saving in potassium were observed as compare to flat bed sowing. The saving in input used was realized due to sowing of seeds and applying fertilizers only on discrete raised beds separated by deep furrow. Despite of using lesser amount of inputs on raised beds, the grain yield of chickpea increased by almost 19% as compared to flatbed cultivation system.

The effect of furrow irrigated raised bed cultivation over flatbed cultivation for chickpea was found to be significant for traits like plant height (49.5 cm and 43.8 cm), plant population per m² (32.5 and 37.3), primary branching (3.62 and 2.65), secondary branching (6.83 and 5.63), No. of pods per plant (51.1 and 41.9) and grain yield (17.12 and 14.35 q.ha⁻¹) are given in Table 3. This is in consonance with the results reported by Singh *et al* (2016) and Tripathi *et al.* (2004), who obtained 37% higher grain yield in raised bed planted chickpea. The root zone of crops grown on furrow irrigated raised bed had a better environment for aeration, water movement and root development leading to increase in yield (Hassan *et al.*, 2005).

The comparative economics of operation for cultivation of chickpea per hectare elaborated in Table-4. Though an additional expenditure of Rs. 727.00 was incurred for the operation of raised bed over that of flat bed chickpea, the same were recovered through additional grain yield and savings of input. The incremental benefit-cost ratio was favorable, and the

entire investment made on acquiring of new equipment can be recovered in less than a year (Table-5).

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Sensory Analysis of Herbal Cow Ghee Supplemented with Flaxseed Oil and Brahmi Ghee

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Abstract

India is the major milk producing country among the world. Ghee is considered as an important part of Indian diet which possess many therapeutic properties. Many types of herbal ghee are available in the market. In the present study, Investigation was made to observe the sensory properties of cow ghee supplemented with flaxseed oil and brahmi herbs. Flaxseed oil and brahmi herbs are known for their health benefits. The sample of herbal cow ghee was analyzed for sensory score like flavour (aroma and taste) score, texture score, colour Score and freedom from suspended impurities. From the result of present investigation, the most acceptable quality of cow ghee was prepared by using 10 percent flaxseed oil and 10 percent brahmi leaves. It observed that the mean value of flavour (aroma and taste) score, texture score, colour score and freedom from suspended impurities (ghee residue) score was found to be 41.25 ± 0.96 , 21.25 ± 0.96 , 6.00 ± 0.82 and 6.50 ± 0.58 respectively.

Key words : Cow ghee, sensory, flavour, texture, colour

Introduction

India is the major milk producing country among the world. Many indigenous dairy products are prepared in India. Among the indigenous dairy products, production of ghee is the largest segment. There are above 30% of milk is converted in to ghee in India. Ghee is commonly produced and consumed in India, Ethiopia, Sudan and the Middle East (El-Shourbagy & El-Zahar, 2014; Kumar *et al.*, 2000). Ghee is also a good source of fat-soluble vitamins and provides all the essential fatty acids (Chand *et al.*, 1986). Ghee is considered as an important part of Indian diet which possess many therapeutic properties (Heyn, 1993). Flaxseed is being consumed in various forms as a food ingredient. Another name of flaxseed is Linseed. Flaxseed is known for its medicinal properties since ancient times. Linseed has many therapeutic properties to preventing many diseases such as mammary and prostate gland, exerts anticarcinogenic effect, possess laxative effect, has anti-inflammatory properties and reduces osteoporotic effect. Flaxseed has also antioxidative properties (Alhassane and Xu, 2010; Ivanova *et al.* 2011; Singh *et al.* 2011). Brahmi is a known as Ayurvedic medicinal herb. It is highly beneficial to treatment of memory and other disorders. Its medicinal influence is reported by the many researchers. The significance of Brahmi is to improving memory and learning skills (Singh and Dhawan, 1997). In the traditional system of medicine in India, Brahmi is one of the unique herbs prescribed for improving the cognitive ability of human beings.

Material and Methods

Procurement of materials

(i) Cow milk was collected from local farms of Prayagraj.

(ii) Ghee was prepared from cream obtained from cow milk in Dairy Chemistry laboratory, WCDT, SHUATS, Prayagraj.

(iii) Flaxseed oil was procured from Kamani oil Industries Pvt. Ltd., Khopoli, Maharashtra, India and

(iv) Brahmi leaves was procured from Patanjali Pvt. Ltd., Haridwar, India

The product was standardized on the basis of sensory score and evaluated for sensory properties by using BIS Scale (BIS, 1981) such as-

(i) Flavor (Aroma and Taste) Score (50)

(ii) Texture Score (30)

(iii) Colour Score (10)

(iv) Freedom from suspended impurities (ghee residue) Score (10)

Statistical analysis : The observation recorded in present investigation were analysed for ANOVA and Critical Difference using WASP software developed by ICAR Research complex at GOA.

Results and Discussion

The acceptability of the food product is assessed by its sensory analysis by the panel of judges. Good quality

ghee should have white with or without a greenish tint to bright yellow colour with rich nutty flavour and it should have also a medium to large grain size uniformly distributed throughout the ghee. For evaluating sensory quality like flavour (Aroma and Taste) score, texture score, colour score, and Freedom from suspended impurities (ghee residue) Score of herbal ghee supplemented with flaxseed oil and brahmi leaves, the score card for cow ghee evaluated by BIS score.

Effect of incorporation of flaxseed oil and brahmi leaves on Flavour (Aroma and taste) Scores of Cow ghee samples : In the present investigation, flaxseed oil was added @ 5%, 10% and 15% and brahmi leaves were added @5%, 10%, 15% and 20% in cow ghee samples. The highest value for Flavour (Aroma and Taste) Score was 47.50 for T6 sample and treatments T0, T5, T2, T7, T3, T8, T4, T9, T10, T11 and T12 has the mean value of 47.00, 46.50, 46.50, 45.25, 44.50, 43.50, 43.25, 42.50, 41.25, 39.25 and 37.25 respectively. The flavour score of herbal ghee (Arjuna ghee) were varied from 35.00 to 46.50 (Rajnikant, 2005).

The ANOVA observation, it has been found that the difference between the mean observation of Flavour (Aroma and Taste) Score between treatments of T0 - T3, T0 - T4, T0-T7, T0-T8, T0-T9, T0-T10, T0-T11, T0 - T12, T1-T3, T1-T4, T1-T6, T1-T7, T1-T8, T1-T9, T1-T10, T1-T11, T1-T12, T2-T3, T2 - T4, T2 - T8, T2 - T9, T2 - T10, T2 - T11, T2 - T12, T3-T5, T3 -T6, T3- T9, T3- T10, T3-T11, T3-T12, T4- T5, T4 -T6, T4- T7, T4- T10, T4 -T11, T4- T12, T5- T8, T5- T9, T5 -T10, T5- T11, T5 - T12, T6 - T7, T6- T8, T6 - T9, T6- T10, T6- T11, T6 - T12, T7- T8, T7- T9, T7 -T10, T7 -T11, T7 - T12, T8- T10, T8- T11, T8 - T12, T9- T11, T9 -T12, T10-T11, T10-T12 and T11-T12 was found to be significantly different ($P<0.05$) and the difference between the mean value of Flavour (Aroma and Taste) score between treatments T0 - T1, T0 -T2, T0 -T5, T0-T6, T1 - T2, T1-T5, T2 - T5, T2 - T6, T2 - T7, T3-T4, T3-T7, T3- T8, T4- T8, T4- T9, T5 -T6, T5- T7, T8- T9 and T9- T10 was found to be non-significant ($P>0.05$).

It has been observed that when cow ghee samples were incorporated with 5% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Flavour (Aroma and Taste) Score was found to decrease significantly ($P<0.05$) from 46.00 to 42.50. When cow ghee samples were incorporated with 10% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Flavour (Aroma and Taste) Score was found to decrease significantly ($P<0.05$) from 46.50 to 41.25. When cow ghee samples were incorporated with 15% Brahmi leaves and the level of flaxseed oil increased from

5% to 15%, then the Flavour (Aroma and Taste) Score was found to decrease significantly ($P<0.05$) from 44.50 to 39.25. When cow ghee samples were incorporated with 20% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Flavour (Aroma and Taste) Score was found to decrease significantly ($P<0.05$) from 43.25 to 37.75. When the brahmi leaves were constant, there was no significant difference ($P>0.05$) among Flavour (Aroma and Taste) Score of treatments suggesting that Brahmi leaves do not exert any significant influence on Flavour (Aroma and Taste) Score of ghee samples.

The observations for the Flavour (Aroma and Taste) Score of the cow ghee samples are presented graphically in fig.-1.

Effect of incorporation of flaxseed oil and brahmi leaves on Texture Scores of Cow ghee samples : In the present investigation, flaxseed oil was added @ 5%, 10% and 15% and brahmi leaves were added @5%, 10%, 15% and 20% in cow ghee samples The highest value for Texture Score was 27.50 for T6 sample and treatments T0, T1, T5, T2, T3, T7, T4, T8, T9, T10, T11 and T12 has the mean value of 27.00, 26.50, 26.25, 26.00, 25.75, 25.50, 24.25, 24.00, 22.50, 21.25, 20.00 and 17.75 respectively. Similar result was observed by Rajnikant (2005). Rajnikant (2005) suggested that the body and texture score of the herbal ghee (Arjuna ghee) was found in the ranged from 20.00 to 25.20.

From the ANOVA observation, it has been found that the difference between the mean observation of Texture Score between treatments of T0 - T4, T0-T8, T0-T9, T0-T10, T0-T11, T0 - T12, T1-T4, T1-T8, T1-T9, T1-T10, T1-T11, T1-T12, T2 - T4, T2 - T8, T2 - T9, T2 - T10, T2 - T11, T2 - T12, T3 -T6, T3- T8, T3- T9, T3- T10, T3-T11, T3-T12, T4- T5, T4 -T6, T4- T9, T4- T10, T4 -T11, T4- T12, T5- T8, T5- T9, T5 -T10, T5- T11, T5 - T12, T6 - T7, T6- T8, T6 - T9, T6- T10, T6- T11, T6 - T12, T7- T8, T7- T9, T7 -T10, T7 -T11, T7 - T12, T8- T10, T8- T11, T8 - T12, T9- T11, T9 -T12, T10-T12 and T11-T12 was found to be significantly different ($P<0.05$) and the difference between the mean value of Texture score between treatments T0 - T1, T0 -T2, T0 - T3, T0 -T5, T0-T6, T0-T7, T1 - T2, T1-T3, T1-T5, T1-T6, T1-T7, T2-T3, T2 - T5, T2 - T6, T2 - T7, T3-T4, T3-T5, T3-T7, T4- T7, T4- T8, T5 -T6, T5- T7, T8- T9, T9- T10, T10-T11, was found to be non-significant ($P>0.05$).

It has been observed that when cow ghee samples were incorporated with 5% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Texture Score was found to decrease significantly ($P<0.05$) from 26.50 to 22.50. When cow ghee samples were

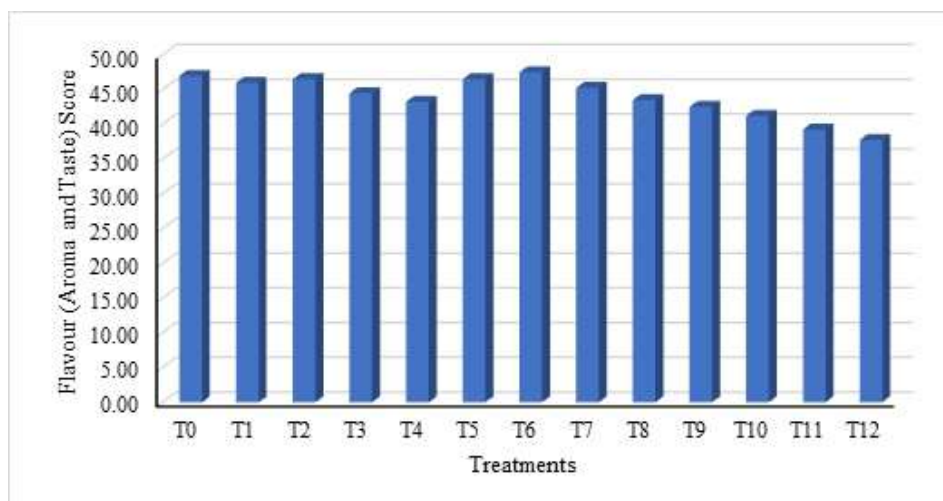


Fig.-1 : Graph showing Flavour (Aroma and taste) score of control and Cow ghee samples supplemented with flaxseed oil and brahmi leaves.

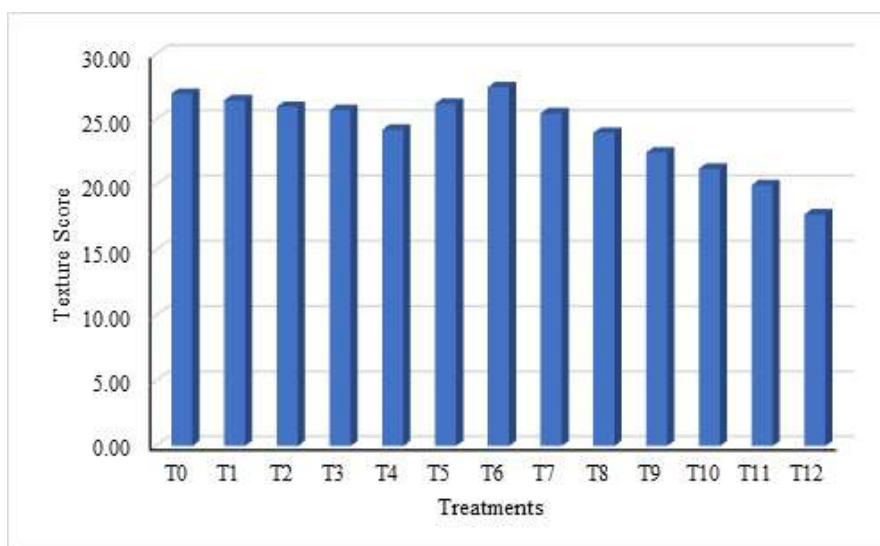


Fig.-2 : Graph showing Texture score of control and cow ghee samples supplemented with flaxseed oil and brahmi leaves.

incorporated with 10% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Texture Score was found to decrease significantly ($P < 0.05$) from 26.00 to 21.25. When cow ghee samples were incorporated with 15% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Texture Score was found to decrease significantly ($P < 0.05$) from 25.75 to 20.00. When cow ghee samples were incorporated with 20% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Texture Score was found to decrease significantly ($P < 0.05$) from 24.25 to 17.75. When the brahmi leaves were constant, there was no significant difference ($P > 0.05$) among Texture Score of treatments suggesting that Brahmi leaves do not exert any significant influence on Texture Score of ghee samples.

The observations for the Texture Score of the cow ghee samples are presented graphically in fig.-2.

Effect of incorporation of flaxseed oil and brahmi leaves on Colour Scores of Cow ghee samples : The highest value for Colour Score was 8.50 for sample T6 and treatments T0, T5, T1, T2, T7, T4, T8, T9, T10, T11 and T12 has the mean value of 8.00, 7.50, 7.50, 7.25, 7.25, 6.75, 6.50, 6.25, 6.00, 5.75 and 5.50 respectively. Rajnikant (2005) reported that the colour and appearance score of herbal ghee (Arjuna ghee) was found in the range from 8.4 to 9.3. The colour and appearance is one of the most important sensory qualities of cow ghee.

From the ANOVA observation, it has been found that the difference between the mean observation of Colour Score between treatments of T0 - T3, T0 - T4, T0-T8, T0-T9, T0-T10, T0-T11, T0 - T12, T1-T6, T1-T8, T1-T9,

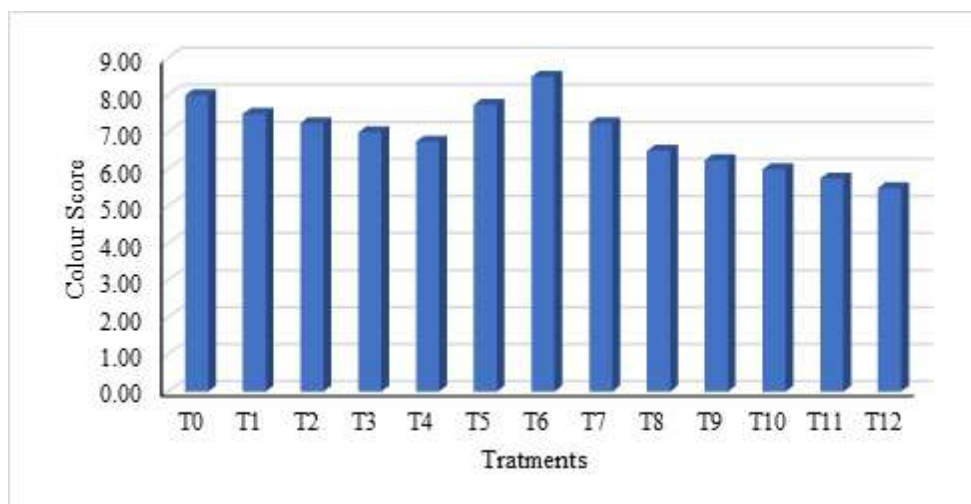


Fig-3 : Graph showing Colour score of control and cow ghee samples supplemented with flaxseed oil and brahmi leaves.

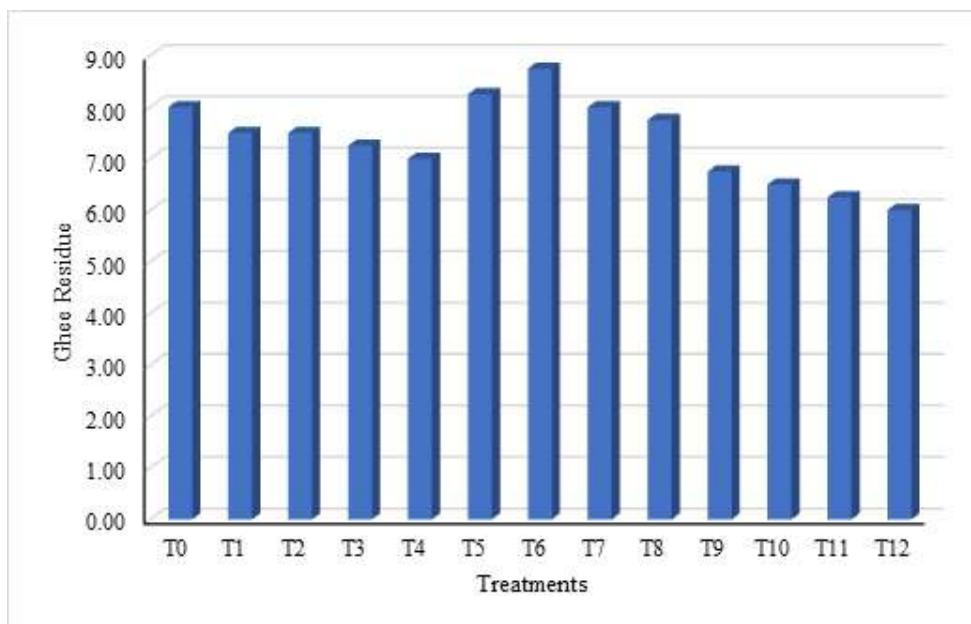


Fig-4 : Graph showing Freedom from suspended impurities (ghee residue) score of control and Cow ghee samples supplemented with flaxseed oil and brahmi leaves.

T1-T10, T1-T11, T1-T12, T2 - T6, T2 - T9, T2 - T10, T2 - T11, T2 - T12, T3 -T6, T3- T10, T3-T11, T3-T12, T4 -T6, T4 -T11, T4- T12, T5- T8, T5- T9, T5 -T10, T5- T11, T5 - T12, T6 - T7, T6- T8, T6 - T9, T6- T10, T6- T11, T6 - T12, T7- T9, T7 -T10, T7 -T11, T7 - T12 and T8 - T12 was found to be significantly different ($P<0.05$) and the difference between the mean value of Colour score between treatments T0 - T1, T0 -T2, T0 -T5, T0-T6, T0-T7, T1 - T2, T1-T3, T1-T4, T1-T5, T1-T7, T2-T3, T2 - T4, T2 - T5, T2 - T7, T2 - T8, T3-T4, T3-T5, T3-T7, T3-T8, T3- T9, T4- T5, T4- T7, T4- T8, T4- T9, T4- T10, T5 -T6, T5- T7, T7- T8, T8- T9, T8- T10, T8- T11, T9- T10, T9- T11, T9 -T12, T10-T11, T10-T12 and T11-T12 was found to be non-significant ($P\geq 0.05$).

It has been observed that when cow ghee samples were incorporated with 5% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Colour Score was found to decrease significantly ($P<0.05$) from 7.50 to 6.25. When cow ghee samples were incorporated with 10% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Colour Score was found to decrease significantly ($P<0.05$) from 7.25 to 6.00. When cow ghee samples were incorporated with 15% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Colour Score was found to decrease significantly ($P<0.05$) from 7.00 to 5.75. When cow ghee samples were incorporated with 20% Brahmi leaves and the level of flaxseed oil increased from 5% to

15%, then the Colour Score was found to decrease significantly ($P<0.05$) from 6.75 to 5.50. When the brahmi leaves were constant, there was no significant difference ($P>0.05$) among Colour Score of treatments suggesting that Brahmi leaves do not exert any significant influence on Colour Score of ghee samples.

The observations for the Colour Score of the cow ghee samples are presented graphically in fig.-3.

Effect of incorporation of flaxseed oil and brahmi leaves on Freedom from suspended impurities (ghee residue) Score of Cow ghee samples : In the present investigation, flaxseed oil was added @ 5%, 10% and 15% and brahmi leaves were added @ 5%, 10%, 15% and 20% in cow ghee samples. The samples were analysed for Freedom from suspended impurities (ghee residue) Score and the observations were found that the highest value for Freedom from suspended impurities (ghee residue) score was 8.75 for sample T6 and treatments T5, T0, T7, T8, T1, T2, T3, T4, T9, T10, T11 and T12 has the mean value of 8.25, 8.00, 8.00, 7.75, 7.50, 7.50, 7.25, 7.00, 6.75, 6.50, 6.25 and 6.00 respectively. Rajnikant (2005) reported that the sensory score of the suspended solid score of herbal ghee (Arjuna ghee) was found in the range of 9.00 to 9.90.

From the ANOVA observation, it has been found that the difference between the mean observation of Freedom from suspended impurities (ghee residue) Score between treatments of T0 - T3, T0 - T4, T0-T6, T0-T9, T0-T10, T0-T11, T0 - T12, T1-T5, T1-T6, T1-T9, T1-T10, T1-T11, T1-T12, T2 - T5, T2 - T6, T2 - T9, T2 - T10, T2 - T11, T2 - T12, T3-T5, T3 -T6, T3-T7, T3- T10, T3-T11, T3-T12, T4-T5, T4 -T6, T4- T7, T4- T8, T4 -T11, T4- T12, T5- T9, T5 -T10, T5- T11, T5 - T12, T6 - T7, T6- T8, T6 - T9, T6- T10, T6- T11, T6 - T12, T7- T9, T7 -T10, T7 -T11, T7 - T12, T8-T9, T8- T10, T8- T11, T8 - T12 and T9 -T12 was found to be significantly different ($P<0.05$) and the difference between the mean value of Freedom from suspended impurities (ghee residue) score between treatments T0 - T1, T0 -T2, T0 -T5, T0-T7, T0-T8, T1 - T2, T1-T3, T1-T4, T1-T7, T1-T8, T2-T3, T2 - T4, T2 - T7, T2 - T8, T3-T4, T3- T8, T3- T9, T4- T9, T4- T10, T5 -T6, T5- T7, T5- T8, T7- T8, T9- T10, T9- T11, T10-T11, T10-T12 and T11-T12 was found to be non-significant ($P>0.05$). It has been observed that when cow ghee samples were incorporated with 5% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Freedom from suspended impurities (ghee residue) Score was found to decrease significantly ($P<0.05$) from 7.50 to 6.75. When cow ghee samples were incorporated with 10% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Freedom from suspended

impurities (ghee residue) Score was found to decrease significantly ($P<0.05$) from 7.50 to 6.50. When cow ghee samples were incorporated with 15% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Freedom from suspended impurities (ghee residue) Score was found to decrease significantly ($P<0.05$) from 7.25 to 5.25. When cow ghee samples were incorporated with 20% Brahmi leaves and the level of flaxseed oil increased from 5% to 15%, then the Freedom from suspended impurities (ghee residue) Score was found to decrease significantly ($P<0.05$) from 7.00 to 6.00. When the brahmi leaves were constant, there was no significant difference ($P>0.05$) among Freedom from suspended impurities (ghee residue) Score of treatments suggesting that Brahmi leaves do not exert any significant influence on Freedom from suspended impurities (ghee residue) Score of ghee samples.

The observations for the Freedom from suspended impurities (ghee residue) Score of the cow ghee samples are presented graphically in fig.-4.

Conclusions

From the result, it may be concluded that flaxseed oil and brahmi leaves was successfully utilized for preparation of herbal cow ghee. Addition of flaxseed oil and brahmi leaves in cow ghee improved the sensory characteristics and acceptability of the product. The most acceptable quality of cow ghee can be prepared by using 10 percent flaxseed oil and 10 percent brahmi leaves. Addition of more than 10 percent of flaxseed oil revealed that the decrease the sensory score. The most acceptable quality of herbal cow ghee samples supplemented with flaxseed oil and brahmi leaves was observed the highest scores of 10 percent flaxseed and 10 percent brahmi leaves in sensory characteristics. Flavour (Aroma and Taste) Score for different samples of various treatments was found to ranges from 47.50 to 37.25. Texture Score for different samples of various treatments was found to ranges from 27.50 to 17.75. Colour Score for different samples of various treatments was found to ranges from 8.50 to 5.50. With increase in the flaxseed oil concentration from 5 to 15 percent the Colour Score decreased significantly ($P<0.05$). Freedom from suspended impurities (ghee residue) Score for different samples of various treatments was found to ranges from 8.75 to 6.00.

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Goat Marketing in Bihar : A Case Study

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Introduction

The Working Group on Animal Husbandry & Dairying for the 12th Five Year Plan (2012 – 2017) in India identifies that the small ruminants, particularly goats play a tremendous role in providing livelihood and income generating opportunities to landless and marginal farmers along with the other vulnerable sections of the society. Due to changing food habits a large segment of predominantly vegetarian society is converting into non-vegetarian. As a consequence, demand for meat is increasing.

Apart from changing food habits, enhanced purchasing power of the consumers has further boosted the food diversity and demand of food items with increasing share of high-value commodities. Evidence indicates that the consumption food from animal sources is picking up. This trend is even likely to rise further as the population growth in India is still momentous. Goat meat is the only red meat, which is relished by all religious groups in India who prefer non-vegetarian foods. However a large segment of goat production and marketing in India is still unorganised. The goat meat value chains are disjointed and unregulated. Goat markets are predominantly in the hands of small aggregators, informal agents and butchers. This case study attempts to understand the characteristics of goat markets and depicts the intricacies of goat marketing in Bihar.

Research Methodology

Locale : The present case study depends upon the information elicited from the goat market located at Jagdeo Path at Bailey road in Patna. It is one of the largest goat markets in the city where goats are brought from all across the state for marketing.

Selection procedure : The goat market at Jagdeo Path, Patna was selected purposely on the basis of volume of business and proximity to Bihar Animal sciences university, Patna.

Elicitation of data : A team of scientists from Sanjay Gandhi Institute of Dairy Technology, Patna and

ICAR-Central Institute Research for Goat (CIRG), Makhdum, Mathura visited the goat market in February 2018. A couple of visits were made to this market and various stakeholders present in the market during the visits were contacted. Five focussed group meetings (FGD) with different stakeholders like transporters/ truck drivers, agents, traders, purchasers (mostly local butchers) were conducted separately. The last (sixth) FGD was convened involving 3 to 4 participants from each group of stakeholders.

The discussions were initiated and steered as per the checklist prepared purposely for this study. All the participants were encouraged to speak and relevant information and feedbacks were recorded.

Analysis of data : The collected data were tabulated and analyzed to draw inferences.

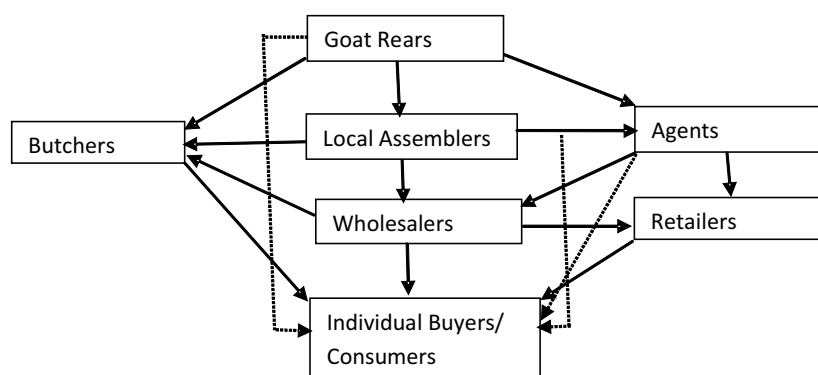
Results and Discussion

Patna Goat market is one of the largest goat markets in Bihar that facilitates goat marketing in Bihar. Sellers/ traders of goat from nearby villages, neighbouring districts and states access this market to sell the goats. Truck loads of goats are brought to the market and sold to the buyers/traders at negotiated prices. The live goats are procured from the goat rears by local aggregators, agents etc. and sold to the retail and wholesale traders in the local markets/mandil. From local markets/mandis goats are purchased and transported to the Patna market by the local traders.

The main players in the goat markets are wholesalers, retailers, agents, transporters and butchers. Some of the important supply chains are depicted in the Fig-1.

It is obvious that before reaching at an individual consumer either live or as meat, the goat passes through a number of channels having different stakeholders. The shortest chain operates between a goat rear and an individual consumer whereas the largest chain involves goat rears, assemblers, agents, wholesalers, retailers, butchers and ultimately consumers.

The profiles of goat traders are depicted in table-1.

Fig.1: Important Stakeholders in Goat Supply Chains in Bihar**Table-1 : Profiles of goat traders in the Patna goat market.**

Type of traders	Average age (years)	Average education	Years of experience in goat trading
Wholesalers	55 - 60	Less educated or illiterate	30 - 40
Retailers	45 - 50	Less educated or illiterate	20 - 30
Agents	40 - 50	Less educated or illiterate	20 - 30
Transporters	45 - 55	Less educated or illiterate	10 - 20
Butchers	35 - 50	Less educated or illiterate	20 - 25

Most of the goat traders are either uneducated or less educated. The traders involved in goat trade as wholesalers possess 30-40 years of experience. Other stakeholders, including Retailers are mostly middle aged persons between 35 to 55 years of age with 10 to 30 years of experience in the business.

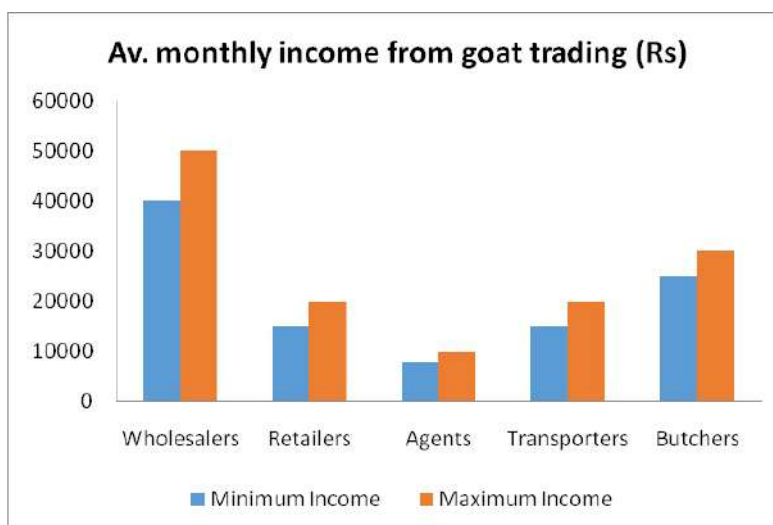
Goat marketing largely depends on the goats procured from the rural goat keepers who rear goats as one of the supplementary sources of income. Distress sale of goat, which is sold in times of need seems to be confirmed by the fact that most of the goats are sold before reaching at their ideal age. The ideal age of goat for marketing is around 10 months, whereas in markets kids of 5-10 months are sold in plenty. At one hand, where a large number of goats are sold too young, before reaching their optimal body size, a significant number of goats are sold at an age of 1 – 3 years, meaning they are kept longer than necessary. Keeping goats until the need for cash income arises is not very costly for these households, as long as labour costs for grazing are low (Christopher, et al. 2018). However, the high share of goats being sold before maturity despite low production costs is a serious limitation to the success of goat production.

There is a distinct preference for male goats in markets for the chevon (goat meat). However, she-goats are also sold during the events of distress or when good prices are paid during the periods of high demands. Despite, selling of young productive she-goats is rare.

Domestic market : During discussions with the traders in the Jagdeo Path goat market in Patna, it emerged that goat markets in Bihar, by and large depend of informal traders. There are assemblers who keep on strolling in the villages and have good contacts with the goat keepers. Most of these aggregators are trader-cum-butchers who operate in specific areas, virtually without competition and dictate price. After meeting their own requirements they sell the surplus stock in the hands of large traders who come to the urban markets to sell goats. A large number of goat producers access market through local itinerant traders with price being the main determinant for selecting a trader for each transaction.

It is to be noted that dedicated goat markets often offer higher prices but the limiting factor is the scale of production that constrain the access of these small producers. With one or two goats they cannot afford to access the dedicated markets, which are often located in urban or peri-urban areas due to high transaction and transportation costs

In general, the price of a goat at sale is not determined directly by its live weight, but by a visual assessment of the buyer taking into accounts several factors such as age, body condition, appearance and sex. About Rs 300-350/ kg are paid on approximate live body weight of goat. The typical retail outlet for goat meat is the roadside butcher shop. These are of varying standards and in many cases owned and run by Muslims. Slaughterhouses in some urban agglomerations also



cater for small ruminants, but most butchers slaughter in or near the butcher shop.

The owner of a roadside butcher shop sells all meat at a uniform price, irrespective of the particular cut and specific cuts are normally not available. However, liver and kidneys as well as heads and legs are sold at specific prices. Age and sex of the slaughtered goat do not appear to greatly influence the meat price. Although some supermarket chains also offer – mainly frozen – goat meat, the Indian consumer apparently prefers to buy it fresh at the roadside shop, despite varying hygienic conditions. In rural areas, butcher shops are often integrated into the weekly markets, selling only on the particular market day.

A number of the local butchers also trade goats at the local level. After purchasing goats from farmers they slaughter as many as they require for their own shop and then sell the remaining animals to larger traders or at a local goat market.

Income from goat marketing : Goat trade offers opportunity for earning a good income. During the FGD it emerged that the traders involved in goat marketing earn any amount between Rs 8000 to Rs 50000 depending upon the role and scale of business.

A fair commission is charged in lieu of facilitation of marketing that often varies between 10% to 20%. During festive seasons/days like holi, ramjan, year endings and new year the demand for goat meat increases many fold and goats are thus sold on premium prices, which vary between 20 to 30 percent more than that of normal regular prices.

Market information : No formal market information service for goats exist in the areas studied. However, because of a great variation in live-weight and quality, standard units, which would be required for a formal

information system, are difficult to define. Therefore, traders and producers have to rely on word of mouth or on visiting markets directly to gain information on prices and volumes. However, the spread of the internet and of mobile phones appears to have reduced the need for a formalized market information service.

Before annual religious holidays such as Eid-ul-Fitr, Eid-ul-Azr, Dashera, Holi and Diwali prices for goats increase considerably, of which goat keepers are generally aware. Where possible they try to adjust their production cycle and sales accordingly.

Transport services : A large share of the goats being sold reaches the closest market and/or roadside butcher shop by trekking or on a two-wheeler. However, it is also common to load goats on pick-ups or large trucks to transport them to bigger markets or urban consumer centres. Goats are traded to different neighbouring states and districts inside the state.

Conclusions

The dominant goat husbandry found in the study area is a traditional low-input system with common grazing and lopped tree leaves being the major feed sources, supplemented in dry periods by crop-residues and other by-products.

Animal health care services are not reaching most goat farming communities. This situation together with poor feeding regimes can be seen as the major cause for high mortality rates, especially among young stock. Preventive vaccinations against the most important infectious diseases (e.g. peste-de-petits-ruminants (PPR), enterotoxaemia (ET), foot-and-mouth-disease (FMD), haemorrhagic septicaemia (HS)) would be a first step to efficiently reduce mortality. Most goats kept in rural areas are of the “non-descript” type, but are well

adapted to the harsh husbandry conditions. Attempts to improve the genetic potential would make sense only if feeding and health care are improved simultaneously.

Goats are an important livelihood component for landless, marginal and small farmers. They are an essential part of the financial “safety net” as they can be easily sold in times of need. Goats require only a low initial investment and – kept under the prevailing extensive system with grazing on communal property resources – limited operational costs.

Although the demand for goat meat is expected to continue to rise, productivity in the traditional system remains low. Attempts to stimulate the establishment of “commercial goat farmers” with large flocks in semi-intensive or intensive systems have so far been only moderately successful.

Marketing and trading of goats is neither interfered with nor supported by the public sector and does not fall under any regulatory framework. Nevertheless, goat farmers are generally well connected to markets through a wide network of traders on local/village, state and inter-state levels. However, since most goat keepers sell only a few animals per year and often only when they are in urgent need of cash, their bargaining position tends to be rather weak.

The high degree of fragmentation in the goat sector would require a considerable amount of extension and advisory effort if individual farmers were to be targeted with intensified outreach programmes. Therefore, some NGOs and development agencies are supporting farmer self-help organisations in order to reach large numbers of smallholder goat farmers. These are mainly women's groups, since it is mostly women who are in charge of goats.

On the other hand, a ready market for goats exists and prices are expected to increasingly continue. Any measure to increase productivity in the traditional goat sector will most likely contribute to poverty alleviation as a good income can be earned.

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Probiotics and their Beneficial Effect on Human Health : A Review

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Abstract

Probiotic bacteria have become increasingly popular during the last two decades due to their beneficial effects on human health. They have been applied as various products with the food and food supplement. Food Industry are now a day very active in studying and promoting them due to their popularity and increased demand among consumers. Within this market the probiotics have been incorporated in various products, mainly fermented dairy foods. Despite scientific evidence and ongoing Researches have established the fact of associating these microorganisms to various health benefits, but again further research is needed to know more about their effects and side effects on human health. This article will highlight the various uses of probiotic in order to establish them and evaluate their safety as well as their nutritional aspects.

Key words : Probiotics, prebiotics, diarrhoea, allergy, cancer,

Introduction

Probiotic : Probiotic are microorganisms, which when consumed, are believed to provide health benefits to humans and other organisms. Generally we think of bacteria as something that causes diseases but our body is full of bacteria, both good and bad. Probiotics are often called “good” or “helpful” bacteria because they help keep your gut healthy. (Table-1) We lose “good” bacteria in our body by taking an antibiotics but probiotics can help to regain them. Probiotics are naturally found in our body and their association with well-being has been studied since a long. It was Tissier who observed that gut microbiota from healthy breast fed infants were dominated by rods with a bifid shape (bifidobacteria) which were absent from formula fed infants suffering from diarrhoea, establishing the concept that they played a role in maintaining health. (Kechagia, *et al.*, 2013). The population is facing many adverse effects after consuming antibiotics. Their increased demands for something natural that can be ecofriendly to our guts with no side effects have led to scientific evolution of research in the field of Probiotic. The functional food market is expanding, especially in Japan—its birthplace—with further growth prospects in Europe and the United States and in most countries the largest share of its products is held by probiotics (Ziemer *et al.*, 1998). The reported beneficial effects of probiotic consumption include improvement of intestinal health (Salminen *et al.*, 1998) Boosting immunity by modulating mucosal and systemic immunity as well as nutritional and microbial balance in the intestinal tract (Mercenier, *et al.*, 2008). Amelioration of symptoms of lactose intolerance, and reduction of the risk of various other diseases (Sheehan *et al.*, 2007). A variety of well-characterized strains of *Lactobacilli* and *Bifidobacteria*

are available for human use. The evidence, shown that they are promising too even then the role of probiotics in human health as well as the safety of their application should be further investigated as the current knowledge of the characteristics that are necessary for their functionality in the gut is not complete.

Probiotic, Pre biotics and synbiotics and Other Related Terms

The term probiotic is derived from the Greek language Etymologically meaning “for life” but the definition of probiotics has evolved over time simultaneously with the increasing interest in the use of viable bacterial supplements and in relation to the progress made in understanding their mechanisms of action. In 1908 Ellie Metchnikoff who received nobel prize for proposing first the beneficial effect of probiotic microorganism on human health. These bacteria affect gut microflora positively and decrease the microbial toxic activity (Cakir 2003)

Desirable Probiotic Properties

In order for a potential probiotic strain to be able to exert its beneficial effects, it is expected to exhibit certain desirable properties. The ones currently determined by in vitro tests area.

1. Acid and bile tolerance which seems to be crucial for oral administration.
2. Adhesion to mucosal and epithelial surfaces, an important property for successful immune modulation, competitive exclusion of pathogens, as well as prevention of pathogen adhesion and colonisation.
3. Antimicrobial activity against pathogenic bacteria.
4. Bile salt hydrolase activity.

Probiotics and Food Products

The range of food products containing probiotic strains is wide and still growing. The main products existing in the market are dairy-based ones including fermented milks, cheese, ice cream, buttermilk, milk powder, and yogurts. Non dairy food applications include soy based products, nutrition bars, cereals, and a variety of juices. The factors that must be addressed in evaluating the effectiveness of the incorporation of the probiotic strains into such products are, besides safety, the compatibility of the product with the microorganism and the maintenance of its viability through food processing, packaging, and storage conditions. Current technological innovations provide ways to overcome probiotic stability and viability issues offering new options for their incorporation in new media and subsequent satisfaction of the increasing consumer demand. Microencapsulation technologies have been developed to protect the bacteria from damage caused by external environment. In addition, viable spores of a spore forming probiotic are available in the market offering advantages during processing. In the same time, the potential of antibiotics'—substances with antimicrobial properties—production by bifidobacteria is being explored in order to be applied in the food area.

Health Benefits of Probiotics

There is increasing evidence in favour of the claims of beneficial effects attributed to probiotics, including improvement of intestinal health, enhancement of the immune response, reduction of serum cholesterol, and cancer prevention. These health properties are strain specific and are impacted by the various mechanisms mentioned above. While some of the health benefits are well documented others require additional studies in order to be established. In fact, there is substantial evidence to support probiotic use in the treatment of acute diarrhoeal diseases, prevention of antibiotic-associated diarrhoea, and improvement of lactose metabolism, but there is insufficient evidence to recommend them for use in other clinical conditions.

Antibiotic-Associated Diarrhoea : In the normal diarrhoea the patients are treated by antibiotics. By this way the normal microflora also gets down and we feel weakness due to loss of natural beneficial microorganisms. These loss also associated with the other mucosal abnormalities. Hempel *etal*, 2017 Reported severe form of antibiotic-associated diarrhoea caused by *Clostridium difficile*, cytotoxic strains of which may emerge after antibiotic use The name of the condition is derived from the plaque-like adhesion of fibrinopurulent material to the damaged mucosal layer and it is characterized by diarrhoea, abdominal distention,

vomiting, fever, and leukocytosis and if untreated might lead to complications such as toxic megacolon and perforation. Treatment consists of withdrawal of the causal antibiotic agent, correction of the electrolyte disorders, and in severe cases therapy with metronidazole or vancomycin. Treatment with probiotics has been used in clinical practice with *L. rhamnosus* and *S. boulardii* being administered.

Infectious Diarrhoea

Rotavirus is the most common cause of acute infantile diarrhoea in the world and a significant cause of infant mortality. The virus replicates in the highly differentiated absorptive columnar cells of the small intestinal epithelium and the normal microflora seems to play an important role in the host response to the infection. Probiotic supplementation of infant formulas has been aimed both at the prevention of rotaviral infections and the treatment of established disease. Freedman *etal.*, 2020.

Lactose Intolerance

Lactose intolerance is a genetically determined beta-galactosidase deficiency resulting in the inability to hydrolyse lactose into the monosaccharides glucose and galactose. Upon reaching the large bowel the undigested lactose is degraded by bacterial enzymes leading to osmotic diarrhoea. Acquired, usually reversible, causes of beta-galactosidase deficiency include pelvic radiotherapy which damages the mucosa, as well as infection with rotavirus which infects lactase producing cells, and short bowel syndrome. Lactose intolerant individuals develop diarrhoea, abdominal discomfort, and flatulence after consumption of milk or milk products. Although conventional yoghurt preparations, using *S. thermophilus* and *L. delbrueckii* ssp. *Bulgaricus*, are even more effective in this direction, partly because of higher beta-galactosidase activity, Oak & Jha R. 2019. reported improvement of lactose metabolism is a claimed health benefit attributed to probiotics and seems to involve certain strains more than others and in specific concentrations. Therefore and as certain individuals have responded positively to probiotic supplementation, clinicians should consider it as a therapeutic alternative

Probiotics and Allergy

A lot of evidences have shown that probiotic have shown a potential role in treatment of many allergic reaction viz Eczema, asthma and other allergic reactions. Isolauri *etal.*, 2001 studied the role of probiotic on human health. Ouwehand *etal.* 2001, also studied the role of probiotic on allergic reaction and found that species of bifidobacterium is helpful in combating many of the allergic reactions on body. Wheeler *etal.*, 1997 studied the role of probiotic on combating the Asthma on human being

Table-1 : List of Probiotic Bacteria
Adapted from Holzapfel *et al.*, 2001

Microorganisms considered as probiotics	
<i>Lactobacillus species</i>	<i>Bifidobacterium species</i>
<i>L. acidophilus</i>	<i>B. adolescentis</i>
<i>L. casei</i>	<i>B. animalis</i>
<i>L. crispatus</i>	<i>B. bifidum</i>
<i>L. gallinarum</i>	<i>B. breve</i>
<i>L. gasseri</i>	<i>B. infantis</i>
<i>L. johnsonii</i>	<i>B. lactis</i>
<i>L. paracasei</i>	<i>B. longum</i>
<i>L. plantarum</i>	
<i>L. reuteri</i>	
<i>L. rhamnosus</i>	
<i>Other lactic acid bacteria</i>	<i>Nonlactic acid bacteria</i>
<i>Enterococcus faecalis</i>	<i>Bacillus cereus</i> var. <i>toyo</i>
<i>E. faecium</i>	<i>Escherichia coli</i> strain nissle
<i>Lactococcus lactis</i>	<i>Propionibacterium</i>
<i>Leuconostoc mesenteroides</i>	<i>freudenreichii</i>
<i>Pediococcus acidilactici</i>	<i>Saccharomyces cerevisiae</i>
<i>Sporolactobacillus inulinus</i>	<i>S. boulardii</i>
<i>Streptococcus thermophilus</i>	

Other Health Benefits

Probiotics are effective in the prevention and treatment of many bowel diseases as inflammatory bowel disease (IBD), diarrhea, irritable bowel syndrome, gluten intolerance, gastroenteritis, *Helicobacter pylori* infection, and colon cancer. Classical examples are strains from the *Lactobacillus*, and *Bifidobacterium* genus that have probiotic properties with a potential use in the prophylaxis, as well as in the treatment of a variety of gastrointestinal tract disorders. Researchers are focusing on extremely important studies regarding the possibility of using probiotics to promote a balanced microbiota composition, and a sufficient immunological surveillance system as a way to prevent cancer. (Debora *et al.*, 2020) The list of health benefits mediated by probiotics is not limited to the ones mentioned so far and includes a range of promising effects that require however further human studies in order to be substantiated. There is evidence that probiotic bacteria are dietary components that may play a role in decreasing cancer incidence. The exact mechanisms are under investigation, but studies have demonstrated that certain members of *Lactobacillus* and *Bifidobacterium* spp. decrease the levels of carcinogenetic enzymes produced by colonic flora through normalization of intestinal permeability and microflora balance as well as production of antimutagenic organic acids and enhancement of the host's immune system.

Conclusions

Probiotic are considered as a magic bullet to combat many of the disease as evident from the above research findings. Lots of work have been done on evaluating the

role of probiotic on treating the chronicle disease of the human being but still many research facts are needed to be revalidate the to the know the proper use of probiotic as we are aiming towards consuming live microorganism. If probiotic validation may be proven the future will be targeted towards their large marketing and popularization of probiotic to combat many untreated disease.

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Impact of KVK Training Programs on Adaptation of Cucumber Production Technology

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Abstract

The study was carried out in Bawan and Hariyawan block of Hardoi district of Uttar Pradesh. The above blocks were purposely selected because of large number of farmer's participation in training program. The data regarding gain in knowledge and adaptation of level about improved cucumber production technologies were recorded under two heads like knowledge after training. The finding of study revealed that farmers had gained knowledge about cucumber production technologies ranging from 10 percent of land preparation to 75 percent of high yielding variety after training programs. The study showed that the none of farmers were following the improved practices of cucumber production like soil testing, soil treatment, seed rate and spacing before training programs, whereas, after training program they were adopting high yielding variety (76.6%), training of vine (73.3%), seed treatment (70%) and seed rate and spacing (68.3%). The study also revealed that they were adopting the cucumber production technologies ranging from 13.3 percent for land preparation to 76.6 percent for high yielding variety after training programs.

Introduction

The estimated total world production for cucumber in 2018 was 75,219,440 metric tons. China was largest producer accounting nearly 75 % of global production. India has 25th rank in cucumber production. The major cucumber producing states in India are Haryana, Madhya Pradesh, Karnataka, Andhra Pradesh, Uttar Pradesh, Punjab, Assam, Telangana, Maharashtra and Kerala. India export cucumber to major destination like France, USA, Russia, Belgium and Spain (Kumar et al 2008). Cucumber is used as salad or as snack. In fact, they contain a lot of nutrients which you need like Vitamin B1, B2, B3, B5, B6, C and Zinc, Potassium, Iron, Calcium, Folic Acid etc. Apart from this it is use in constipation, treat as eye purifiers, Juice are used in reducing blood pressure, heart rate and also reduce the risk of cancer etc. Keeping above in view, an effective extension approach of training for dissemination of technology was thought to assess the impact of training programs organized and to find out the extent of knowledge and adaptation of cucumber production technology by the KVK trainees.

Materials and Methods

Krishi Vigyan Kendra Hardoi since its establishment has directed its efforts towards agricultural development in the district and bringing about entrepreneurship and skills among practitioners of agriculture and rural youth with a view to ensure livelihood security. The study was carried out in Bawan and Hariyawan block of Hardoi district in Uttar Pradesh. The selection of these two blocks because of large number of farmer's participation in KVK's training program. For the selection of respondents a list of cucumber trainees of KVK during preceding three years

2019-20 to 2021-22 was prepared. Out of trainees list only 60 farmers were randomly selected from KVK adopted villages of selected block. The data were collected through personnel contact with the help of well structured interviewed schedule. The collected and gathered data were processed tabulated classified and analyzed in term of percentage in the light of objectives of the study. Total thirteen practices were selected to find out the extent of knowledge and adaptation of cucumber production technologies.

Results and Discussion

Gain in knowledge : It is assumed that the knowledge of a farmer to a large depends upon the extent of exposure given to him about technology. The gain in knowledge by the respondents about improved package of practices of cucumber was measured in the term of percentage. The data regarding gain in knowledge about improved cucumber production technology were recorded under two heads i.e. knowledge before training and knowledge after training. The data in the table 1 depicted that the beneficiary farmers of cucumber production training program were gained highest knowledge about high yielding variety (75%) followed by training of cucumber vine (73.3%), weed management (71.66%), seed treatment (68.33%), seed rate and spacing (65%), plant protection measures (60%), soil treatment (56.66%), nutrient management (56.66%), irrigation management (50%), packaging and marketing (38.33%), sowing time (30%), harvesting (26.66%) and land preparation (10%). The finding of the study also revealed that they had gained knowledge ranging from 10.0 percent of land preparation to 75 percent of high yielding variety after training program. This might be due to the fact that they were

Table-1 : Impact of training on change in knowledge Level.

Technology	Before Training	After Training	Gain in Knowledge
Land Preparation	54 (90)	60 (100)	06 (10)
Soil Treatment	00 (00)	34 (56.66)	34 (56.66)
Seed Treatment	5 (8.33)	46 (76.66)	41 (68.33)
High Yielding Variety	15 (25)	60 (100)	45 (75)
Sowing Time	40 (66.66)	58 (96.66)	18 (30)
Seed Rate and Spacing	12 (20)	51 (85)	39 (65)
Training of vine	16 (26.66)	60 (100)	44 (73.33)
Irrigation Management	28 (46.66)	58 (96.66)	30 (50)
Weed Management	12 (20)	55 (91.66)	43 (71.66)
Nutrient Management	14 (23.33)	48 (80)	34 (56.66)
Plant Protection Measures	16 (26.66)	52 (86.66)	36 (60)
Harvesting	26 (43.33)	42 (70)	16 (26.66)
Packaging and Marketing	17 (28.33)	40 (66.66)	23 (38.33)

Table-2 : Change in adaptation level of the respondents regarding cucumber production technologies.

Technology	Before Training	After Training	Gain in Knowledge
Land Preparation	52 (86.66)	60 (100)	8 (13.33)
Soil Treatment	00 (00)	30 (50)	30 (50)
Seed Treatment	00 (00)	20 (33.33)	20 (33.33)
High Yielding Variety	14 (28.33)	60 (100)	46 (76.66)
Sowing Time	00 (00)	42 (70)	42 (70)
Seed Rate and Spacing	00 (00)	41 (68.33)	41 (68.33)
Training of vine	16 (26.66)	60 (100)	44 (73.33)
Irrigation Management	23 (38.33)	48 (80)	25 (41.66)
Weed Management	14 (23.33)	51 (85)	37 (61.66)
Nutrient Management	18 (30.0)	36 (60.0)	18 (30.00)
Plant Protection Measures	16 (26.66)	42 (70.0)	26 (43.33)
Harvesting	18 (30.0)	39 (65.00)	21 (35.00)
Packaging and Marketing	8 (13.33)	18 (30.0)	10 (16.66)

convinced through training programmers about cucumber production technology by KVK which were designed to import latest knowledge through work experience.

Extent of adoption : The data presented in Table-2 revealed that the none of the farmers were following the improved practices like soil testing, soil treatment, seed treatment, seed rate and spacing before acquiring training whereas, after attending training program they adopted seed treatment (70%), seed rate and spacing (68.33%), soil testing (50%) and soil treatment (33.33%). Over 88.66 per cent farmers were practicing land preparation before training program and the remaining 13.44 per cent began after training program regarding high yielding variety 28.33 percent farmers were using before training while after training program all the farmers started to grow high yielding variety of cucumber on their farms.

They were following improved practices of cucumber like high yielding variety (76.66%), training of cucumber vine (73.33%), weeding (61.66%), plant protection measures (43.33%), Irrigation scheduling (41.66%), Harvesting (35.0%), fertilizer adaptation (30%), fertilizer adaptation (30%) and packaging (16.66%). Farmers were adopting the production technologies ranging from 13.33

percent land preparation to 76.66 percent for high yielding variety. This might be due the fact that increase in knowledge, skill and confidence level of farmers through training program on different production technologies like high yielding variety, seed rate and spacing, seed treatment, soil testing, soil treatment, weeding, training of vine, plant protection measures, irrigation scheduling, fertilizer application and harvesting has helped farmers to improve the yield of cucumber crop.

Conclusions

The finding of the study revealed that farmers had gained knowledge about cucumber production technology ranging from 10 per cent of land preparation to 75 per cent of high yielding variety after attending training program organized by the KVK. The study showed that none of the farmers were following the improved package of practices of cucumber production like soil testing, soil treatment, seed rate and spacing before acquiring the training where after attending the training program they adopted high yielding variety (76.66%) , training of vine (73.33%), seed treatment (70%) and seed treatment and spacing (68.33%). The study also revealed that they started adopting the cucumber production technologies ranging

from 13.33 per cent for land preparation to 76.66 per cent for high yielding variety after attending training program thus it can concluded that training program conducted by KVK is one of the important tool for dissemination of knowledge and technical skills to the farmers. Meanwhile conductance of short duration trainingis playing an important role in motivating the farmers for adaptation of improved agricultural technologies, thus, resulting in their increased yield and profits.

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Effect of Plant Growth Promoting Microorganism (PGPM) on Growth and Yield of Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] in Arid and Semi Arid Region

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Abstract

A field experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner, (Rajasthan) during *kharif*, 2015 on loamy sand soil to study the effect of PGPM on growth and yield of clusterbean [*cyamopsis tetra gonoloba* (L.) taub]. The experiment was laid out according to randomized block design with three replications. The treatments consisting of four levels of seed inoculations with PGPM (no inoculation, *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM) were applied to the clusterbean var. RGC-1038. The main findings of investigation are summarized as: Seed inoculation with *Rhizobium* + PSB + VAM significantly increased the plant height, dry matter accumulation (30 DAS and at harvest), number of pods per plant; number of seeds per pod; seed and straw yield; chlorophyll content in leaves; number of total and effective root nodules. However, there was no significant effect on test weight with inoculation of *Rhizobium* + PSB + VAM.

Key words : PGPM, clusterbean, growth and yield parameters.

Clusterbean [*Cyamopsis tetragonoloba* (L)] is popularly known by its vernacular name 'guar' is an important legume crop mainly grown under rainfed condition in arid and semi arid regions of Rajasthan during *kharif* season. It is very hard and drought tolerant crop. It is having deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rainfed cropping system and also survive even in moderate salinity and alkalinity conditions of the seed. Thus sustainable irrigation systems using saline soils and waters have the potential to improve crop production in arid region. (Meena *et al.*, 2021).

Cluster bean can be grown in a different variety of soils. It does not thrive well on heavy and waterlogged soils. It does not thrive well in saline and alkaline soils. Well-drained sandy loam with a pH range of 7 to 8.5 and warm climate is suitable for Cluster bean cultivation. The soils of arid region were neutral to alkaline in reaction ranging between 7.0-8.30 with an average pH of 7.61. The organic carbon content ranged from 0.05% to 0.13%. Among major nutrients, available nitrogen, potassium and phosphorus was low medium and low respectively. (Meena *et al.*, 2021). Clusterbean is grown for different purpose and it provides nutritional concentrate and fodder for cattle and adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen. Among dry land crops guar occupies an important place in the national economy due to the presence of gum in its

endosperm (35 to 40 %), (Anonymous, 2013-14). Guar gum is produced from the seed and this is turned into powder. The powder is used in a host of industries, ranging from bakery, dairy, meat, dressing and sausages, beverages, pharmaceuticals and cosmetics, textile printing, mining, water treatment and paper industry (Sharma, 2010). In India, clusterbean is mostly grown in Rajasthan, Haryana, Punjab, Uttar Pradesh and Madhya Pradesh. Among these state Rajasthan is a major clusterbean producing state in India.

However, plant growth promoting microbes (PGPM) have shown potential as sustainable plant growth enhancers and have potential to help with a range of stresses in their environment. Considering the long-term evolutionary relationships between plants and microbes, it is probably that much remains unknown about potential benefits of microbes that could be harnessed from PGPM. Greater exploitation of PGPM in this regard, would be interesting to explore as they have the potential to address multiple stresses in a more sustainable fashion. The seeds of pulses were inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the micro-biologically fixed nitrogen for the plant growth.

The inoculation of seeds with suitable *Rhizobium* culture increased the green pod yield over inoculated control (Vaisya *et al.*, 1983). The association of *Rhizobium*

Table-1 : Effect of PGPM on plant height, at harvest ,total chlorophyll content, Total nodules per plant, Effective nodules per plant, dry matter accumulation at 30 DAS (g) and at harvest stage (g).

Treatments	Plant height (cm)	Total chlorophyll content (mg g ⁻¹)	Total nodules per plant	Effective nodules per plant	DM accumulation 30 DAS (g)	DMt Harvest stage (g)
PGPM						
P ₀ (control)	73.59	2.46	23.22	13.13	17.85	103.00
P ₁ (<i>Rhizobium</i>)	82.34	2.79	25.75	20.09	20.75	118.60
P ₂ (<i>Rhizobium</i> + PSB)	84.78	3.02	26.33	21.19	23.15	131.03
P ₃ (<i>Rhizobium</i> + PSB + VAM)	85.55	3.20	27.01	21.99	24.85	141.55
SEm+	2.06	0.06	0.73	0.61	0.57	3.54
60Cd (p = 0.05)	5.95	0.17	2.12	1.76	1.64	10.23

Table-2 : Effect of PGPM on pods per plant, seeds per pod, test weight (gm), Seed yield (qha⁻¹) and straw yield (qha⁻¹).

Treatments	Pods per plant	Seeds per pod	Test weight (gm)	Seed yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)
PGPM					
P ₀ (control)	24.90	7.55	27.01	9.92	26.93
P ₁ (<i>Rhizobium</i>)	28.74	8.49	27.54	11.04	29.13
P ₂ (<i>Rhizobium</i> + PSB)	29.78	8.76	27.85	11.33	30.01
P ₃ (<i>Rhizobium</i> + PSB + VAM)	30.12	8.95	28.03	11.48	30.55
SEm+	0.89	0.28	0.56	0.29	0.65
Cd (p = 0.05)	2.58	0.81	NS	0.82	1.88

and pulse plants helps in improving fertility of soil and is a cost effective method of nitrogen fertilization in legumes. Phosphorus solubilising microorganisms (bacteria and fungi) enable P to become available for plant uptake after solubilisation. Several soil bacteria, particularly those belonging to the genera *Bacillus* and *Pseudomonas* and fungi belonging to the genera *Aspergillus* and *Penicillium* possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphates. Vesicular arbuscular mycorrhiza plays an important role in phosphorus cycling and in the uptake of phosphorus by plants. VAM as symbiotic association with plant roots helps in mobilization of 'P'. VAM fungi are beneficial symbiotic micro-organisms that increase the growth and yield of most crop plants through improved P uptake. It also increases tolerance to biotic and abiotic stresses. VAM can play an important role in enhancing P availability to plant in P deficient soils. VAM fungi can save P-fertilizer by 25-30% (Somani *et al.*, 2004). Therefore the present study is based on effect of plant growth promoting microorganism (PGPM) on growth and Yield of Clusterbean.

Materials and Methods

The field experiment was conducted at Agronomy farm, S.K.N College of Agriculture Jobner, Jaipur (Rajasthan). The Agronomy farm is situated at 75° 28' East longitude and 26° 08' North latitude and 427m above mean sea level. This region falls under Agro-climatic zone-III A

(Semi-Arid Eastern Plains) of Rajasthan. The experimental soil was loamy sand in texture with high infiltration rate and saturated hydraulic conductivity. The experiment was laid out in randomized block design and replicated thrice. The variety of Clusterbean used as a test crop was RGC-1038.

Results and Discussion

Effect of PGPM on Growth parameters of clusterbean

The result revealed that plant height, total nodules, effective nodules significantly increased with inoculations of *Rhizobium*, while, chlorophyll content and dry matter accumulation significantly increased with *Rhizobium* + PSB + VAM inoculation over control. Inoculation of seeds with N₂ fixer might have increased the concentration of an efficient and healthy strain of *Rhizobium* bacteria in the root nodules which might have resulted in greater fixation of atmospheric nitrogen and consequently for use by the plants resulting in vigorous growth of plant.

The plant height of clusterbean significantly increased with inoculation of *Rhizobium* over control which was at par with *Rhizobium*+ PSB and *Rhizobium*+ PSB + VAM. The maximum plant height (85.55 cm) was observed under the treatment P₃ (*Rhizobium* + PSB + VAM) and minimum plant height (73.59 cm) under control (P₀). The increase in plant height was obtained to the extent of 11.59, 15.20 and 16.25 per cent with *Rhizobium*, *Rhizobium* + PSB and *Rhizobium*+ PSB + VAM respectively, over control (P₀). (Table-1)

The inoculation of clusterbean seed with *Rhizobium* + PSB + VAM significantly increased Chlorophyll content

in leaves at flowering stage over rest of the treatment (Table 1). The maximum Chlorophyll content (3.20 mg g^{-1}) was observed under the treatment P_3 (*Rhizobium* + PSB + VAM) and minimum Chlorophyll content (2.46 mg g^{-1}) under control (P_0). The increment with Chlorophyll content was obtained to the extent of 13.41, 22.76 and 30.08 per cent *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM respectively, as compared to control (P_0).

The number of total and effective nodules of clusterbean significantly increased with inoculation of *Rhizobium* over control and remained at par with *Rhizobium* + PSB and *Rhizobium* + PSB + VAM. The maximum number of total (27.01) and effective nodules (21.99) was observed under the treatment P_3 (*Rhizobium* + PSB + VAM) and minimum number of total (23.22) and effective nodules (13.13) under control (P_0). The increase in number of total and effective nodules was obtained to the extent of 10.89 & 53.00, 17.39 & 61.38 and 16.32 & 67.47 per cent corresponding to *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM respectively, as compared to control (P_0). The dry matter accumulation increased at 30 DAS and at harvest of crops was obtained to the extent of 16.24 & 15.14, 29.69 & 27.21 and 39.21 & 37.42 per cent with *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM respectively, as compared to control (P_0).

Seed inoculation with *Rhizobium* recorded higher values of growth parameters. The inoculation of *Rhizobium* has proved one of the most efficient treatments in increasing growth parameters viz., plant height, total nodules, effective nodules, chlorophyll content and dry matter at 30 DAS and at harvest stages (Table-1). Dual inoculation might have contributed something towards enhanced plant growth and increased nitrogen and soluble phosphorus. Furthermore, some of the bacteria involved might be interacting on more metabolic levels i.e phosphorus solubilizes may also be active as auxin, IAA, gibberellins producers and N_2 fixers may also solublizer's phosphorus into a soluble form and also produced fungisatiac and growth promoting substances which influenced the plant growth favorably. The results obtained in present investigation are line with the finding of Kuswaha (2007).

VAM inoculation helps in uniform crop growth, increased yield of crop and also enhance resistant to root disease and improve hardness of transplant stock. So due to its obligatory symbiont nature and above discussed characteristics, VAM is only used in leguminous crops (Yawalkar et al., 1996). Significant increase of plant height, number of nodules (total and

effective) per plant, chlorophyll content, with VAM were mainly attributed to mobilization of phosphorus to plant which might have helped in easy uptake. The relatively higher availability of phosphorus in rhizosphere might have helped in *Rhizobium* activity and resulted in more number of nodules per plant. Similar results were also reported by Bahadur et al. (2006) in pea, Djebali et al. (2010) in common bean, pea, alfalfa and Ramana et al. (2010) in French bean and Patel et al. (2010), Kumar et al. (2012), Deshmukh et al. (2014) in clusterbean. who observed significantly higher plant height, root nodules and other growth attributes due to inoculation with VAM over uninoculated control. Inoculation of *Rhizobium* + PSB + VAM recorded highest growth parameters over all other treatments which may be due to combined effect of *Rhizobium*, PSB and VAM on crop. These findings corroborate the results of Ansari et al. (2015).

Effect of pgpm on yield and yield attributes : The number of pods per plant, number of seeds per pod, test weight, grain and straw yield were significantly influenced with the inoculations of PGPM and highest significant increase in yield and yield attributes were recorded with the application of *Rhizobium* over control (Table-2). The maximum number of pods per plant (30.12) was observed under the treatment P_3 (*Rhizobium* + PSB + VAM) and minimum number of pods per plant (24.90) under control (P_0). The increase in number of pods per plant was obtained to the extent of 15.42, 19.59 and 20.96 per cent at *Rhizobium*, *Rhizobium* + PSB and *Rhizobium*+ PSB + VAM respectively, over control (P_0). The results showed that number of seeds per pods of clusterbean significantly increased with inoculation of *Rhizobium* over control which was at par with *Rhizobium*+ PSB and *Rhizobium*+ PSB + VAM. The maximum number of seeds per pod (8.95) was observed under the treatment P_3 (*Rhizobium* + PSB + VAM) and minimum number of seeds per pod (7.55) under control (P_0). The increase in Number of seeds per pod was obtained to the extent of 12.45, 16.02 and 18.54 per cent with *Rhizobium*, *Rhizobium* + PSB and *Rhizobium*+ PSB + VAM respectively, over control (P_0). (Table no. 2). The test weight in the Table no. 2 showed that inoculation of clusterbean seed with *Rhizobium* + PSB + VAM resulted in maximum test weight over rest of the treatment, but statistically found to be appear with all treatments. The increased test weight was obtained to the extent of 1.96, 3.01 and 3.78 per cent with *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM respectively, as compared to control (P_0). The Seed and straw yield results revealed that seed and straw yield of clusterbean significantly increased with inoculation of *Rhizobium* over control which was at par with *Rhizobium* + PSB and *Rhizobium* + PSB + VAM. The maximum Seed

and straw yield (11.48 & 30.55 q ha⁻¹) was observed under the treatment P₃ (*Rhizobium* + PSB + VAM) and minimum seed and straw yield (9.92 & 26.33 q ha⁻¹) under control (P₀). The increase in seed and straw yield was obtained to the extent of 11.29, 8.16 & 14.21, 11.43 and 15.72, 13.44 per cent at *Rhizobium*, *Rhizobium* + PSB and *Rhizobium* + PSB + VAM respectively, over control (P₀).

Inoculation of seed with *Rhizobium* might have increased the concentration of an efficient and healthy strain of *Rhizobium* in rhizosphere, which in turn resulted in greater fixation of atmosphere nitrogen in soil for use by the plants and consequently resulting in to higher plant growth, which in turn resulted into higher production of assimilates and their partitioning to different reproductive structures such as yield attributes and ultimately, the seed yield increased. The increase in straw yield was the result of increased plant growth in terms of plant height, number of branches, due to over all better nutritional environments in the rhizosphere. Yadav and Malik (2005) and Kumawat *et al.* (2010) also reported similar results in cowpea and greengram and Kumawat and Khangarot (2002) also reported similar results in clusterbean. Inoculation of seed with PSB also significantly enhanced the yield and yield attributes. The beneficial effect of phosphate solubilizing bacteria as explained earlier increased the availability of phosphorus. Greater root extension under higher availability of phosphorus might have helped in greater uptake of other nutrients especially micronutrient and secondary nutrients, enhanced photosynthesis, production of photosynthates and their partitioning between vegetative and reproductive structure might have helped in improving the yield attributes (days to flower initiation, number of pickings, number of pods per plant, number of seeds per pod, fresh pod weight) finally the green pod yield. These findings corroborate the results of Yadav (2009) in pea, Nagar and Meena (2004) and Singh *et al.* (2012) in clusterbean.

VAM inoculation in soil significantly plays an important role in P cycling, mobilization and uptake by plants *i.e.* earlier P availability, greater root extension, higher nutrient uptake, higher photosynthesis and balanced portioning as discussed in previous section are the main factors of significant increase in yield attributes and yield. It is well established that pod yield of a crop is function of yield attributes. Increase in these yield attributes such as number of pods per plant, number of seeds per pod, pod length and fresh weight of pod due to different biofertilizers might have increased pod yield of pea. These findings corroborate the results of Ram *et al.* (2007) in chickpea, Sammuaria *et al.* (2009), Patel *et al.* (2010), Singh and Kumar (2016) in clusterbean crop.

Inoculation of *Rhizobium* + PSB + VAM recorded highest yield parameters over all other treatments which may be due to combined effect of *Rhizobium*, PSB and VAM on crop. These findings corroborate the results of Ansari *et al.* (2015).

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Study on Inter Cropping Systems on Nutrient Uptake, Profitability and Yield in Ajwain (*Trachyspermum ammi sprage*) Crop Production

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Abstract

A field experiment comprising 10 treatments viz., sole ajwain, sole french radish, sole knolkhol, sole fenugreek, ajwain intercropping with french radish, knolkhol and fenugreek in 1:1 and 2:2 row ratio was conducted in Randomized Block Design with four replications during *rabi* season, 2016-17 at research farm of ICAR-NRCSS, Ajmer. Intercropping of ajwain with French radish in 1:1 row ratio resulted significantly higher land equivalent ratio (1.81), ajwain equivalent yield (3274 kg/ha), gross return (Rs. 327388/- ha), net return (Rs. 270238/- ha) and BCR (4.72) followed by intercropping of ajwain with french radish in 2:2 paired row ratio. After Ajwain has been harvested, the residual availability of nutrients has been altered by the intercropping system's inclusion of legumes. After crop harvest, residual N, P, and K availability was considerably higher when Ajwain and fenugreek were interplanted in the ratios of 1:1 and 2:2. Thus, it can be concluded that intercropping Ajwain with french radish in a row ratio of 1:1 is preferable for achieving higher yield and profitability, whereas intercropping coriander and fenugreek in a row ratio of 1:1 can achieve higher residual availability of N, P, and K after harvesting the crop.

Key words : Ajwain, Intercropping, NPK fertilizer, Net returns, LER, yield.

Introduction

Ajwain (*Trachyspermum ammi sprague*) generally called as "Ajwain" belongs to the Apiaceae family. It is mainly grown in Rajasthan, Gujarat, Madhya Pradesh, Tamilnadu and Uttar Pradesh. Ajwain is an important seed spice crop of Rajasthan which. Area, production and productivity of Ajwain in Rajasthan are 0.06 lakh hectares, 0.04 lakh metric tons, and 680 kg/ha, respectively (Anon - 2015). Ahlawat and Gangaiah (2010) reported higher system productivity in chickpea intercropped with linseed over sole chickpea. Mustard and chickpea intercropping have exhibited higher land equivalent ratio (1.41) over in sole crops (Thomas *et al.*, 2010). Shortages of vegetables in the country have focused the attention on intercropping systems which have capacity to improve the physical, biological and chemical properties of soil (Mehta *et al.* 2010). Productivity of system can be enhanced with change in crop configuration for inclusion of other crops in the existing cropping system. Hence the study on effect of different inter cropping systems on nutrient uptake, yield and profitability in Ajwain (*Trachyspermum ammi sprage*) production was undertaken with an objective to find most efficient inter cropping system for realizing higher system productivity

Materials and Methods

The experiment was laid out at Research farm of

ICAR-National Research Center on Seed Spices, Ajmer, Rajasthan, during 'Rabi' season of 2016-17. The soil of research farm is sandy loam, poor in fertility and water holding capacity, having pH 8.3, and organic carbon 0.23 %, available N 100.38 kg/ha, P₂O₅ 7.76 kg/ha, K₂O 392.26 kg/ha.. The experiment comprising of 10 treatments viz., sole ajwain, sole French radish, sole knolkhol, sole fenugreek, ajwain intercropping with French radish, knolkhol and fenugreek different row ratios (1:1 and 2:2) was laid in randomized block design with four replications. As per technical programme one row of French radish, knolkhol and fenugreek was added between two rows of ajwain in 1:1 intercropping ratio and two rows of vegetable crops were added in a pair of two rows of ajwain (paired row having 25/35 cm). A uniform recommended dose of 60 Kg N and 40 kg P₂O₅ ha⁻¹ and 30 kg K₂O for sole ajwain, 120 kg N, 60 kg P₂O₅ and 40 kg K₂O for sole knolkhol, 100 kg N, 50 kg P₂O₅ and 40 kg K₂O for french radish and 20 kg N, 40 kg P₂O₅ and 30 kg K₂O for fenugreek was applied. In intercropping of ajwain and vegetables 100 % NPK of sole ajwain and 50 % NPK of respective vegetables were applied. 1/3 N and full dose of phosphorus and potash were applied at the time of sowing and remaining 2/3 N was applied with low pressure drip irrigation through urea at an interval of 8 days. The standard agronomic practices were applied for raising healthy ajwain crop as well as French radish, knolkhol and fenugreek. Immediately after sowing irrigation was

Table-1 : Effect of intercropping system on available NPK in soil after harvesting of crop.

Treatment	Available N	Available P ₂ O ₅	Available K ₂ O
Sole Ajwain	90.04	6.90	280.36
Sole French radish	89.34	6.85	255.67
Sole knolkhol	88.86	6.81	242.90
Sole fenugreek	91.22	6.97	286.33
Ajwain + French radish 1:1	88.53	6.83	253.65
Ajwain + French radish 2:2	88.38	6.81	250.07
Ajwain + knolkhol 1:1	87.60	6.79	240.10
Ajwain + knolkhol 2:2	87.33	6.77	238.45
Ajwain + fenugreek 1:1	90.09	6.92	282.52
Ajwain + fenugreek 2:2	90.08	6.90	281.20
Initial value	100.38	7.76	392.26
SEm	3.11	0.44	4.11
CD (P=0.05)	10.14	1.32	12.15

Table-2 : Effect of intercropping systems on yield of ajwain , inter- crops and ajwain equivalent yield.

Treatment	Seed yield of Ajwain (q/ha)	Seed yield of intercrops (q/ha)	Ajwain equivalent (q/ha)
Sole Ajwain	13.77	-	13.77
Sole French radish	-	274.30	21.94
Sole knolkhol	-	138.84	13.84
Sole fenugreek	-	273.39	21.87
Ajwain + French radish 1:1	12.21	256.61	32.74
Ajwain + French radish 2:2	11.18	254.70	31.56
Ajwain + knolkhol 1:1	11.90	121.79	24.09
Ajwain + knolkhol 2:2	10.94	113.76	22.32
Ajwain + fenugreek 1:1	11.69	246.53	31.42
Ajwain + fenugreek 2:2	10.63	237.75	29.65
SEm	4.8	-	0.89
CD (P=0.05)	14.1	-	2.58

provided with low pressure drip irrigation having normal operating pressure of 0.1 kg sq cm⁻¹. Available residual N in soil was determined by alkaline potassium permanganate method (Jackson, 1973), available P₂O₅ by Olsen *et al.* (1954) and available potassium by flame photometric method (Jackson, 1973.). Yield of component crop was calculated based on proportionate area occupied by them. The yield of ajwain, french radish, knolkhol and fenugreek was converted into ajwain equivalent yield as per prevailing rates in market and treatment evaluation was done accordingly. Economic analysis of the different treatment was done for drawing conclusion.

Results and Discussion

Effect of intercropping system on residual NPK

availability in soil after harvesting of crop : Different intercropping system significantly influenced the N, P and K availability in soil after harvesting of crops. Available N, P and K after harvesting of crops is less in all treatments as compared to initial value. Among different intercropping system available N, P and K after harvesting is more in intercropping of ajwain with fenugreek in both 1:1 and 2:2 ratio followed by intercropping of ajwain with knolkhol in both the ratio. Available N, P and K in all sole crops is higher compared to intercropping with respective vegetable crops. In comparison to respective sole crops, N, P and K availability after harvesting is less under different intercropping system which might be due to more extraction and utilization of these nutrients combinedly by ajwain and respective intercrops. Among intercropping systems, higher N, P and K availability in intercropping of

Table-3 : Effect of intercropping systems on gross return, net return, benefit cost ratio and land equivalent ratio.

Treatment	Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B : C ratio	LER
Sole Ajwain	53000	137700	84700	1.59	1.00
Sole French redish	61550	219440	157890	2.56	1.00
Sole knolkhol	64300	138440	74140	1.15	1.00
Sole fenugreek	66050	218712	152662	2.31	1.00
Ajwain + French radish 1:1	57150	327388	270238	4.72	1.81
Ajwain + French radish 2:2	57150	315660	258510	4.52	1.73
Ajwain + Knolkhol 1:1	58950	240890	181940	3.08	1.73
Ajwain + Knolkhol 2:2	58950	223160	164210	2.75	1.61
Ajwain + Fenugreek 1:1	60038	314224	254136	4.23	1.74
Ajwain + Fenugreek 2:2	60038	296500	236462	3.93	1.63
SEm	-	-	-	0.05	0.05
CD (P=0.05)	-	-	-	015	0.15

ajwain with fenugreek in both 1:1 row ratio and 2:2 paired row ratio might be due to more nitrogen fixation in nodules of fenugreek which after utilizing by fenugreek and ajwain, remain soil. Similar result has also been reported by Tanware *et al.* (2011).

Yield of main crop and intercrops : Seed yield of ajwain was recorded higher when grown as sole compared to inter cropping. Among intercropping systems, the higher seed yield of ajwain was obtained in intercropping of ajwain with french reddish in both 1:1 and 2:2 ratio. The higher yield of ajwain in sole crop might be due to no competition with other crops resulting in better growth, yield attributes and yield. Yield of intercrops was recorded higher in respective sole vegetable crops as compared to intercropping with ajwain. Further, perusal of data in Table 2 reveals that among different intercropping ratios, the higher yield of intercrops was exhibited in 1:1 ratio. Intercropping of ajwain + french radish in all the ratios resulted higher economic yield of french radish as compared to knolkhol and fenugreek. The higher yield of all the intercrops crops in 1:1 ratio was on account of higher plant population due to accommodation of more number of rows in between interspaces as compared to 2:2 ratio. Mehta *et al.* (2012 and 2015) also reported higher yield of intercrops in 1:1 row ratio with fennel.

Ajwain equivalent yield and Land Equivalent Ratio : Ajwain equivalent yield (AEY) and land equivalent ratio (LER) were significantly influenced with different inter cropping system. Significantly higher Ajwain equivalent yield and land equivalent ratio was recorded in intercropping systems as compared to sole cropping (Table 3). Ajwain + french radish in all ratios resulted higher AEY and LER as compared to its intercropping with

knolkhol and fenugreek. Further analysis showed that intercropping of Ajwain with all intercrops in 1:1 ratio proved superior resulting in higher AEY and LER over 2:2 ratio. The higher AEY and LER in intercropping system was on account of additional yield of intercrops without much reduction in yield of base crop. The highest AEY and LER in 1:1 ratio with french radish, knolkhol and fenugreek was due to proportionately less reduction in ajwain yield as compared with 2:2 ratio resulting in better yield of intercrop. Ahlawat and Gangaiah (2010) reported higher system productivity in chickpea intercropped with linseed over sole chickpea. Thomas *et al.* (2010) reported the highest LER of 1.41 in mustard and chickpea. Bhati (1992) reported higher fennel equivalent yield in intercropping as compared to sole crops. Intercropping over sole crops. Mehta *et al.* (2015) also reported higher fennel equivalent yield and LER in intercropping system over sole cropping.

Economic analysis : Gross return, net return and BCR are affected by different intercropping system. Intercropping of ajwain + french radish in 1:1 ratio exhibited significantly higher net return (Rs 270238/ha) and B: C ratio (4.72) which was 219.00 and 196 percent higher, respectively over sole ajwain. Intercropping of ajwain + french radish/knolkhol/fenugreek in 1:1 ratio proved superior which resulted in higher net return and B: C ratio over 2:2 ratio. Similar benefits of inter-cropping on economics in fenugreek + mustard was reported by Yadav *et al.* (2003). Khurana and Bhatia (1995) in intercropping of onion and potato with fennel and Ahlawat and Gangaiah (2010) in chickpea + linseed reported similar results.

Thus, it is inferred that intercropping of ajwain with

french radish in 1:1 row ratio is better for realizing higher yield and profitability but higher residual availability of N,P and K after harvesting of crop can be realized with inter cropping of coriander and fenugreek in 1:1

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Role of Information Communication Technology in Betterment of Youth Farming

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Abstract

Smallholdings in developing countries have long been associated with poor farming practices, intensive labour and low income, which make the sector unattractive to a new generation of farmers. Lack of youth interest and involvement in agriculture affects the sustainability and survival of family farms. This interest in farming is further strengthened by ICT providing access to markets and information to boost production. Researchers found that youngsters easily grasp the ICT applications, acquire information, and jump onto new market opportunities. Considering the above facts the present paper will address the issue of the role that ICT can play in invoking the interest of youth in farming.

Key words: ICT, youth, farming.

Introduction

Engaging youth in agriculture has been a prominent topic recently and has risen up the development agenda, as there is growing concern worldwide that young people have become disenchanted with agriculture. With most young people – around 85% – living in developing countries, where agriculture is likely to provide the main source of income it is vital that young people are connected with farming.

But ICTs play an increasingly important role in agricultural value chains. Though important, cellphones aren't the only ICT being used to improve agriculture. ICTs encompass radios, digital cameras, geographic information systems (GIS), cloud computing, tracking mechanisms, etc.

The increasingly important role of ICTs in agriculture can help change the face of the sector. In fact, it should form part of the larger thrust to attract more young people to the sector. ICTs offer employment opportunities in the sector that are both attractive to young people and are in demand.

Agriculture has an image problem. There is a decreasing interest among youth in entering agricultural related fields due to the persistent perception of agriculture as an outdated field with minimal financial returns. But it remains true that youth face large challenges accessing land and finance without collateral.

From a back breaking, hardly remunerative, labour consuming task to a much more profitable and honest source of income. Information and Communication

Technology (ICT) not only improves the status of young person's using it, but also of the farming sector in general. Youngsters who used to see farming as a type of last resort source of income without much perspective now see it as a potentially strong source of rewarding business.

ICTs can play a role in countering youth migration to urban areas by enhancing access to market information, production techniques, new technologies and financing opportunities. The use of ICTs enables choice, the option to stay on farms and take full advantage of new technologies and farming techniques, while incorporating valuable traditional practices and knowledge. Efforts should be aimed at further fostering youth involvement in agricultural activities and decision-making processes. These efforts can seize on the youth's affinity for using ICTs, their capacity to innovate and their propensity for taking higher entrepreneurial risks.

Challenges Hindering Youth Involvement in Agriculture (USAID)

Family and community pressures : In many rural agricultural communities, parents encourage their children to seek out alternate career paths that will take them away from the difficult, subsistence based lifestyle of working on the family farm.

Perceived lack of profitability : Youth do not believe farming is a profitable career path. The seasonality of planting and harvesting adds to this perception, given that profits from farming can come many weeks or months after large financial investments in inputs, machinery, or labor at the beginning of the season.

Access to land : land is a communal resource and must be passed down within a family, rented, or purchased. Though youth have opportunities to work on their parent's land, and family land is often subdivided among the children, youth are limited in their ability to access new or additional land to begin or grow their own farms.

Access to finance : Financial resources are required for both on- and off-farm pursuits. This is a challenge for all demographic groups, but particularly so for youth who often lack collateral or other requirements for accessing credit from a bank. Youth access to finance is thus typically limited to family or community resources.

Access to training, education, and information : Agricultural knowledge is often passed down generationally and within communities, but youth particularly demand new knowledge, access to improved technologies, and an understanding of how to apply advanced techniques or grow new crops. Without a structured system to provide youth with this knowledge, many seek out other career paths.

Attracting Youth

Right now, youth are the largest generation in human history, with half of the world's population younger than age 30, and 1.7 billion people aged 10–24 (USAID, 2012). Nearly 90 percent of the world's youth live in less developed countries, where two-thirds of the population lives in small farm households, working on land plots smaller than 2 hectares (UNFPA, 2014; Rapsomanikis, 2015). However, as youth seek out what they believe to be profitable and business-focused careers, they are increasingly turning away from agriculture. At the same

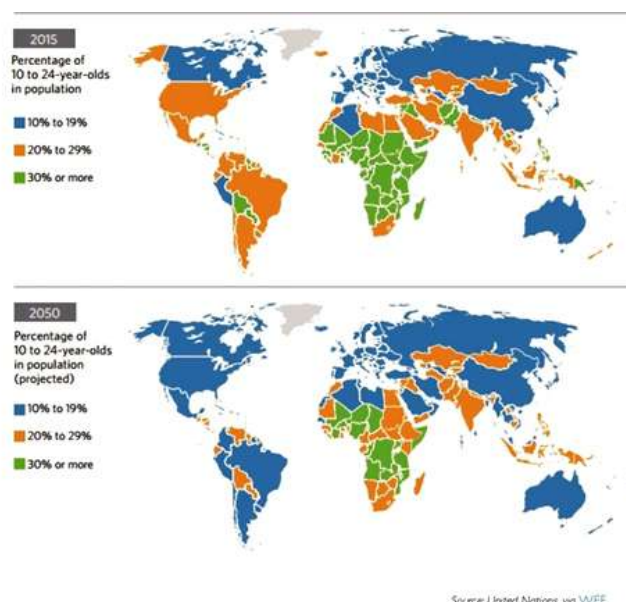
time, the average age of farmers is increasing. Globally, the average age of farmers is 60 years old, and young people are increasingly pursuing nonagricultural careers rather than following in the footsteps of their parents and grandparents (World Farmers' Organization, 2017). The major challenges that are holding back the youth from joining agriculture are access to land, financing, climate change, interest, market, sustainability, education and training, facility, policy and programmes, top-down approach and low service quality.

Working with youth and media to provide more interesting portrayals of agricultural careers is important, as is working with ICTs and social media to reach a broader respondent.

A study conducted by Corporate Communications - International Institute for Communication and Development (IICD) on SEPTEMBER 4, 2014 concluded that both perceptions and practice are positively conducive for ICTS to improve the farming practices among young farmers.

Based on the research, the study offers a number of recommendations :

- focus on young smallholder families who already made a conscious choice for farming and are likely to apply ICTs to their farming activities;
- differentiate and tailor ICT training approaches and user support on the basis of age, marital status, gender, and ownership of or access to land;
- pay attention to removing obstacles that prohibit young women from fully participating in, and taking advantage of, ICT-related activities;



Source: United Nations, via [WVE](#)

Fig.-1 : Young in the World: Changing Proportions in 2015, and 2050.

furnish ICT centres as learning spaces to support informal exchanges and networking by young farmers (male and female);

encourage the emergence of diverse early adopters and role models to inspire diverse profiles and groups of youths to follow suit;

consider strategies to diffuse integration of ICT from specific value chain crops to diverse crops and activities; and

Include ongoing monitoring, evaluation and learning activities as part of the programmes to identify unintended negative effects and undertake corrective action when necessary.

Education

The skills and competencies of agricultural graduates do not meet the needs of today's agricultural sector. Curriculum reform in tertiary level agricultural education is required to meet the demands of the labour sector, with particular attention to agribusiness and entrepreneurship, where many youth demonstrate an interest. Youth require a range of skills and competencies beyond their technical discipline, particularly those 'soft' skills such as communication, leadership and business skills. Reform of the agricultural curriculum must be a fully inclusive process which involves a wide range of stakeholders including youth.

Growth is contingent on countries with youthful demographics providing adequate education, training, and employment to its young citizens. Failing to do so could be risky, with a "lack of meaningful work among young people playing into frustration that has in some instances contributed to social unrest or unmanaged migration" (UNFPA, 2014).

With high unemployment rates globally and the lack of interest in traditional agricultural pursuits, a greater focus on entrepreneurship in agriculture is emerging. Entrepreneurship has the potential to contribute to the rejuvenation of the industry, creating more employment opportunities, increasing the potential for profit and moving away from the perception of agriculture as a low prestige career.

Making agriculture attractive

To increase the number of these young people and to make agriculture remunerative and attractive at the same time it is required to include agriculture in school curriculum, not just including but making it a compulsory subject is very important to get back the attention of the youth in agriculture. The stakeholders should employ enough programmes, projects and pilot studies including the youths in them to make them realise

the importance of agriculture but this should be done in an innovative manner as to gain their interest and attention. The youth should be made open-minded to accept any innovation in agriculture but at the same time critical enough to judge properly their applicability in their own situation. The colleges involved in agricultural studies must focus their resources on the needs of youth development and concentrate on giving a positive picture of agriculture to the youth.

The approaches should be made not on the basis of what the policy-makers think but what the youth think of their situation. Entrepreneurs in agriculture or agripreneurs should be encouraged to open new possibilities in the job sector in rural areas. The youth should be encouraged to come up with innovations that can make then early stagnant growth of agriculture to be accelerated. Providing vocational skills to rural unemployed youth would positively increase their self-confidence and also the condition of the agricultural sector.

Web tools such as blog, wikis, facebook, youtube, podcasting and social bookmarking. This can be a great tool for the youth to share their ideas and influence each other to contribute in the agriculture sector learning from each other's experience. Digital assistance should be provided to the farmers in agriculture and allied sectors. nearly all the people in the developing countries have a mobile phone and it is the youth who use them most. Many of the youth know how to surf the internet for information but don't know what to search for. These potentials should be utilized properly to attract the youth to agriculture. With all the proper and timely information, anyone can do wonders in agriculture if they are determined and hard working enough. These youths should be taught what great amount of information these devices hold and how their correct utilization can make them their own boss.

Youth and ICTs

There is a lot of concern about engaging youth in agriculture, in many ways, young people are not very much interested in continuing in agriculture because they don't see much prospect in the future of agriculture, they don't see it as an active profession in the long-run, so many of the smallholder farmers are quite aged. ICTs could provide new opportunity for making agriculture more interesting for young people.

Information and communication technologies (ICT) play acritical role in global development, and venues such as libraries, Village Resource Centres, Community Information Centres, Village Knowledge Centres, telecentres and cybercafés, which offer public access to ICT,

can make ICT accessible to broader sectors of the population. This broader access to ICT can have positive consequences to the social and economic development of marginalized and underserved populations and help bridge the so-called digital divide (Barzilai-Nahon et al., 2009, Warschauer, 2003).

Another mode of access of information in developing countries is the mobile phones. Some have called 2011 the “year of the mobile”. As an affordable and accessible means of communication, rural communities and development workers are realizing the potential of mobile telephony to create economic opportunities and strengthen social networks (Farming First. 2012). Its access, use and ownership are increasing rapidly in the developing countries, especially in South-east Asia and Sub-Saharan Africa. According to a study carried out by the Centre for Economic Policy Research and Vodafone, it is estimated that a staggering 97% of the population are able to access a mobile phone. The growing number of people using mobile phones has led to optimism and speculation regarding its effect on economic and social development. Expectations from mobile phones are high and it has already been coined as Africa’s PC (Rodrigo, 2011)

The increased use of mobile phones in farming can also help deter young people away from stereotypes of traditional farming and help change their perceptions on agriculture, helping them to view it as an exciting and innovative industry.

A chance to make a difference

Farming offers the young generation a chance to make a difference by growing enough food to feed the world.

To help youth see the value and potential of pursuing a career in agriculture Shift the perception of farming within rural families and communities, Expose youth to agriculture early on, incorporating all aspects of the value chain (rather than just farming), increase profitability and productivity of farming, Engage youth in solving agriculture problems.

Access to information does not define itself only in terms of access to different technologies and media, but must take into account the nature and type of information youth need for full participation in society (UNESCO, 2011). Information related to weather forecasts, package of practices, technological innovations, varieties released, market prices, *etc.* are mostly coveted by the farming community. But just providing Information is of no use. Content validity in farmer’s own condition is also very important. Localised information is more welcome in the field condition, specifically in rural areas and to the small

and marginal farmers who dominate the agricultural scenario in the developing countries. And for that reason, ‘community managed location specific’ information services should be started. The information in the web portals should have a very good feedback mechanism so that the users, specially the farmers can give their views and also share their knowledge through the Content Management System (CMS) which will be validated by the concerned personnel. In case of the mobile based services, the feedback of farmers should be taken immediately and after an interval of a week or fortnight to know the utility of information provided and valid suggestions should be updated in the database which would help the other stakeholders. Moreover, in this way the farming community will develop a sense of belonging for the ICTs and utilize them better.

In the far-flung corners of India, ICTs are doing wonders with the help of the rural youths. One of the remotest parts of the least developed North East India has seen computers and touch screen kiosks deliver agriculture related information where the people hardly had access to even electricity. Projects like e-Arik, e-Agri Kiosk and e-Village has solved much problems of the farming by using rural tribal youth as intermediaries along with ICTs and project also attracted considerable number of youth towards the modern agriculture (www.earik.in).

Those who become farmers now have the opportunity to be the generation that end world hunger and alleviate malnutrition, as well as helping the sector adapt to climate change.

Conclusion

ICTs can play an important role in modernizing farming practices, incorporating elements of precision agriculture, and introducing new, innovative techniques to speed up and increase production and Youth bring an innovative, tech-savvy perspective to solving some of the most difficult problems in agriculture, and they are eager to apply their technology skills to create change in their communities

There are many challenges ahead for the sector but if young people are offered education in agriculture, a voice at policy level, and in the media, and are engaged with innovations then the agriculture industry can attract youth again. As we look to find solutions to feeding a world of nine billion people by 2050, it is this new generation that – working together – can help to achieve global development. A responsible agriculture, meeting global food security needs without depleting its resources, can only become a reality if young professionals are actively engaged in shaping the sector’s future.

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Mepiquat Chloride's Ability to Control Plant Development is Evaluated in Relation to Brinjal (*Solanum melongena* L.) Fruit Quality and Yield

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Abstract

During the 2015 rainy season (kharif), a field experiment was conducted at the Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Sciences, Banaras Hindu University, Varanasi. The goal of the current study was to determine how mepiquat chloride affected the yield and yield characteristics of the New Kiran brinjal variety. An experimental design with randomised blocks was used. Mepiquat chloride solutions at concentrations of 1350 ppm, 1700 ppm, and 3400 ppm were foliar sprayed on brinjal plants. In addition to the three concentrations, the foliar spraying schedule included I the first spraying at the beginning of flowering followed by (ii) the second treatment at the same dose after fifteen days following the first spraying. After fifteen days, a second spraying occurs after the first flowering. The current study also intends to determine the stage of the plant and mepiquat chloride concentration to have the highest yield and greatest fruit quality of the brinjal variety New Kiran. Among the concentrations, 3400 ppm concentration under T3as against control yielded the highest number of fruits per plant (16.88), length of fruits (17.61cm), diameter of fruits (5.07 cm), weight of five fruits (477g), weight of fruits per plant (1.25 kg), weight of seeds per plant (60.60 g), and total soluble solids (5.40%). (T8). Similarly large increases were observed in the number of fruits per plant, fruit length (cm), fruit diameter (cm), fruit weight (kg), fruit seed weight (g), and total soluble solids.

Key words : Plant growth regulator, mepiquat chloride, randomized block design.

Introduction

India is the second largest producer of vegetables in the world next to china. Brinjal (*Solanum melongena* L. 2n=24) is third most important vegetable crop after potato and tomato. Brinjal is an economically important vegetable crop widely cultivated in the tropics, subtropics and warm temperate regions. In India, it is one of the most common, popular and principal vegetable crops grown throughout the country. Thompson and Kelly (1957) distinguished 3 botanical varieties of *Solanum melongena* i.e., (1) variety esculentum, the common round fruited (2) variety serpentinum, long and slender fruited and (3) variety depressum with small pear shaped fruits on dwarf spreading plants of quick maturity.

The food value of brinjal is quite high. It contains protein (1.4 g), fat (0.3 g), minerals (0.3 g), fiber (1.3 g), calcium (18 mg), magnesium (16mg) and phosphorus (47 mg) and vitamin A (124.14) per 100 g of edible fruit. (Zenia and Halim, 2008).

Indian agriculture is becoming more industrialised, and advances in science have expanded the options for using inputs to boost output and food safety. Plant growth regulators, which can be either promoters or retardants,

are important for directing a plant's internal mechanisms by interacting with crucial metabolic processes such as protein synthesis and nucleic acid metabolism. They might be a good substitute for raising agricultural yield. Recently, the significance of PGRs in raising crop output has come to the attention of the entire world. Plant growth regulators are less time-consuming and have an immediate influence on crop development programmes.

Growth retardants are natural or synthetic chemical substances which are directly applied to crops to alter some structural processes. It is expected that these alterations modify hormonal balance and growth, leading to increased yield, improved crop quality or facilitated harvesting. Plant growth regulators (PGRs) have a particularly interesting role in modern agriculture (Ashraf *et al.* 2010). Thereby increased total dry mass of a field crop (Chibu *et al.* 2000, Dakua 2002, Islam 2007, Cho *et al.* 2008). Growth and yield potential of brinjal can be improved with the adoption of scientific cultivation technology including use of plant growth regulators.

Materials and Methods

The current study was conducted in 2015 during the rainy season (kharif) at Banaras Hindu University's Vegetable

Table-1 :

Treatment	No. of fruits per plant	Length of fruits (cm)	Diameter of fruits (cm)	Weight of five fruits (g)
T ₁	9.73	12.65	2.78	307
T ₂	12.58	14.17	3.36	373
T ₃	16.18	17.61	5.07	477
T ₄	9.33	12.38	2.73	303
T ₅	12.51	14.10	3.26	362
T ₆	15.62	17.54	5.03	460
T ₇	14.33	15.14	3.91	427
T ₈	8.66	10.99	2.66	273
SE m ±	0.37	0.16	0.08	9.86
CD 5%	0.71	0.44	0.25	29.93

Table-2 :

Treatment	Weight of fruits per plant (g)	Yield per plot (kg)	Weight of seeds per plant (g)	Total Soluble Solids (%)
T ₁	0.86	9.567	42.60	5.15
T ₂	1.10	11.400	52.59	5.21
T ₃	1.25	15.483	60.60	5.40
T ₄	0.77	9.067	42.00	5.12
T ₅	1.01	11.160	52.20	5.14
T ₆	1.24	14.963	59.00	5.35
T ₇	1.12	12.633	55.00	5.20
T ₈	0.66	7.433	36.60	4.80
SE m ±	0.01	0.15	1.42	0.05
CD 5%	0.05	0.46	3.06	0.16

Research Farm, Department of Horticulture, Institute of Agriculture Sciences, and Varanasi. The Vegetable Research Farm, which is geographically located at 25° 15' North latitude and 83° 03' East longitude, is located approximately 10 kilometres from Varanasi Railway Station in the city's South-Eastern direction. The area is located at a height of roughly 123.23 metres above mean sea level. Varanasi is located in the eastern region of Uttar Pradesh, in the middle of the north alluvial plain, on the left bank of the Ganges. It has a humid subtropical climate with significant seasonal temperature variations, such as extremely hot summers.

The experiment included eight treatment combinations with mepiquat chloride concentrations (T₁, T₄, T₇ 1350 ppm), (T₂, T₅ 1700 ppm), (T₃, T₆ 3400 ppm), and (T₈) water spray (control) as well as plant stages (T₁, T₂, T₃) at the beginning of flowering, (T₄, T₅, T₆) at fifteen days after the beginning of flowering, and (T₇) first spraying at the beginning of flowering followed by second spray. The experiment was set up using a factorial approach and randomised block design with three replications each with 24 plots. In the well prepared beds, healthy seedlings were implanted. There were 12 plants per bed, with a 60 cm between rows and 45 cm between individual plants. The entire experimental area could fit the 288 plants in total.

Results and Discussion

Plant growth retardants are supposed to play a significant role in agriculture and horticulture in order to increase production. Thousands of synthetic chemicals are known that can retard the plant height. Muradi *et al.* (2003) reported that chlormequat treatments on mogra (*Jasminumsambac*) were effective in suppressing apical dominance, thus promoting the growth of axillary buds into new stems. Retarding of plant height and formation of lateral branches considerably increased the flowers and fruit bearing sites.

Number of fruits per plant after application of different concentrations of mepiquat chloride : Mehrotra *et al.* (1970) reported that the chlormequat at 500 ppm, increased the yield and fruit number per plant in okra. Number of fruits per plant was significantly improved by different treatments over control Table-1. The highest (16.18) number of fruits per plant was noted with T₃ followed by T₆ (15.62), T₇ (14.33), T₂ (12.58) and T₅ (12.51). However, T₄ and T₁ remained comparable with each other. The lowest (8.66) number of fruits per plant was recorded with T₈ (control).

Length of fruits (cm) after application of different concentrations of mepiquat chloride : treatments significantly outperformed the control. It was the least

manageable (T8), the greatest (17.61 cm), T1 and T4 did not significantly differ from one another, though. T2 and T5 were discovered to be on par with one another. T3 and T6 were shown to be equal, whereas T6 was statistically superior to T7. 60 cm and 45 cm between plants

Diameter of fruits (cm) after application on different concentrations of mepiquat chloride : The statistics in Table-1 make it clear that all treatments had a significant impact on fruit diameter when compared to the control. Fruit's diameter was measured with T3 and was the biggest (5.07 cm), while it was the lowest (2.66 cm) under control. T2 (3.36 cm), T7 (3.91 cm), T6 (5.03 cm), and T5 were the next to arrive (3.26 cm). T1 and T4 did not, however, significantly differ from one another.

Weight of five fruits (g) after application of different concentrations of mepiquat chloride : Shriram and Prasad (2001) reported that in cotton, application of 50-ppm chlormequat chloride increased number of bolls per plant, with an average weight per boll and seed yield. A perusal of data in given in table-1 reveals that all treatments were significantly superior to control. The highest (480 g) weight of five fruits were recorded with T₃ which was followed by T₆ and T₇. Never the less T₆ and T₇ did not show any statistical difference between then. Similarly, T₂ and T₅ remained at par with each other. However, T₃ gave significantly more weight of fruits over T₁. The lowest (270 g) weight of five fruits noted under T₈ (control).

Weight of fruits per plant (kg) after application of different concentrations of mepiquat chloride : The treatments significantly outperformed the control. T3 had the most fruits per plant (91.25 kg), followed by T6 (1.24 kg), T7 (1.12 kg), T2 (1.10 kg), and T5 (1.01 kg). T4 (0.75 kg) and T1 (0.86 kg) did not significantly differ from one another, though. T2 (1.10 kg) and T7 (1.127 kg) were comparable to one another as well. T8 plants had the fewest fruits per plant (0.66 kilogramme) on record (control). examination of the information in Table-1 reveals that it

Yield per plot (kg) after application of different concentrations of mepiquat chloride : Shekoofa and Emam (2008) reported that although both cycocel and ethephon application increased the grain yield of winter wheat plants but the highest grain yield was obtained in the plots treated with cycocel. It is evident from data presented in Table-2 that all the treatments remained significantly superior to control. The highest (15.48 kg) yield per plot was recorded with T₃ which was statistically significant over other treatments. Similarly, T₆ produced more yield per plant as compared to T₇, T₂, T₅, T₁ and T₄. However, T₂ and T₅ did not differ significantly between

themselves. Further, it was discovered that T₇, show significantly more yield over T₇, T₅, T₃ and T₄. Similarly, T₁ was significantly superior to T₄. The lowest (7.43 kg) yield per plant was recorded under control.

Weight of seeds per plant (g) after application of different concentrations of mepiquat chloride : The seed yield was highest with application of 1000 ppm cycocel at flower initiation stage in safflower (Kanade *et al.*, 2002). The data presumed in Table-2 clearly reveal that all treatments were found significantly superior to control. The highest (60.60 g) weight of seeds per plant was noted with T₃ followed by T₆ (59.00g), T₇ (55.00 g.) T₂, (52.59g.) and T₅ (52.20 g.). Never the less, T₆ (59.00g) and T₃ (60.60 g) did not differ significantly between themselves. Similarly, T₅ (52.20g), and T₂(52.59g), were found at par to each other. The lowest (36.60 g.) weight of seeds were under (control).

Total Soluble Solids (TSS) after application of different concentrations of mepiquat chloride : The statistics shown in Table-2 clearly demonstrate that all treatments were superior to the control in a significant way. T3 had the highest amount of total soluble solids (5.40%), followed by T6 (5.35%), T2 (5.21%), T7 (5.20%), and T5 (5.14 percent). T3 and T6 did not, however, significantly differ from one another. T1, T2, T4, T5, and T6 were discovered to be on par with one another. T8 was used to determine the minimum (4.80 percent) total soluble solids of fruits (control).

Conclusion

The use of mepiquat chloride (3400 ppm) at the beginning of the plant's flowering stage was found to be the best treatment because it resulted in the highest yield per plot (kg), weight of seeds per plant (g), and total soluble solids (percent) while also producing the most fruits per plant (g), length of fruits (cm), diameter of fruits (cm), weight of five fruits (g), and weight of fruits per plant (kg). However, the control treatment.

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IMPACT ASSESSMENT OF IRRIGATION ON SUGARCANE CULTIVATION IN ANDHRA PRADESH, INDIA

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ABSTRACT

The present study was an attempt to estimate the impact of irrigation factor on sugarcane cultivation in Andhra Pradesh for the period 2020-21. The data on various aspects of costs and returns involved in crop along with constraints collected from farmers based on multistage sampling. Budgeting techniques, Cost Concepts, Benefit Cost Ratio (BCR) and Bisliah model of Yield gap Analysis were employed for achieving objectives. The results revealed that Benefit Cost Ratio (BCR on Operational Cost) is higher for plant crop in rainfed (1.01) than irrigated (0.99). There was a 44.82 % yield gap between irrigated and rainfed, in which input usage (24.75%) had higher effect than cultural practices (20.07%). So, irrigated sugarcane method is a more remunerative, yields can be sustainable if irrigation is assured with proper package of practices.

Keywords : Sugarcane, Yield gap analysis, Irrigation, Srikakulam, Vizianagaram, Visakhapatnam, North Coastal Zone Andhra Pradesh

During 2020, the area under sugarcane in world was 26.47 million hectares (mha) with production of 1869.72 million tonnes (mt) recorded yield was 70.64 tons per hectare (t/ha). Brazil stands first place in area and production of 10.01 mha and 757.12 mt with yield 75.6 t/ha (FAO, 2021). The area under sugarcane in India has steadily increased from 2.21 mha in 1931 to 3.28 mha in 1987-88 and to 5.06 mha in 2018-19 and it was decreased to 4.85 mha during 2020-21 contributing 405.4 mt. As per the 4th advance estimates for the year 2021-22, total production of sugarcane is 431.81 million tonnes. Uttar Pradesh ranked first in terms of area under sugarcane with 2.18 mha (44.94%) with a production of 179.5 mt (48.46%) (Department of Agriculture and Farmers Welfare, Annual report 2020-21).

In Andhra Pradesh, the average area under sugarcane was 1.22 Lakh Hectares (Lha) in 2015-16 and it was decreased to 0.86 Lha in 2019-20. In North Coastal Districts of Andhra Pradesh, the area under sugarcane is about 0.75 Lha during the year 2006-07 and it was decreased to 0.45 Lha during the year 2019-20 (Agricultural Statistics at a Glance, 2019-20).

Among the six Agro-Climatic Zones (ACZs) in Andhra Pradesh, North Coastal Zone (NCZ) is the major sugarcane growing Zone (nearly 50% of the area). The yields of sugarcane in North Coastal Zone is stagnant since last two decades (hovering between 75 to 80 tonnes per hectare). This was mainly because of the more area under rainfed condition (Nearly 40%) where average yield is 40 to 45 t/ha. To know the impact of irrigation on yield

-gap, present study was taken up with following objectives.

- (1) To work out costs and returns in different methods of cultivation.
- (2) To assess the most important factors effecting the production in in different methods of cultivation.
- (3) To assess the impact of irrigation in yield gap between irrigated and rainfed method of cultivation.

MATERIALS AND METHODS

The study was conducted during 2020-2021. Multistage sampling technique was adopted in selecting the sampling units at various levels. In order to assess the impact of irrigation, the sugarcane cultivation was classified as irrigated and rain-fed. In irrigated condition the water source is assured through irrigation, whereas in rain-fed condition crop is totally depend on rainfall for irrigation sources. Andhra Pradesh comprises of six Agro-Climatic Zones (ACZs). North Coastal Zone (NCZ) was selected based on highest area criteria. NCZ comprises of three districts Viz., Srikakulam, Vizianagaram and Visakhapatnam. From each district two mandals (one each for irrigated and rainfed) and from each mandal two villages (one each for irrigated and rainfed) were selected based on highest area criteria. Twenty farmers were selected at random from each village. Sampling design was one state, three district, six mandals, 12 villages and 240 farmers (120 each for irrigated and rainfed conditions).

Analytical tools : Apart from budgeting techniques and cost concepts following were employed :

(1) Benefit Cost Ratio (BCR): It is calculated as Gross returns accrued divide by total cost incurred on i^{th} enterprise by j^{th} farmers as given below :

$$BCR_{ij} = \frac{GR_{ij}}{TC_{ij}}$$

(2) Decomposition of sources of yield gaps : The following Cobb-Douglas type of production function was fitted to identify the most important factors effecting the production in both Irrigated and Rain fed method of cultivation;

$$Y = a_0 H^{a_1} M^{a_2} N^{a_3} P^{a_4} S^{a_5} e^u$$

Where,

Y = Out put of main produce (quintals) per hectare

a_0 = Intercept

H = Human labour (man-days) per hectare

M = Manure (quintals) per hectare

N = Nitrogen (kg) per hectare

P = Phosphorous (kg) per hectare

K = Potassium (kg) per hectare

S = Seed rate (kg) per hectare

e^u = Error term

a_1 to a_5 are the elasticities of production

Then, to examine the structural break in production relations in irrigated and Rainfed sugarcane the above equation was estimated by the Ordinary Least Square (OLS) technique as follows;

$$\log Y_1 = \log a_0 + a_1 \log H_1 + a_2 \log M_1 + a_3 \log N_1 + a_4 \log P_1 + a_5 \log S_1 + a_6 \log I_1 + U_1 \dots (1)$$

$$\log Y_2 = \log b_0 + b_1 \log H_2 + b_2 \log M_2 + b_3 \log N_2 + b_4 \log P_2 + b_5 \log S_2 + b_6 \log I_2 + U_2 \dots (2)$$

Where, Y_1 and Y_2 are yield levels on rainfed and irrigated method plots respectively. The inputs have the symbols as stated above along with associated coefficients. The combination of different resources to yield gap was estimated with the Decomposition model (Bisaliah, 1977). The following functional forms specified as Eq (1) and (2) above mentioned were used.

$$\log (Y_2/Y_1) = [\log (b_0/a_0)] + [(b_1-a_1) \log H_1 + (b_2-a_2) \log M_1 + (b_3-a_3) \log N_1 + (b_4-a_4) \log P_1 + (b_5-a_5) \log S_1 + (b_6-a_6) \log I_1] + [b_1 \log (H_2/H_1) + b_2 \log (M_2/M_1) + b_3 \log (N_2/N_1) + b_4 \log (P_2/P_1) + b_5 \log (S_2/S_1) + b_6 \log (I_2/I_1)] + [U_2-U_1]$$

This equation involves decomposing the yield gap.

The summation of 1st and 2nd bold bracketed term on the right hand side of equation represents the yield gap, attributable to the difference in the cultural practices. The 3rd term represents the yield gap attributable to the difference in the input use (input gaps) between irrigated method and rainfed method. The last term takes care of the random disturbance.

RESULTS AND DISCUSSION

(I) Comparative Costs and returns in cultivation of Irrigated and Rain fed Sugarcane : Table-1 reveals that the total cost of cultivation per hectare irrigated conditions; in plant crop was ₹ 2,67,628 with working cost was ₹ 1,87,188 (69.9% of total cost), in ratoon crop was ₹ 1,97,915 with working cost was ₹ 1,37,469 (69% of total cost). Under rainfed condition; in plant crop, cost of cultivation was ₹ 1,83,428 with working cost ₹ 1,32,956 (72.5 % of total cost), in ratoon crop, cost of cultivation was ₹ 1,08,976 with working cost ₹ 88,863 (81.5 % of total cost). In terms of percentages working cost is higher in rainfed sugarcane. Out of the total operational cost, under irrigated conditions, 74% (₹ 1,38,820) was incurred on labour charges and 26% (₹ 48,670) was spent on materials in plant crop, where as, in rainfed condition 69% (₹ 91,740) was incurred on labour charges and 31% (₹ 41,216) was spent on materials. This shows the labour-intensive nature of sugarcane under irrigated conditions. Among the working costs, in irrigated plant crop, harvesting and transport charges was highest ₹ 68,875 (36.8%), followed by seed material and planting ₹ 29,656 (15.8%), TT Propping ₹ 21,563 (11.5%) *etc.* Similar kind of trend was noticed in all other methods. Whatever may be the method the higher costs were incurred on labour related activities than material related. That shows the labour intensive nature of sugarcane cultivation.

Rao (2012) reported that during 2008-09, operational cost of cultivation (per ha) of sugarcane in Visakhapatnam district was ₹ 90,939. In present study operational cost of cultivation (per ha) of sugarcane in NCZ (Visakhapatnam district is part of that) was ₹ 1,87,188. Thus, there was increase of ₹ 96,249 per hectare *ie.*, 106 per cent in 12 years. The major contributor for this increase was labour wages. Between these 12 years, labour wages (on an average) increased from ₹ 120/- to 375/- *ie.*, more than 3 times.

(2) Comparative resource use pattern in cultivation of irrigated and rainfed Sugarcane : The per hectare productivity (t/ha^{-1}) under irrigated and rainfed condition was 7.25 and 5.0 (Table 2). There was 44.8 % higher yield in under irrigated than rainfed condition. Except

Table-1 : Comparative cost of cultivation (per Ha) of irrigated and rainfed Sugarcane in 2020-21.

Particulars	Irrigated		Rainfed	
	Plant	Ratoon	Plant	Ratoon
Land preparation/Stubble Shaving	9,844	5,000	9,844	2,925
Furrow preparation	4,750		4,750	
Seed material/Gap filling	23,156	3,563	17,813	3,562.5
Cutting and Transplanting cost	6,500		4,688	
Manures and fertilizers Application	22,500	25,500	18,075	16400
Weeding & Plant protection	20,000	17,500	11,850	9825
Irrigation	10,000	4,000	1,950	1950
TT propping (3 times)	21,563	20,156	17,738	16200
Harvesting & transportation	68,875	61,750	46,250	38000
Working cost	1,87,188	1,37,469	1,32,956	88,863
Interest on working capital	20,591	7,876	7,617	5091
Operational cost	2,07,778	1,45,345	140,574	93954
Depreciation	4,563	3,438	2,138	1812.5
Land cess	750	750	500	200
Rental value of Own land	48,125	42,750	35,625	11400
Interest on fixed capital	6,413	5,633	4,592	1610
Fixed costs	59,850	52,570	42,854	15022
Total cost of cultivation	2,67,628	1,97,915	183,428	108976
Gross Returns	2,06,625	1,85,250	142,500	121125
BCR on OC	0.99	1.35	1.01	1.29
BCR on TC	0.77	0.94	0.78	1.11

Table-2 : Comparative resource use between irrigated and rainfed Sugarcane (per Ha).

S. No.	Resource Particulars	Units	Irrigated		Rainfed	
			Plant	Ratoon	Plant	Ratoon
1.	Human Labour	Mandays	468	262	245	137
2.	Manure	Quintals	125	7.5	50	3
3.	Nitrogen	Kilograms	178	253	158	225
4.	Phosphorus	Kilograms	168	58	149	51
5.	Potassium	Kilograms	50	25	75	45
6.	Seed Rate	Kilograms	8,750	500	7,500	429
7.	Productivity	Quintals/hectare	725	650	500	425

potassium, all the resources use was higher in irrigated condition than rainfed condition. This was reflected in the cost of cultivation of sugarcane. Usage of potassium higher in rainfed condition is because of potassium gives the crop resistance to drought condition.

(3) Production function estimates in cultivation of irrigated and rainfed Sugarcane : The Cobb-Douglas type of production function was fitted to the observations for the estimation of elasticities of important variables contributing to the yield of sugarcane plant crop in both irrigated and rainfed conditions (Table-3). The analysis of variance in respect of the production function showed significant variance indicating the overall significance of estimated production function. The value of coefficient of multiple determinations (R^2) in irrigated condition was 0.81, which suggest that the six resources included in the production function had jointly explained as high as 81% of total variation. R^2 was 0.69, in rainfed method, which suggests that the six resources included in the production function had jointly explained as high as 69% of total

variation. That shows the variables taken into consideration were crucial factors in irrigated than in rainfed conditions. This is because irrigated sugarcane is being in more under controlled conditions than rainfed, which is vulnerable to natural vagaries.

Except, seed rate under rainfed condition all other variables found significant. Negatively significant was noticed in Phosphorous in rainfed condition and Potassium in irrigated condition. Coefficients of all variables are higher in irrigated than rainfed except Human Labour and Potassium. That shows the more response of rainfed sugarcane for Potassium than other nutrients in comparison with irrigated conditions.

(4) Sources of yield gap between Irrigated and Rain fed Sugarcane : The decomposition analysis of yield gaps showed the 44.82% of the potential farm yield of sugarcane left untapped owing to rainfed method of cultivation (Table-4). Among the different sources of yield gap, input usage (24.75%) turns out to be major contributor than cultural practices (20.07%). This shows

Table-3 : Cobb-Douglas production function estimate for Irrigated and Rain fed Sugarcane (plant crop).

S. No.	Particulars	Method of Cultivation	
		Irrigated	Rainfed
1.	Human Labour (X_1)	0.62*	1.18*
2.	Seed Rate (X_2)	0.39*	- 0.13
3.	Manure (X_3)	0.51**	0.39**
4.	Nitrogen (X_4)	0.46**	0.32*
5.	Phosphorus (X_5)	0.20*	-0.01**
6.	Potassium (X_6)	-0.10*	0.29**
7.	Intercept	- 2.39**	-2.48**
	R^2	81	69
	F Value	228	318

Note : (1) * and ** indicates significance at 5 and 1 per cent respectively.

(2) Figures in parenthesis are standard errors for the respective regression coefficients.

Table-4 : Decomposition of yield gap between Irrigated and Rain fed sugarcane (plant).

S. No.	Sources of Difference	%
A.	Total	44.82
1.	Cultural Practices	20.07
2.	Input Usage	24.75
	(a) Human Labour (X_1)	3.97
	(b) Seed Rate (X_2)	9.73
	(c) Manure (X_3)	12.19
	(d) Nitrogen (X_4)	-1.63
	(e) Phosphorus (X_5)	-2.25
	(f) Potassium (X_6)	2.74

that irrigation is an important factor in the sugarcane cultivation. In input usage manure turns out to be very crucial factor. In the raw data also wherever manure was applied more than 15 t/ha⁻¹, the yield was more than 90 t/ha⁻¹. The next important factors are potassium and labour. But, Nitrogen (-1.63) and Phosphorous (-2.25) contributed negatively to the usage shows that there was higher usage of these nutrients than requirement. Thus, increase in dose of Nitrogen and Phosphorous automatically results in input usage negative effect and results in decrease in yields. Through appropriate usage of inputs can reduce the yield gap between rainfed and irrigated method to the tune of 44.82 per cent.

Rao (2012) by using the Bislahi (1977) model of decomposition, estimated that yield gap between irrigated and rainfed method of sugarcane was 67.79 %, in which input usage (41.86%) had higher role than cultural practices (25.93%). Similar trend was noticed in the present study; with less magnitude, where yield gap was 44.82%, in which input usage (24.75%) had higher role than cultural practices (20.07%).

CONCLUSIONS

1. Higher return on Investment in ratoon crop than plant crop.

2. Most important factor under rainfed and irrigation conditions were human labour.

3. There was 44.82% of yield gap between irrigated and rainfed; in which, 24.75% and 22.07% were contributed by in-put use and cultural practices respectively.

POLICY IMPLICATIONS

(1) There was a higher yield in plant crop than ratoon crop. But, BCR was higher for ratoon crop. That is why farmers are going for ratooning continuously and average yields are decreasing. So, to increase yields farmers should be encouraged to take-up fresh plantings after one or two ratoons. Otherwise seed material should be supplied at subsidized rate.

(2) Input use (24.75%) is major contributor for yield gap than Cultural practices (20.07%) between irrigated and rainfed method, reveals that by proper use of irrigation water and inputs the yields can be increased by another 44.82%.

(3) The major constraint in sugarcane cultivation is Labour shortage necessitates the urgency of mechanization in sugarcane.

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Relational Analysis of Selected Entrepreneurial Characteristics of Oil Palm Growers with the Profitability

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Abstract

Correlation analysis revealed that training received, market orientation, management orientation, socio-economic, status were positively and significantly related with profitability at 1 per cent level of significance. Achievement motivation, extension contact, education and innovativeness were shown positive and significant relation with profitability at 5 per cent level of significance. Multiple regression analysis revealed that all the independent variables put together explain the variation on extent of 49.34.

Key words : Profitability, entrepreneurial characteristics, oil palm.

Introduction

Oil palm is the crop of present and future vegetable oil economy of world as well as India. Palm oil has good consumer acceptance as cooking oil because of its price advantage. It is good raw material for manufacturing oleo chemicals used in making soaps, candles, plasticizers, etc. It has also a variety of uses ranging from edible oil, cosmetics, pharmaceuticals, to bio fuel to bio lubricants. The present study was conducted with main objective of studying the farming performance of oil palm growers in terms of profitability and entrepreneurial characteristics and how their entrepreneurial characteristics are influencing the profitability.

Materials and Methods

Ex post facto research design was followed in present investigation. East Godavari, West Godavari and Krishna districts were selected from Krishna-Godavari zone for investigation on the basis of highest coverage of the area under oil palm cultivation. Two mandals from each district, two village from each mandal thus 12 villages were selected from three districts randomly. A total of 180 oil palm growers from each village were selected randomly. Fifteen independent variables and five components of farming performance index were identified for the study. Data were collected from the respondents face to face through pre-tested structured interview schedule individually.

Results and Discussion

Correlation and prediction of contribution of selected entrepreneurial characteristics of Oil palm growers with the profitability

Correlation between selected entrepreneurial characteristics with the profitability

Null hypothesis : There will be no significant relationship between the scores on entrepreneurial characteristics and the scores on profitability.

Empirical hypothesis : There will be a positive and significant relationship between the scores on entrepreneurial characteristics and the scores on profitability.

It can be seen from the Table-1 that training received, market orientation, management orientation and Socio economic status were positively and significantly related with profitability at 1 per cent level of significance.

Achievement motivation, extension contact, education and innovativeness were shown positively and significantly related with profitability at 5 per cent level of significance.

Cosmopoliteness, information seeking, leadership status, value orientation, risk orientation, decision making ability and self confidence were shown non significant relationship with profitability.

Based on the relationship arrived null hypothesis was accepted for the variables viz., Cosmopoliteness, information seeking, leadership status, value orientation, risk orientation, decision making ability and self confidence and rejected for the remaining variables.

Training received was found to have positive and significant relationship with profitability. Oil palm growers who have undergone more number of training

Table-1 : Correlation and multiple linear relationship between selected entrepreneurial characteristics and profitability.

S. No.	Variable	r-value	Regression co-efficient (b)	Standard error of b	t-value
1.	Education	0.1775*	0.292	0.119	2.450*
2.	Socio-economic status	0.2620**	0.255	0.191	1.336NS
3.	Extension contact	0.1823*	0.514	0.290	1.775NS
4.	Training received	0.5350**	2.349	0.814	2.886**
5.	Cosmo politeness	0.0155NS	-0.559	0.526	1.063NS
6.	Information seeking	0.0346NS	0.297	0.212	1.401NS
7.	Leadership status	0.0536NS	0.820	0.229	3.581**
8.	Innovativeness	0.1607*	0.515	0.204	2.525*
9.	Risk orientation	0.0166NS	0.351	0.309	1.136NS
10.	Self confidence	0.0287NS	0.128	0.151	0.849NS
11.	Market orientation	0.443NS	7.550	1.890	3.996**
12.	Management orientation	0.2653**	4.264	1.452	2.936**
13.	Achievement motivation	0.1906*	0.440	0.255	1.729NS
14.	Value orientation	0.0219NS	-0.188	0.266	0.707NS
15.	Decision making ability	0.1156NS	0.220	0.153	1.440NS

 $R^2=0.4934$

F=10.50

NS-Non Significant

*Significant at 5 per cent level

**Significant at 1 per cent level

programmes usually acquire more knowledge and skills and it would be have helped them lot to get more yields and returns per unit area. Hence positive and significant relationship have been observed between training received and profitability. This finding is in accordance with the results of Rao (1985), Goud (1990), Sreedevi (1996)

Socio economic status had shown positive and significant relationship with profitability. Timely investment on inputs for adopting the recommended practices of Oil palm cultivation might have resulted more yield and higher returns ultimately more profits.

Market orientation and management orientation were found to be positive and significant relationship with profitability. capability of planning production and market functions would helped them to get more returns per unit area.

Innovativeness was found to be positive and significant relationship with profitability. Oil palm groers having more innovativeness would have adopted all the recommended practices of Oil palm cultivation immediately after knowing the practices and would have got more yields. Hence positive and significant relationship have been observed between innovativeness and profitability.

The variable education was shown positive and significant relationship with profitability. Oil palm growers having more education have got more returns per unit area with minimum cost of cultivation, because of their rational use of inputs. Hence positive and significant

relationship would have been observed between education and profitability. This finding is in conformity with the results of Rao (1985), Goud (1990), Sreedevi (1996).

Extension contact has shown positive and significant relationship with profitability. Due to frequent contact with extension personnel, oil palm growers would have got more returns by adopting all the recommended practices. This result was inline with results of Sridevi 1996.

Prediction of the contribution of selected entrepreneurial characteristics with the profitability

Null hypothesis : The additional sum of squares of regression added by the independent variable x_1 to x_{15} is zero in explaining the amount of variation in profitability

Empirical hypothesis : The scores of 15 independent variables will explain a significant amount of variation in profitability

The result of multiple linear regression analysis for prediction of independent variable that contribute for variation in profitability were presented in the Table-11.

Multiple regression analysis revealed that the variables namely education ($P<0.05$), training received ($P<0.01$), leadership status ($P<0.01$), innovativeness ($P<0.05$) market orientation ($P<0.01$) and management orientation ($P<0.01$) were found to have positive and significant regression coefficients. The value of R^2 (0.4934) indicates that all the independent variables put together explain the variation on profitability to the extent of 49.34 per cent. The computed F value (10.50) was found to be significant.

Based on the R² variance ratio the null hypothesis was rejected and concluded that the data supported the original proposition that the scores on 15 independent variables explained a significant amount of variation in profitability.

Market orientation was the most important determinant of the profitability with a unit change in this variable there was a change of 7.55 units in the profitability. Management orientation and training received were other important determinants of profitability with per unit change these variables, there was a change of 4.26 and 2.34 units respectively in profitability.

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Growth and Instability Analysis of Inland Fish Production of India

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Abstract

Inland fish production can be an alternative to raise income and employment on agricultural farms. Besides it has key role in reducing nutritional gap in the diet of people of developing countries. Since inland fish farming is dependent upon weather conditions and certain other constraints, its production is supposedly subject to significant variations over time. The instability will have adverse impact upon growth of inland fish production. This study examined the growth and instability in inland fish production for a period from 1980 – 2020. The overall growth rate was found to be 6.29 per cent. Decade wise, instability was found to be approximately 2 per cent while it was 4.94 per cent for whole period, i.e., 1980 – 2020. In both the case it was too low. Inland fish production having high growth rate and low instability can be a good alternative to be adopted by farmers, especially small and marginal farmers, whose income enhancement always poses a challenge to scientific community.

Key words : Growth, instability, inland fish production, exponential time trend, CDVI.

Introduction

It has always been a challenge to feed ever rising population of India. Though our agriculture has been able to tackle this task very well, and not only we met our national demand of foodgrains and other agricultural commodities but also reduced the dependence upon foreign countries.

In view of the further rising population and hence reduction in per capita availability of land, it is imperative to develop alternate food supply resources from land and water resources. Furthermore, India as a developing country has not only inadequate food supply but the diets of majority of the people suffer from nutritive inadequacy due to shortage of protein, fat etc; particularly the protein gap is the highlighting characteristics of developing countries. The only solution for this problem is aquaculture, which can give a surprising boost to fish production which in turn will reduce nutritional gap in the diet of people of developing countries by providing quality protein. The potential for aquaculture is vast in India as it can be evident from vast availability of fresh waterbodies. India is bestowed with 3.15 million ha of reservoirs, 2.36 million ha of ponds and tanks as well as 0.19 million ha of rivers and canals (Jayasankar, 2018).

Moreover, India's approximately 75 per cent farms are small. These farms occupy approximately 25 per cent of total cultivable land. These small farms are endowed with poor resource base and hence characterized by poor production on these farms, particularly, because of

lack/shortage of capital. This poses challenge among the scientist to increase the income or production on these farms. To this effect, the scientists has suggested a variety of enterprises as part of integrated farming systems like dairy farming, pig farming, poultry farming etc. These has been tested and included in their farming systems, while other enterprises like fish farming are coming up. However, it is claimed that fish farming has ample scope in generating income and employment. Not much empirical evidence is available with regards to fish farming being supplementary or complementary enterprise. However, some studies suggest its suitability in increasing income and employment on agricultural farm. "D-Silva, J. *et al* (1995), observed returns on investment from fish farming as much as 135 per cent in his study". "Popma, T.J. *et al* (1995) reported that average ponds occupied only 2 per cent of the farm's land, the market value of fish harvested increased on-farm income by 18 per cent. "Katiha, P. K. *et al* (2005) reported benefit-cost ratios for different systems of aquaculture varied between 1.22 and 1.86." Hence fresh water fish farming has ample scope in raising income on these small farms. This can also be evident from the fact that "fresh water aquaculture with a share of 34% in inland fisheries in mid 1980s has increased to about 80% in recent years (DADF, 2017).

Instability is an indispensable characteristic of any out-of-door activity/production. Since inland fish farming is dependent upon weather conditions and certain other constraints, its production is subject to significant

variations over time. The instability will have adverse impact upon growth of inland fish production. It will make it riskier and have adverse effect on income of fish farmers. Therefore, this study aims at studying the growth and instability in inland fish production.

In view of the above, the following objectives has been taken into account for this study.

To study the growth of inland fish production.

To study the instability in inland fish production.

Research Methodology

This study is based on the secondary data with respect to India's fish production. The data used in this analysis will be taken from government source. Inland fish production for a period of 40 years consisting of four decades viz., 1980's, 1990's, 2000's and 2010's will provide the data base for the study.

The growth rates are proposed to be estimated by fitting an exponential time trend of the following form:

$$Y_t = a (1+r)^t \quad \dots(1)$$

Where r = growth rate in decimal form.

Let us convert equation (1) into log-linear form.

$$\text{Log } Y_t = \text{Log } a + t \text{ log } (1+r) \quad \dots(2)$$

Equation (2) can be rewritten as follows :

$$Y = A + bt \quad \dots(3)$$

Where :

$$\text{Log } Y_t = Y$$

$$\text{Log } a = A$$

$$\text{Log } (1+r) = b$$

Further in equation (3) (which is now simple linear equation):

Y = Logarithmic value of Inland fish production.

A = Constant

b = Regression coefficient that shows the rate of change or growth rate in a series.

Annual compound growth rate can be calculated as follows-

$$\text{Since } b = \text{Log } (1+r)$$

$$\text{Antilog } b = \text{antilog } [\text{Log } (1+r)]$$

$$\text{Antilog } b = 1+r$$

$$\text{Hence, } r = \text{Antilog } b - 1$$

Growth rate (r) thus calculated will be in decimal form which can, upon multiplying by 100, be converted into per cent form.

The agricultural instability can be measured by various methods. In this paper Cuddy Della Valle index has been used to measure the instability in our time series data. This method has advantage over C.V. (Coefficient of variation) method of computing instability because CDVI method attempts to detrend the CV by using coefficient of determination (R^2). Otherwise, the trend value of time series data may unnecessarily increase the CV value which will thus be a defective measure of instability.

This method was developed by Cuddy and Valle in 1978 to compute the instability in case of time-series data having trend value. The formula is as follows:

$$\text{CDVI} = \text{CV} \sqrt{1-R^2}$$

Where :

CDVI = Cuddy Della Valle index

C.V. = Coefficient of variation

R^2 = Coefficient of determination from time-trend regression adjusted by the number of degrees of freedom.

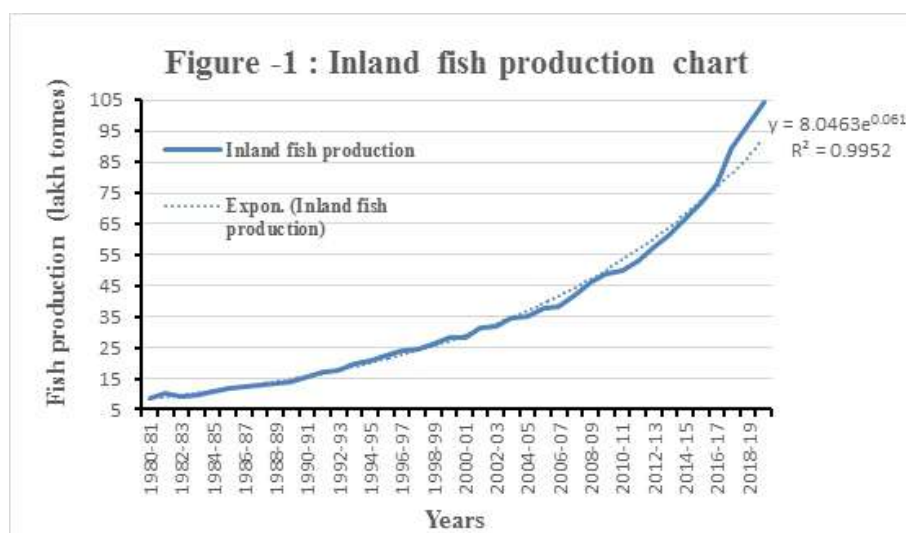
Results and Discussion

Growth of inland fish production : In order to work out compound growth rate an exponential time-trend equation was fitted to original data. With a view to see the accuracy of fitted exponential time-trend with the original data, a chart was prepared showing actual data in continuous line and exponential time trend in dotted line (figure-1). It can easily be seen that continuous curve and dotted line curve, both are moving in the same direction and on same path (almost overlapping each other). Thus, indicative of a good fit. Furthermore, the R^2 value, i.e., 99 per cent is also indicative of the same.

In this section, compound annual growth rates of inland fish production in India over four decades of time, i.e., 1980s, 1990s, 2000s, and 2010s and also for a period of 1980-2020, has been analysed and presented in table-1.

The annual growth rate of inland fish production was found to be 5.28 percent in 1980s followed by 6.60, 5.85 and 8.81 per cent in 1990s, 2000s and 2010s decade respectively. The overall growth rates for a period of 1980 – 2020 was found to be 6.29 per cent. This amount of growth appears to be remarkable comparative to agricultural growth. It is indicative of its lucrative nature and this may be the reason of its being adopted on continuous basis to make this growth feasible. Hence fish farming can also be included in agricultural farming systems for increasing on farm income.

The above results show highest growth rate 8.81 per cent in 2010s followed by 6.60 per cent in 1990s decade.



Here it may be mentioned that 1990s decade is known for economic reforms. The reform began in 1991, basically to resolve the balance of payment crisis. It opened the doors for major economic packages leading to liberalization of economy. Therefore, it can be said that growth enhancement in the subsequent decades may be result of economic reforms initiated in 1990s decade.

Instability in inland fish production : Decade wise mean, CV, and instability index (CDVI) are presented in Table-2. The coefficient of variation was maximum, i.e., 70.57 per cent during whole period (40-years). While decade wise maximum value was found to be 25.99 per cent in 2010s, followed by 19.06, 17.66 and 15.80 per cent in 1990s, 2000s and 1980s, respectively. Decade wise CV values were in good / acceptable range (CV <10 is very good, CV = 10-20 is good, CV = 20-30 is acceptable, while CV > 30 is not acceptable). When CV value was calculated for all four decades collectively, it was found to be 70.57 per cent. This was because of high trend values in long time series data. Therefore, it can be concluded that a long time series data having high trend values will increase coefficient of variation (CV) to large extent. Therefore, CV values for instability analysis was altogether left and in its place another measure, CDVI, was considered for this study.

The instability in inland fish production was found to be maximum, i.e., 3.48 per cent in I decade followed by 2.67, 2.37 and 2.31 per cent in III, II and IV decades, respectively. Decade wise not much variation in instability was observed, it was approximately 2% in all decades except 3.48 % in I decade. However, it was found to be 4.94 % for all decades, collectively. These ranges of instabilities are very low and make this enterprise suitable for farmers to adopt wholly or as a component of their farming systems. "The ranges of instability are as – low

instability (0 – 15), median instability (greater than 15 lower than 30), high instability (greater than 30) (Sihmar, 2014)".

Since fish farming is an out of door activity, it is bound to have production fluctuation with the fluctuation in climatic factors. This production fluctuation makes the enterprise unstable and risky. Besides, there may be operating certain constraints responsible for hindering rapid development of fish farming. These constraints may include one or many categories such as -production constraints, management constraints, marketing constraints, miscellaneous constraints, etc. These factors can collectively aggravate production-fluctuation, and thus can make the enterprise more and more unstable and risky. The instability, if further grows, may slow adoption and expansion of aquaculture. Therefore, the constraints of fish production were looked up through various research studies and relevant literature is discussed below. If these constraints are causing instability in production, the study of these constraints with a view to eliminate them may be useful in reducing the instability to some extent.

Constraints in inland fish production : The spread of disease, flood and inadequacy of water caused heavy loss to the fishermen in Bihar. Non-cooperation from the fishery department and banks and inadequate knowledge of modern aquaculture techniques are some of the constraints of fish production in the area (Siddiqui, A.Q. *et al*, 1993). The infrastructure facilities at most of the surveyed landing centres, fishing harbours and wholesale and retail markets have been found grossly inadequate and poorly maintained (Kumar, G.B. *et al*, 2008)

The main constraints of fish marketing are related to infrastructure, plant management and institutional management aspect (Alam, M.J. *et al*, 2010). The

Table-1 : Decade-wise growth of inland fisheries in India over a period from 1980-81 to 2019-20.

Sr. No.	Decade	Growth parameter*	R ²	Growth = [Exp (Growth parameter)-1]	Growth (%)
1.	1980-81 to 1989-90	0.051413 (0.003865)	0.956736	0.052757	5.28
2.	1990-91 to 1999-2000	0.064007 (0.002678)	0.986193	0.066099	6.60
3.	2000-01 to 2009-10	0.056834 (0.002895)	0.979669	0.058480	5.85
4.	2010-11 to 2019-20	0.08448 (.002505)	0.993015	0.088151	8.81
5.	Overall (from 1980-2020)	0.061009 (0.00688)	0.995187	0.062908	6.29

R² = Statistically significant at P 0.05 confidence level, Figures in parentheses are standard error, *Statistically significant at P 0.05 confidence level.

Table-2 : Instability in inland fish production.

S. No.	Decades	Mean (in lakh tonnes)	C.V. (%)	CDVI (%)
I	1980s	11.343	15.8048	3.4878
II	1990s	21.613	19.0674	2.3739
III	2000s	37.505	17.6653	2.6733
IV	2010s	72.894	25.9946	2.3105
V	Overall (1980 – 2020)	35.838	70.5767	4.9404

problems and constraints faced by farmers in fresh water aquaculture were Theft and pilferages, non availability of quality fish seeds, lack of natural feed, lack of government support, lack of resource, lack of extension services, gas formation during rainy and summer season, quarrel and litigation among the owners of the pond, distance from the house, adaptability of fish seed is very low in new environment, diseases of fish, productivity of the soil of the pond. While, problems and constraints faced by the market intermediaries in marketing of fish were— high perishability of the product, huge competition, inconsistent supply of fish, lack of storage facility, high bargaining and lack of purchasing power, high price fluctuation, unsuitable position of market yard, dependence on other state for supply, lack of government support, lack of processing unit (Rahman, S.M. *et al*, 2013).

Rainfall, river inflow, snowmelt, and consequent fluctuation in water level are the hydro-climatic factors that influence the inland fisheries production worldwide. Increasing rainfall and water level favours the reproduction, recruitment and immigration of fish in the inland reservoirs. However, heavy rainfall and increased water levels reduces the fish catch and the catch per unit effort (CPUE) significantly. During rainy season fish migrate to the newly inundated areas and shallow peripheries and escape from fishing gear because of the water level rise in the inland reservoirs. Reduction in CPUE also justify by the reduction in the number of

fishers, boat, nets and fishing duration in the rainy days. Fingerling stocking and ceasing of fishing activities in rainy seasons are the common management practices in tropical countries like Sri Lanka (Patrick, 2016).

From foregoing analysis, it can be concluded that besides hydro-climatic factors, theft and pilferages, inadequate knowledge of aquaculture, low institutional support, lack of extension services, disease, supply of fish seed etc are the major production constraints. While poor infrastructure facilities, high perishability of the product, price fluctuation, huge competition, poor storage facility etc are the major marketing constraints.

However, our analysis revealed, comparative to agriculture, a better growth rate and a very low instability in inland fish production. Therefore, it seems that above stated constraints have been working in low magnitude and not affecting the present growth rate considerably.

Conclusions

Declining land availability due to rising population has forced us to develop alternate food supply sources from land and water resources. Moreover, the diets of people of developing countries suffer from not only inadequate food supply but also nutritive inadequacy due to shortage of protein. Inland fish production can play a key role in reducing nutritional gap in the diet of people of developing countries. Besides it can be an alternative to raise income and employment on agricultural farms. In this regard various enterprises have been tested and included in

farming systems. But fish farming has come up lately and not much empirical evidence is available with this regard. Since fish farming is an out of door activity, it is bound to have production fluctuation with the fluctuation in climatic factors. This production fluctuation makes the enterprise unstable and risky. Therefore, this study aimed at studying the growth and instability in inland fish production. In total 40 years-data on fish production was collected for this study between 1980-81 to 2019-20. The overall growth rate was found to be 6.29 per cent. Decade wise, instability was approximately 2 per cent while it was 4.94 per cent for whole period, i.e., 1980 – 2020. In both the case it was too low. Inland fish production having high growth rate and low instability can be a good alternative to be adopted by farmers, especially small and marginal farmers, whose income enhancement has always been a challenge to scientific community.

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Growth and Instability Analysis of Marine Fish Production in India

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Abstract

Fish being a biological activity is subject to production fluctuation with the variation in environmental factors and various other factors. Marine fisheries sector provides employment, contribute to food and nutritional security and serves as a source of income to various families engaged in the work of fisheries. The instability will have adverse impact upon growth of marine fish production. It will make it riskier and have adverse effect on income of families engaged in the work of marine fisheries. The present paper seeks to find out growth and instability of marine fish production in India. Decade wise maximum instability found to be 8.45% in 1980s decade, whereas, it was 9.38% for all decades collectively. Thus, it was a case of very low instability. However, the growth obtained in the sector was not attractive. It was maximum (3.79%) in 1980s decade and as low as 0.75% in 2000s decade. In spite of having low instability, the growth rate is not up to the mark. It indicates there operates a set of constraints in marine sector preventing it to register a good growth rate.

Key words : Growth, instability, marine fish production, exponential time trend, CDVI.

Introduction

The importance of fisheries sector to the state and national economy is widely acknowledged. Its significance lies in three areas: (1) as a source of animal protein for human consumption, (2) as a source of employment, and (3) as a source of foreign exchange earnings (Bhatta et al 2003). India is the third largest producer of fish and second largest producer of freshwater fish in the world. Under Exclusive Economic Zone (EEZ), an area of 2.02 million sq km of sea has come under our jurisdiction with absolute right of exploring, exploiting and natural utilization of living resources falling within it. Besides, the country has a long coastline and large areas under estuaries, backwaters, lagoons etc., conducive for developing capture as well as culture fisheries (Pandey, 2017).

Instability is an indispensable characteristic of any out-of-door activity/production. Since marine fisheries is dependent upon weather conditions and certain other constraints, its production is subject to significant variations over time. The instability will have adverse impact upon growth of marine fish production. It will make it riskier and have adverse effect on income of the person engaged in marine fisheries sector. Therefore, this study aims at studying the growth and instability in marine fish production.

In view of the above, the following objectives has been taken into account for this study.

to study the growth of marine fish production.

To study the instability in marine fish production.

Research Methodology

Data collection : This study is based on the secondary data with respect to India's marine fish production. The data used in this analysis will be taken from Handbook of Fisheries Statistics 2020. Inland fish production for a period of 40 years consisting of four decades viz., 1980's, 1990's, 2000's and 2010's will provide the data base for the study. Problems of marine fisheries sector will be looked up through various secondary sources including research paper etc.

Analytical Framework

Procedure for Computing Compound Growth Rate :

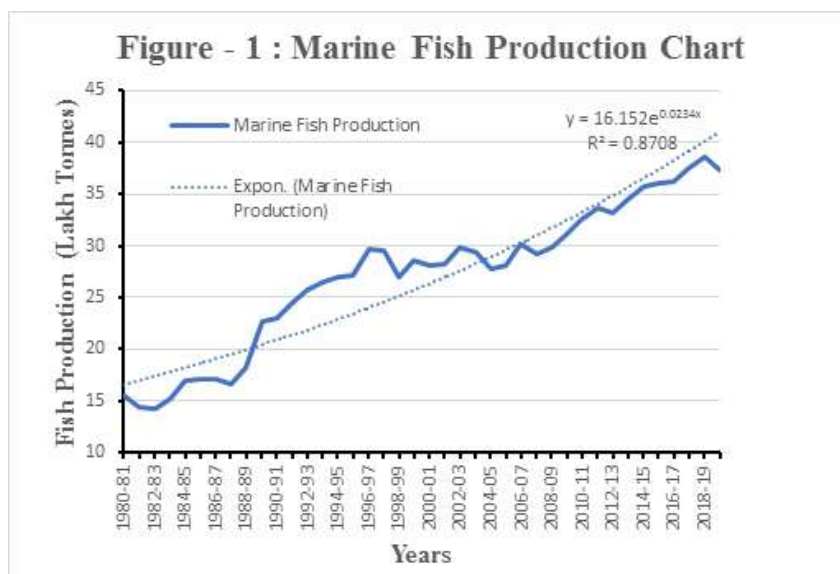
The growth rate was estimated using exponential trend model (Pandey, 2017). If y_t denotes the observation (marine fish production) at time t and r is the compound growth rate, model employed for estimating r (that is growth rate) is based on Eq. (1) :

$$y_t = y_0 (1+r)^t \quad \dots(1)$$

The model may be linearized by means of logarithmic transformation, giving Eq. (2) :

$$\ln(y_t) = \ln(y_0) + t \ln(1+r) \quad \dots(2)$$

$$Y = A + Bt + \quad \dots(3)$$



where, $Y = \ln(y_t)$, $A = \ln(y_0)$, $B = \ln(1 + r)$ and ϵ is an error term. Eq. (3) is then fitted to data using “method of least squares” and goodness of fit is assessed by the coefficient of determination R^2 .

Finally, the compound growth rate is estimated by Eq. (4) :

$$r^A = \exp(B^A) - 1 \quad \dots(4)$$

Growth rate (r) thus calculated will be in decimal form which can, upon multiplying by 100, be converted into per cent form.

Procedure for Computing Instability : The agricultural instability can be measured by various methods. In this paper Cuddy Della Valle index has been used to measure the instability in our time series data. This method has advantage over C.V. (Coefficient of variation) method of computing instability because CDVI method attempts to detrend the CV by using coefficient of determination (R^2). Otherwise, the trend value of time series data may unnecessarily increase the CV value which will thus be a defective measure of instability.

This method was developed by Cuddy and Valle in 1978 to compute the instability in case of time-series data having trend value. The formula is as follows :

$$CDVI = CV \sqrt{1-R^2}$$

Where :

CDVI = Cuddy Della Valle index

C.V. = Coefficient of variation

R^2 = Coefficient of determination from time-trend regression adjusted by the number of degrees of freedom.

Results and Discussion

Growth of marine fish production : A chart was prepared showing actual data in continuous line and exponential time trend in dotted line (figure-1). It can easily be seen that continuous curve and dotted line curve; both are moving in the same direction and on same path. Thus, indicative of a good fit. Moreover, the R^2 value, i.e., 88 per cent is also an indicator of good fit. In order to work out compound growth rate an exponential time-trend equation was fitted to original data.

In this section, compound annual growth rates of marine fish production in India over four decades of time, i.e., 1980s, 1990s, 2000s, and 2010s and also for a period of 1980-2020, has been analysed and presented in table-1.

The annual growth rate of marine fish production was found to be 3.79 per cent in 1980s followed by 2.23, 1.80 and 0.75 per cent in 1990s, 2010s and 2000s decade, respectively. The overall growth rates for a period of 1980 – 2020 was found to be 2.36 per cent. This amount of growth appears to be somewhat equivalent to agricultural growth. This growth rate is too less than 6.14 % of inland fish production growth rate as reported by (Pandey, 2017).

Since marine fish production mostly comes under capture fishery, there is every possibility that fishery after fishery may be responsible for poor growth rate as the stock in the sea gets reduced owing to heavy fishery in comparison to replacement rate (as fish is a renewable stock). Besides, there may have been weather and other constraints responsible for low catch which eventually led to low growth rate in marine fisheries sector.

Table-1 : Decade-wise growth of marine fisheries in India over a period from 1980-81 to 2019-20.

Sr. No.	Decade	Growth parameter*	R ²	Growth = [Exp (Growth parameter)-1]	Growth (%)
1.	1980-81 to 1989-90	0.037269 (0.008664)	0.698157	0.037972	3.79
2.	1990-91 to 1999-2000	0.022048 (0.005048)	0.704517	0.022292	2.23
3.	2000-01 to 2009-10	0.007439 (0.003388)	0.375977	0.007466	0.75
4.	2010-11 to 2019-20	0.017846 (0.00193)	0.914406	0.018006	1.80
5.	Overall (from 1980-2020)	0.023351 (0.001459)	0.870791	0.023625	2.36

Figures in parentheses are standard error, R² = Statistically significant at P 0.05 confidence level, *Statistically significant at P 0.05 confidence level.

Table-2 : Instability in marine fish production.

S. No.	Decades	Mean (in lakh tonnes)	C.V. (%)	CDVI (%)
I	1980s	16.823	14.5159	8.4589
II	1990s	26.836	7.8195	4.5084
III	2000s	29.193	3.6831	3.0860
IV	2010s	35.516	5.6282	1.7465
V	Overall (1980 – 2020)	27.092	25.7628	9.3817

The exact growth rate has been computed and given in Table 1. R² value given in the table suggests the goodness of fit of the model. Model and growth parameters were found significant at P0.05 level.

Instability in marine fish production : Decade wise mean, CV, and instability index (CDVI) are presented in Table-2. The coefficient of variation was maximum, i.e., 25.76 per cent during whole period (40-years). While decade wise maximum value was found to be 14.51 per cent in 1980s, followed by 7.81, 5.62 and 3.68 per cent in 1990s, 2010s and 2000s, respectively. Decade wise CV values were in good / acceptable range (CV <10 is very good, CV = 10-20 is good, CV = 20-30 is acceptable, while CV > 30 is not acceptable). When CV value was calculated for all four decades collectively, it was found to be 25.76 per cent. This was because of high trend values in long time series data. Therefore, it can be concluded that a long time series data having high trend values will increase coefficient of variation (CV) to a significant extent. Therefore, CV values for instability analysis was altogether left and in its place another measure, CDVI, was considered for this study.

The instability in marine fish production was found to be maximum, i.e., 8.45 per cent in I decade followed by 4.50, 3.08 and 1.74 per cent in II, III and IV decades, respectively. Decade wise analysis reveals that instability was highest in I decade and then it gradually declined to nearly 2% in IV decade. However, it was found to be 9.38% for all decades, collectively. These ranges of instabilities are very low and make this enterprise suitable for fishermen to adopt. "The reference ranges of instability are as – low instability (0 – 15), median instability (greater

than 15 lower than 30), high instability (greater than 30) (Sihmar, 2014)".

Foregoing analysis suggests very low instability in marine fish production. However, the finding of low instability does not fit within the framework of slow growth rate and wide variety of constraints of marine fisheries. This could be perceived again from the fact that marine fish production registered two-fold increase from 1980-81 (15.55 lakh tonnes) to 2019-20 (37.27 lakh tonnes), whereas fresh water fish production registered twelve-fold increase from 8.87 lakh tonnes to 104.37 lakh tonnes during the same period. So, in spite of having low instability, not much growth rate accrued to marine sector. Hence, instability computation method seems to be murky not clear, in case of marine fisheries. Therefore, some new methods of instability computation has to be developed which should take into account some other parameters also like catch per unit effort, etc.

Since marine fisheries is an out of door activity, it is bound to have production fluctuation with the fluctuation in climatic factors. This production fluctuation makes the enterprise unstable and risky. Besides, there may be operating certain constraints responsible for hindering rapid development of marine fisheries. These factors can collectively aggravate production-fluctuation, and thus can make the enterprise more and more unstable and risky. The instability, if further grows, may slow development and expansion of marine fisheries. Therefore, the constraints of fish production were looked up through various research studies and relevant literature is discussed below. If these constraints are causing instability in production, the study of these

constraints with a view to eliminate them may be useful in reducing the instability.

Constraints in marine fish production : Jesintha *et al* (2020) reported that in recent years, human activities are threatening the health of the ocean and putting enormous pressure on marine ecosystems. Overfishing, pollution, indiscriminate fishing practices and climate change are together causing, irreversible changes in the ocean that could threaten its environmental health and economic vitality. Hence, there is urgent need of strengthening sustainable practices and policies in fisheries around the globe to drive marine capture fisheries towards sustainability.

Nammalwar *et al* (1979) identified several factors such as low social status, poor economic conditions, illiteracy, heavy leaning on middle men, traditional fishing equipment and methods of fishing, low production rate and income influence the socio-economic conditions of fishermen.

Patilkhede *et al* (2018) observed that “over exploitation of the middlemen / agents / traders / cooperative societies” (87.50 per cent), was the major constraint in fishing activities followed by “debt” (88.33 per cent), “lack of ready package of fish culture” (91.67 per cent), “no drying and processing land” (66.67 per cent), “dominance of middlemen in marketing”, (87.50 per cent), and “inefficient execution and implementation of government programmes” (77.92 per cent).

Devaraj *et al* (1999) found that the improvement made so far on the craft and gear technologies with an objective to increase fish production are becoming counterproductive. Inappropriate exploitation patterns such as concentration of 80 % of the total fishing effort in the inshore waters and over-dependence on trawlers are showing signs of detrimental effects on the fisheries.

Kanaga *et al* (2015) found that high fishing expenses, co-workers problems, in-efficient of society are the main constraints in marine capture fishing. During ban period, poverty, unemployment and lack of credit are the major constraints to fishermen. Major reason for debt was purchasing of craft, instruments and maintains.

Kumar *et al* (2003) stated that further enhancement of marine fish production requires diversification of fishing activities not only in the offshore oceanic regime but also in deep sea fishing which is capital intensive and risk prone. There have already been strong protests in India against foreign equity participation in deep sea fishing and government had to rescind its Deep-Sea Fishing Policy in March 1997. Utilization of marine resources by catch and fishing for unconventional fish species may not be

economically viable initially. The conservation of resources and genetic diversity in EEZ would further slow down efforts towards higher production from the marine sector.

Deepthi, A. *et al* (2014) put constraints in two categories, namely, (1) Constraints in fisheries and (2) Other constraints. Under first category– loss of income, lack of employment, lack of alternative income generation other than fishing, lack of credit during ban period were the major constraints. The constraints listed in second category were inadequate subsidies, improper running of fishermen cooperatives, problem on capital investment, problem of debt.

World Bank report (2010) listed certain constraints as (1) the current policy, legal and administrative systems can only serve as a partial foundation for reform towards more progressive fisheries management. (2) The biological and economic sustainability of marine fish stock in India faces challenges. (3) small scale fishers are losing their livelihoods and opportunities for development and there are presently few options for alternatives. (4) Fisheries management needs to be strengthened, especially for inshore waters. (5) market channels are inefficient and hinder delivery of high-quality products at optimal prices.

From foregoing studies, it can be concluded that poor socio-economic conditions of fishermen, heavy dependence on middlemen, debt, inefficient market and cooperative societies, no drying and processing land are some major constraints of marine fisheries. Moreover, during ban period poverty, unemployment and lack of credit were the major constraints to fishermen. Overfishing, pollution, indiscriminate fishing practices and climate change are together putting enormous pressure on marine ecosystems. The biological and economic sustainability of marine fish stock in India faces challenges. Besides, inappropriate exploitation patterns such as concentration of 80 % of the total fishing effort in the inshore waters and over-dependence on trawlers are showing signs of detrimental effects on the fisheries. Also, the conservation of resources and genetic diversity in EEZ would further slowdown efforts towards higher production from the marine sector. The removal of above stated constraints is warranted for enhancement of marine fish production. Further enhancement of marine fish production requires diversification of fishing activities not only in the offshore oceanic regime but also in deep sea fishing which is capital intensive and risk prone. Fisheries management needs to be strengthened, especially for inshore waters for further gain in growth rate in marine fisheries.

However, our analysis revealed a slow growth rate and a contradictory very low instability in marine fish production. It seems that above stated constraints may have been working in good magnitude and affecting the present growth rate considerably. The government should take steps, particularly in line with world bank recommendations, to strengthen the condition of marine fisheries.

Conclusions

The significance of fisheries sector lies in three areas: (1) as a source of animal protein for human consumption, (2) as a source of employment, and (3) as a source of foreign exchange earnings. Since marine fisheries is an outdoor activity, it is bound to have production fluctuation with the fluctuation in climatic factors. Besides, certain other constraints may also cause fluctuation in production. This production fluctuation makes the enterprise unstable and risky. Therefore, this study aimed at studying the growth and instability in marine fish production. In total 40 years-data on fish production was collected for this study between 1980-81 to 2019-20. Decade wise maximum instability found to be 8.45% in 1980s decade, whereas, it was 9.38% for all decades collectively. Thus, it was a case of very low instability. However, the growth obtained in the sector was not attractive. It was maximum (3.79%) in 1980s decade and as low as 0.75% in 2000s decade. In spite of having low instability, the growth rate is not up to the mark. It implicates there operates a set of constraints in marine sector preventing it to register a good growth rate. The government should take steps, particularly in line with world bank recommendations, to strengthen the condition of marine fisheries.

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Total Factor Productivity of Sugarcane Crop in Uttar Pradesh

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Abstract

India is one of the leading sugar producing countries in the world. Besides exporting sugar to other countries, India is also a major consumer of it. Bulk of sugar in India and abroad is produced from sugarcane. Thus, the production of sugarcane is a major source of income to the growers besides contributing to the foreign exchange reserves of the nation. In India, it is not possible to increase net-crop area due to limited availability of land. Therefore, increase in productivity of crops is the only option which remains open to increase the supply of sugarcane in India. Growth in input use and growth in Total Factor Productivity (TFP) are two major factors of growth in the productivity of crops. In this paper, an attempt has been made to estimate the TFP of sugarcane crop in Uttar Pradesh. Time series data for a period of 1996-97 to 2018-19 on cost of cultivation of sugarcane crop in Uttar Pradesh as available in the website of Directorate of Economics and Statistics were used for the study. Log-linear form of production function was used to find out Total Factor Productivity of Sugarcane crop in Uttar Pradesh. Capital and labour inputs were used in the production function analysis. Results of the study show that TFP of sugarcane range between 4 to 4.76 during the period of study, but neither increasing nor decreasing trend in growth of TFP was observed in Uttar Pradesh for the specified period. Therefore, more emphasis needs to be stressed on sugarcane research in Uttar Pradesh to boost the growth in Total Factor Productivity of sugarcane crop in Uttar Pradesh.

Introduction

India is one of the leading sugar producing countries in the world. Bulk of sugar is produced from sugarcane in India and abroad. Hence, India also has a significant contribution in the world production of sugarcane. Sugarcane is a major commercial crop after cotton in India in terms of area under coverage of the crop. India ranks first in the world in consumption of sugar. Sugar is also exported to other countries from India. Therefore, sugarcane crop is a major source of income to the farmers in India and also a source to earn foreign exchange for the nation. Sugar mills in India provide assured market to the farmers for growing sugarcane crop. State governments provide fair and remunerative prices to the farmers for sugarcane crop. In India, sugarcane crop is mostly produced in irrigated fields. Therefore, the growth in production of sugarcane in India is necessary to increase the supply of sugar. In India, it is not possible to increase net-crop area due to limited availability of land. Therefore, increase in production of sugarcane is possible either through more use of farm inputs or through technological change. Increase in output due to more use of inputs raises cost and other issues related to over use of natural resources. Therefore, growth in Total Factor Productivity (TFP) is the only possible way to increase farmers' income and earn foreign exchange for the nation. Total Factor Productivity refers to that part of growth in output that is not explained by the growth in inputs. Uttar Pradesh is a major sugarcane growing and producing state in India. In

2019-20, UP contributed nearly 48 per cent to both - total area under coverage and production of sugarcane in India. Therefore, in the present study, an attempt has been made to estimate the TFP of sugarcane crop in Uttar Pradesh.

Research Methodology

Data of cost of cultivation and production of sugarcane crop in Uttar Pradesh from 1996-97 to 2018-19 were obtained from the website of Directorate of Economics and Statistics, Department of Agriculture and Farmers' welfare, Ministry of Agriculture and Farmers' Welfare. Production function approach was used to work-out Total Factor Productivity (TFP) of Sugarcane. Labour and capital inputs used to estimate Cobb-Douglas production function. Year-wise yield of sugarcane was divided by the multiple of both inputs weighted by their factor shares (and parameters) to calculate TFP (A parameter).

$$Y_t = A_t L_t K_t$$

$$A_t = \frac{Y_t}{L_t K_t}$$

Where :

A_t = Total Factor Productivity of sugarcane at year t (TFP_t)

Y_t = Yield of sugarcane at year t

L_t = Per hectare units of labour at year t

K_t = Per hectare units of capital at year t

= Factor share of labour in total output

= Factor share of capital in total output

Table-1 : Year-wise yield of sugarcane (Y_t), physical units labour (L_t) and capital (K_t) in Uttar Pradesh.

Sl. No.	Year	Y_t (q/ha)	L_t (Man hours/ha)	K_t (Rs/ha)
1.	1996-97	479.51	1251.31	6273.42
2.	1997-98	502.4	1217.66	7028.15
3.	1998-99	490.86	1258.55	7363.47
4.	1999-2000	444.96	1209.34	8490.47
5.	2000-01	451.08	1179.02	8429.9
6.	2001-02	452.47	1222.98	8806.06
7.	2002-03	494.1	1284.78	9274.97
8.	2003-04	490.36	1138.09	7576.14
9.	2004-05	529.63	1233.61	8711.64
10.	2005-06	598.93	1412.41	10529.66
11.	2006-07	567.06	1331.47	10487.58
12.	2007-08	523.37	1362.91	12128.12
13.	2008-09	448.89	1177.38	12144.08
14.	2009-10	512.24	1289.62	14705.18
15.	2010-11	509.35	1223.25	17306.09
16.	2011-12	529.05	1271.71	21777.77
17.	2012-13	536.28	1321.02	26214.59
18.	2013-14	497.72	1195.63	26788.72
19.	2014-15	539.07	1184.29	32037.46
20.	2015-16	542.88	1123.64	29820.2
21.	2016-17	548.77	1132.43	31593.33
22.	2017-18	602.42	1288.1	41082.96
23.	2018-19	570.05	1249.3	43034.36

Source : Data on Cost of Cultivation, Directorate of Economics and Statistics, Department of Agriculture and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare.

Results and Discussion

Time series data as available from the website of Directorate of Economics and Statistics were used to obtain output and input data of sugarcane crop in Uttar Pradesh. Year-wise data on yield from sugarcane crop, physical units of labour and capital cost (all on per hectare basis) in UP are shown in the Table-1.

It is evident from the table that physical units of output and input of sugarcane crop have increased all through the years. Log-linear form of production function was used to estimate the intercept term (A) and elasticities of production of labour ($\hat{\alpha}$) and capital ($\hat{\beta}$). Various statistical parameters for analysis of the result are shown in the next tables :

Table-2 : Regression Statistics.

Sl. No.	Statistical Parameters	Regression statistics
1.	Multiple R	0.738193
2.	R^2	0.544929
3.	Adjusted R^2	0.499422
4.	Standard Error	0.059185
5.	Number of Observations	23

Result of the study indicates that both of the slope parameters ($\hat{\alpha}$ and $\hat{\beta}$) are significant at 5% level of significance (Table-4). $R^2 = 0.54$. Hence, 54% variations

in the output of sugarcane crop are explained by labour and capital inputs (Table-2). Correlation coefficient between labour and output is 0.39. For capital and output, the correlation coefficient is 0.66. But, there is no correlation between labour and capital ($r = -0.03$ as shown in Table-5). Hence, there is no multicollinearity in the production function analysis. Costs incurred and returns obtained from sugarcane crop are shown in the Table-6. All through the years, returns from sugarcane are more than double to its operational cost. Therefore, sugarcane is a better remunerative crop for the farmers. Total Factor Productivity of sugarcane (TFP_t) range between 4 to 4.76 during the study period. But TFP_t of sugarcane crop does not show either increasing or decreasing trend. Therefore, no significant growth in the TFP_t has been observed for sugarcane crop in Uttar Pradesh. In order to boost the growth of TFP, continuous varietal improvement of sugarcane crop in UP state through enhanced research and developmental activities is required.

Conclusions

In the present study, an attempt has been made to assess Total Factor Productivity (TFP_t) of sugarcane crop in Uttar Pradesh. Time series data on cost of cultivation and production of sugarcane crop in Uttar Pradesh state from 1996-97 to 2018-19 were used for the study. Log-linear

Table-3 : ANOVA.

Sl. No.	Parameters	DF	SS	MS	F	Significance F
1.	Regression	2	0.083892	0.41946	11.97458	0.000381
2.	Residual	20	0.070058	0.003503		
3.	Total	22	0.15395			

Table-4 : Regression Coefficients.

Sl. No.	Coefficients	Values of Coefficients	Standard Error	t-stat	P-value	Lower 95%	Upper 95%
1.	A	1.482871	1.550553	0.9569	0.350314	-1.75153	4.717268
2.		0.540108	0.215373	2.5078	0.020883	0.090849	0.989367
3.		0.096217	0.022806	4.2189	0.000422	0.048645	0.14379

Table-5 : Correlation Coefficient.

Correlation	Y_t	L_t	K_t
Y_t	1		1
L_t	0.38589	1	
K_t	0.664333	-0.03036	

Table-6 : Year-wise Operational Cost, Gross Returns and Total Factor Productivity (TFPt) of Sugarcane Crop in Uttar Pradesh. (Costs and Returns in Rs '000/ha)*

Sl. No.	Year	Operational Cost	Gross Returns	TFP _t
1.	1996-97	11.88	33.07	4.44
2.	1997-98	12.15	38.71	4.76
3.	1998-99	14.18	40.78	4.44
4.	1999-2000	15.87	39.14	4.09
5.	2000-01	16.61	40.44	4.16
6.	2001-02	18.65	43.14	4.02
7.	2002-03	19.11	42.05	4.27
8.	2003-04	14.42	42.62	4.69
9.	2004-05	17.71	56.51	4.72
10.	2005-06	21.80	70.85	4.61
11.	2006-07	21.87	71.21	4.74
12.	2007-08	22.73	58.87	4.35
13.	2008-09	23.68	63.91	4.01
14.	2009-10	27.57	133.41	4.31
15.	2010-11	37.22	106.36	4.22
16.	2011-12	42.25	132.87	4.29
17.	2012-13	49.84	151.88	4.20
18.	2013-14	46.94	143.95	4.17
19.	2014-15	52.32	163.21	4.54
20.	2015-16	54.66	159.24	4.61
21.	2016-17	50.92	187.94	4.76
22.	2017-18	73.27	201.03	4.64
23.	2018-19	76.25	186.93	4.45

*Costs and Returns data are obtained from Cost of Cultivation Data, Directorate of Economics and Statistics, Department of Agriculture and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare.

form of production function was used for the study. The study shows that the TFP_t of sugarcane crop in UP range between 4 to 4.76 during the period 1996-97 to 2018-19. But no significant trend in growth of TFP_t (either increasing or decreasing) was observed in the study

during the specified period. Hence, the need for varietal improvement through intensified research and developmental activities was emphasized to boost the growth of TFP_t for sugarcane crop in the state.

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A Review on Therapeutic Properties of Black Pepper

Indu

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Abstract

Nicknamed the 'King of Spices', Black Pepper (*Piper nigrum*) is an important and most widely used spice in the world. It is valued for its characteristic sharp and stinging qualities attributed to the alkaloid piperine. Black pepper has a wide array of uses which include food additives, seasoning, and preservatives and even as a potential medicine. Traditionally, it has been used as a remedy for various maladies as Ayurvedic medicine as well as Chinese medicine. Many research studies have been conducted in the recent decades on its physiological and therapeutic effects especially as an anti-oxidant, anti-inflammatory and bio-availability of other compounds. Most of the clinical studies have focussed on its effect on drug metabolism. There have also been reports of its anti-neoplastic properties. This project will review and compile the various literatures or studies available on therapeutic properties of black pepper and its limitations.

Key Words : Black pepper, piperine, therapeutic benefits, bioactive, anti-carcinogenic, anti-inflammatory, antibacterial, anti-Colon toxin, antidepressant, antifungal, antidiarrhoeal.

Introduction

For millennia, spices have been an integral part of human diets and commerce. Recently, the widespread recognition of diet-health linkages bolsters their dietary importance. The bioactive components present in them are of considerable significance owing to their therapeutic potential against various ailments.

Black pepper (*Piper nigrum* L.) (Family: *Piperaceae*) is a perennial vine grown for its berries extensively used as spice and in medicine. The name pepper is derived from the Sanskrit name of long pepper, *pippali*. It has been nicknamed as 'black gold' and the 'king of spices'.

Piper nigrum is native to the tropical forests of the Malabar Coast in south-west India, around the regions of Kerala, Goa and Karnataka. It has one of the longest histories as a sought-after spice, due to its ability to flavour foods, act as a preservative, and add heat to a dish. Black pepper offers a range of health benefits in addition to its flavour-enhancing properties.

Piper nigrum is used for the production of both black pepper (from the unripened fruit) and white pepper (from the dehulled mature berry). The chemical piperine is a major bioactive component present in black pepper (and white pepper as well) that has numerous reported physiological and drug-like interactions. The bioactive components present in them are of considerable significance owing to their therapeutic potential against various ailments. They provide physiological benefits or prevent chronic ailment in addition to fundamental nutrition and often included in the category of functional foods.

Black pepper is an important healthy food owing to its antioxidant, antimicrobial potential and gastro-protective modules. With piperine as an active ingredient, it holds rich phytochemistry that also includes volatile oil, oleoresins and alkaloids. More recently, cell-structure studies and animal modelling predicted the role of black pepper against number of maladies.

In ancient Sanskrit literature, black pepper use for medicinal purposes was documented. In India, it was one of the most commonly used herbs in Ayurvedic medicine and has been considered for the treatment of gastrointestinal disorders and, even more recently, of chronic malaria. Black pepper was also used for the treatment of epilepsy in traditional Chinese medicine.

With the above information, the present study is discussed with the objective given below :

To study the therapeutic properties of Black Pepper and its products; and its role in health.

To know about the limitations of using Black Pepper as a therapeutic medicine.

Review of Literature

Piper species have been used in traditional medicine for intermittent fevers and to promote the secretion of bile. They are also recommended for neurological, broncho-pulmonary and gastrointestinal disorders, (including dyspepsia, flatulence, constipation and hemorrhoids). (L. Majeed and L. Prakash, 2000).

Piperine has been demonstrated in in-vitro studies to protect against oxidative damage by inhibiting or

quenching free radicals and reactive oxygen species. Black pepper or piperine treatment has also been evidenced to lower lipid peroxidation *in vivo* and beneficially influence cellular thiol status, antioxidant molecules and antioxidant enzymes in a number of experimental situations of oxidative stress. (Srinivasan K., 2007).

The most far-reaching attribute of piperine has been its inhibitory influence on enzymatic drug bio-transforming reactions in the liver. It strongly inhibits hepatic and intestinal aryl hydrocarbon hydroxylase and UDP-glucuronyl transferase. (Srinivasan K., 2007).

Piperine has been documented to enhance the bioavailability of a number of therapeutic drugs as well as phytochemicals by this very property. Piperine's bioavailability enhancing property is also partly attributed to increased absorption as a result of its effect on the ultrastructure of intestinal brush border. (Srinivasan K., 2007).

Piperine, while it is non-genotoxic, has in fact been found to possess anti-mutagenic and anti-tumour influences. (Srinivasan K., 2007).

The therapeutic uses of black pepper oil include analgesic, antiseptic, antispasmodic, antitoxic, aphrodisiac, diaphoretic, digestive, diuretic, febrifuge, laxative, rubefacient and tonic (especially of the spleen). (Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008).

Constituents of the piper species have shown *in vitro* inhibitory activity against the enzymes responsible for leukotriene and prostaglandin biosynthesis, 5-lipoxygenase and COX-1, respectively. These effects of piperine seem to be beneficial for inflammatory diseases that are accompanied by severe pain; for example, rheumatoid arthritis. (Bang J.S. *et al.*, 2009).

Many physiological effects of black pepper, its extracts or its bioactive compound, piperine, have been reported in recent decades. By stimulating the digestive enzymes of the pancreas, piperine enhances digestive capacity and significantly reduces gastrointestinal food transit time. (Srinivasan K., 2009).

The scientific literature provides evidence that black pepper may have health benefits, particularly in enhancing digestive tract function. It has been reported, for example, in rats and mice that black pepper and piperine can stimulate digestive enzymes, modify stomach secretions, alter gastrointestinal food transit time and inhibit diarrhoea. (Singletary K., 2010).

There is suggestive evidence that black pepper

piperine may have nervous system benefits and may influence body energy usage in rats. (Singletary K., 2010).

Preliminary evidence in cell culture studies suggests that black pepper contains antioxidant constituents and possesses anti-inflammatory and antimicrobial properties. (Singletary K., 2010).

The biological role of this specie is explained in different experiments that peppercorn and secondary metabolites of *Piper nigrum* can be used as antiapoptotic, antibacterial, anti-Colon toxin, antidepressant, antifungal, antidiarrhoeal, anti-inflammatory, antimutagenic, anti-metastatic activity, antioxidative, antipyretic, antispasmodic, antispermato-genic, antitumor, antithyroid, ciprofloxacin potentiator, cold extremities, gastric ailments, hepatoprotective, insecticidal activity, intermittent fever and larvisidal activity. (Ahmad N. *et al.*, 2012).

Pepper is described as a drug which increases digestive power improves appetite, cures cold, cough, diseases of the throat, intermittent fever, colic, dysentery, worms and piles. It stimulates circulatory system. (Meghwal M. and Goswami T.K., 2012).

Ayurvedic, Yunani, Siddha and folklore medicines in India used pepper and pepper containing preparations for the treatment of intermittent fever, neuritis, cold, pains and diseases of throat are practiced. (Meghwal M. and Goswami T.K., 2012).

Pepper is also used as an anti-periodic in malarial fever and therefore it is claimed having analgesic and antipyretic properties. Analgesic and antipyretic actions of piperine have been experimented on rabbit and mice and found strong antipyretic effect on typhoid vaccinated rabbits at a dose of 30 mg/kg body weight. (Meghwal M. and Goswami T.K., 2012).

Anti-inflammatory drugs make up about half of analgesics, remedying pain by reducing inflammation. It is found that piperine significantly inhibited the production of two important pro-inflammatory mediators, IL6 and PGE2, in IL1 α -stimulated human FLS. (Meghwal M. and Goswami T. K., 2012).

It has been found that piperine can increase absorption of selenium, vitamin B, beta-carotene and curcumin. It can improve digestion and stimulate the secretion from the taste buds and taste bud stimulation is a feedback loop for digestion process. It sends impulses to the stomach to increase digestive juices secretion (eg. Hydrochloric acid). These juices break down the protein in the stomach, improving ability for further digestion in the duodenum. (Meghwal M. and Goswami T.K., 2012).

1. Therapeutic Properties of Black Pepper

Sl. No.	Properties	Author/researchers whose research supports the theory
1.	Anti-oxidant Activity	● Srinivasan K., 2007 ● Singletary K., 2010 ● Ahmad N. <i>et al.</i>, 2012 ● Rondanelli M. <i>et al.</i>, 2012 ● Butt M. S. <i>et al.</i>, 2013 ● Meghwal M. and Goswami T.K., 2013 ● Chavarria D. <i>et al.</i>, 2016 ● Smilkov K. <i>et al.</i>, 2019 ● Stojanovic Z. <i>et al.</i>, 2019
2.	Anti-microbial Property	● Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008 ● Singletary K., 2010 ● Ahmad N. <i>et al.</i>, 2012 ● Meghwal M. and Goswami T.K., 2012 ● Srilakshmi B., 2016 ● Shityakov S., 2019 ● Smilkov K. <i>et al.</i>, 2019
3.	Anti-Inflammatory Property	● L. Majeed and L. Prakash, 2000 ● Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008 ● Bang J.S. <i>et al.</i>, 2009 ● Srinivasan K., 2009 ● Singletary K., 2010 ● Ahmad N. <i>et al.</i>, 2012 ● Meghwal M. and Goswami T.K., 2012 ● Srilakshmi B., 2016 ● Smilkov K. <i>et al.</i>, 2019
4.	Anti-Carcinogenic Property	● Srinivasan K., 2007 ● Ahmad N. <i>et al.</i>, 2012 ● Meghwal M. and Goswami T.K., 2012 ● Butt M.S. <i>et al.</i>, 2013 ● Greenshields A.L. <i>et al.</i>, 2015 ● Chavarria D. <i>et al.</i>, 2016 ● Smilkov K. <i>et al.</i>, 2019 ● Stojanovic Z. <i>et al.</i>, 2019
5.	Bio-availability/Absorption Enhancing Property	● Srinivasan K., 2007 ● Meghwal M. and Goswami T.K., 2012 ● Rondanelli M. <i>et al.</i>, 2012 ● Butt M.S. <i>et al.</i>, 2013 ● Srilakshmi B., 2016 ● Smilkov K. <i>et al.</i>, 2019 ● Stojanovic Z. <i>et al.</i>, 2019
6.	Gastrointestinal/Digestive Property	● L. Majeed and L. Prakash, 2000 ● Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008 ● Srinivasan K., 2009 ● Singletary K., 2010 ● Ahmad N. <i>et al.</i>, 2012 ● Meghwal M. and Goswami T.K., 2012 ● Butt M.S. <i>et al.</i>, 2013 ● Rofes L. <i>et al.</i>, 2014 ● Srilakshmi B., 2016
7.	Anti-pyretic Property	● L. Majeed and L. Prakash, 2000 ● Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008 ● Ahmad N. <i>et al.</i>, 2012 ● Meghwal M. and Goswami T.K., 2012
8.	Neurological Property	● L. Majeed and L. Prakash, 2000 ● Singletary K., 2010 ● Meghwal M. and Goswami T.K., 2012 ● Butt M.S. <i>et al.</i>, 2013 ● Chavarria D. <i>et al.</i>, 2016
9.	Hepatoprotective Property	● L. Majeed and L. Prakash, 2000 ● Srinivasan K., 2007 ● Ahmad N. <i>et al.</i>, 2012 ● Rondanelli M. <i>et al.</i>, 2012
10.	Rubefacient Property	● Parthasarathy V.A., Chempakam B. and Zachariah J.T., 2008 ● Meghwal M. and Goswami T.K., 2012

Limitations of use of Black Pepper as a Therapeutic Medicine.

Sl. No.	Limitations/Disadvantages	Authors/researches whose findings support the theory
1.	Toxicity	● Singletary K., 2010 ● Maffetone P., 2018 ● Stojanovic Z. <i>et al.</i>, 2019 ● Ren T. and Zuo Z., 2019
2.	Low bioavailability of piperine	● Smilkov K. <i>et al.</i>, 2019
3.	Low aqueous solubility	● Gorgani L. <i>et al.</i>, 2016 ● Ren T. and Zuo Z., 2019
4.	Lack of clinical evidence on human trials	● Stojanovic Z. <i>et al.</i>, 2019 ● Ren T. and Zuo Z., 2019

Pepper doesn't have cholesterol. It enhances digestion process by helping faster break down of larger fat molecules into easily digestible simple molecules and prevents the accumulation of fat in body. (Meghwal M. and Goswami T.K., 2012).

Black pepper exhibits immunomodulatory effect on human body. It is able to boost and supports the number and the efficiency of white cells and assists the body to raise a powerful defense against invading microbes and cancer cells. (Meghwal M. and Goswami T.K., 2012).

The berries are used externally as rubefacient in baldness and skin diseases. The berries are decocted and the solution is used as a mouthwash for toothache. (Meghwal M. and Goswami T. K., 2012).

Increasing bioavailability of other anti-tumour spices, pepper dramatically increases their potency and effectiveness against cancer. Black pepper counteracts cancer development directly. Its principal phytochemical is piperine, inhibits some of the pro-inflammatory cytokines that are produced by tumour cells. In doing so it interferes with the signalling mechanisms between cancer cells, thereby reducing the chances of tumour progression. Pepper prevents chemical carcinogenesis by stimulating the xenobiotic biotransformation enzymes. (Meghwal M. and Goswami T.K., 2012).

Ayurvedic medicine uses pepper mixed with ghee (buttery type compound) to treat external problem, nasal congestion, sinusitis, skin eruptions, and epilepsy. (Meghwal M. and Goswami T.K., 2012).

Piperine is an active component of black pepper that can effectively suppress lipid peroxidation and enhance the bioavailability of curcumin and other substances through the inhibition of drug-metabolizing enzymes in the liver. (Rondanelli M. *et al.*, 2012).

The free-radical scavenging activity of black pepper and its active ingredients might be helpful in chemoprevention and controlling progression of tumour growth. (Butt M.S. *et al.*, 2013).

The key alkaloid components of *Piper Nigrum*, that is, piperine assist in cognitive brain functioning, boost nutrient's absorption and improve gastrointestinal functionality. (Butt M. S. *et al.*, 2013).

More recently, piperine has been shown to have fundamental effects on p-glycoprotein and many enzyme systems, leading to bio-transformative effects including chemoprevention, detoxification, and enhancement of the absorption and bioavailability of herbal and conventional drugs. (Meghwal M. and Goswami T.K., 2013).

Based on modern cell, animal, and human studies, piperine has been found to have immunomodulatory, anti-oxidant, anti-asthmatic, anti-carcinogenic, anti-inflammatory, anti-ulcer, and anti-amoebic properties. (Meghwal M. and Goswami T.K., 2013).

Pure piperine was found to be very beneficial in the treatment of dysphagia, as shown in the trial performed on 40 dysphagia patients, randomized into two groups receiving two doses of piperine (150 μ M or 1 mM). Piperine improved the safety of swallow by reducing the prevalence of unsafe swallows, the severity score of penetration-aspiration scale, and shortened the time to laryngeal vestibule closure in a dose-dependent manner. (Rofes L. *et al.*, 2014).

Piperine inhibited the *in vitro* growth of TNBC cells, as well as hormone-dependent breast cancer cells, without affecting normal mammary epithelial cell growth. Exposure to piperine decreased the percentage of TNBC cells in the G2 phase of the cell cycle. (Greenshields A.L. *et al.*, 2015).

Piperine derivatives were shown to modulate the activity of several targets related to neurological disorders, including epilepsy, Parkinson's disease, depression and pain related disorders. (Chavarria D. *et al.*, 2016).

The efflux pump inhibitory ability of piperine and its analogues tackles important drug resistance mechanisms and may improve the clinical efficacy of antibiotic and anticancer drugs. (Chavarria D. *et al.*, 2016).

Black pepper is used along with hot milk for throat infections. Ancient home remedies prescribe pepper as all antidote to cough and chest congestion. (Srilakshmi B., 2016).

Pepper has also been used effectively for the treatment of rheumatism and muscular pain, intestinal gas and headache. (Srilakshmi B., 2016).

It is now believed that the active principle piperine increased the bio-availability of other medicines by increasing their absorption and delaying their metabolism. (Srilakshmi B., 2016).

Its anti-diabetic property has also been confirmed *in vivo* as well as hypolipidemic activity as evidenced by decrease in the level of cholesterol, triglycerides, and low-density lipoprotein and increase in high-density lipoprotein. (Heerasingh Takooree *et al.*, 2019).

Extracts from black pepper (*Piper nigrum*) with antimicrobial properties, including piperine, have the potential to be used as natural dietary supplements together with modern therapeutic approaches. (Shityakov S., 2019).

In its interaction with other drugs, it can act as a bioavailability enhancer; this effect is also manifested in combination with other nutraceuticals, e.g. with curcumin, i.e. piperine can modify curcumin's antioxidant, anti-inflammatory, antimicrobial and anticancer effects. (Smilkov K. *et al.*, 2019).

Clinical studies demonstrated remarkable antioxidant, antitumor, and drug availability-enhancing characteristics of this compound, together with immunomodulatory potential. All these facts point to the therapeutic potential of piperine and the need to incorporate this compound into general health-enhancing medical formulations, as well as into those that would be used as adjunctive therapy in order to enhance the bioavailability of various (chemo)therapeutic drugs. (Stojanovic Z. *et al.*, 2019).

Limitations

The acute effect of black pepper on the human stomach seems to be similar to that for aspirin, although long-term effect of black pepper on the stomach is unknown. (Singletary K., 2010).

In spite of the amazing therapeutic properties of piperine, its pharmaceutical activities have been limited due to its low aqueous solubility. The low aqueous solubility of piperine is the major barrier for its lab-to-clinic development as a drug. (Gorgani L. *et al.*, 2016).

Higher doses of black pepper may be comparable to the harmful gut effects of a single dose of aspirin, which causes mild intestinal bleeding. This *micro-bleeding* can occur with black pepper, which can also reduce the stomach's secretion of healthy digestive juices. (Maffetone P., 2018).

Piperine displays significant immunomodulating, antioxidant, chemopreventive and anticancer activity; these effects have been shown to be dose-dependent and tissue-specific. However, the main limitation associated with piperine seems to be its low bioavailability, a disadvantage that innovative formulations are overcoming. (Smilkov K. *et al.*, 2019).

Its antitumor potential, demonstrated through its apoptotic effect on many cancer types, should be further investigated, especially in the form of human clinical trials, since such data do not exist. (Stojanovic Z. *et al.*, 2019).

Due to some negative effects on the liver and on male fertility when given in high doses, future studies should focus on finding a safe therapeutic dose for pure piperine, since it represents a promising agent for the treatment of many human disorders. (Stojanovic Z. *et al.*, 2019).

Although the CNS beneficial effects of piperine have been extensively studied in preclinical models, clinical evidence on its CNS application is barely available, which may be attributed to its limited aqueous solubility, unclear pharmacokinetic properties in humans and potential toxicities during long-term use at higher doses. (Ren T. and Zuo Z., 2019)

Materials and Methods

Data Collection : Materials for the project were collected from various sources, some of which are listed below :

Websites

Research papers

Journals

Articles

Books (Hard Copy)

E-books

Selection Method : Reviews and research papers were thoroughly scrutinized. Chronological method of review writing was adopted. Findings, results and discussions relevant to the research topic were evaluated, selected, typed and sorted in chronological order from the aforementioned sources.

Analysis : The findings, results and discussions was assessed according to the degree of relevance to the research objectives and classified as such.

Results and Discussion

The result of review of literature conducted on the topic "Therapeutic Properties of black pepper can be divided into two categories based on the two objectives of the research.

The findings and results have been discussed according to the objectives of the research project.

Therapeutic Properties of Black Pepper : After analysis of various research findings on Black Pepper it can be concluded that the factor responsible for its therapeutic potential is due to the bioactive alkaloid compound piperine present in it. The pharmacological properties can be attributed to the presence of metabolites such as phenolic compounds, alkaloids, flavonoids, carotenoids, terpenoids, etc. Black pepper has been a part of traditional medicine for treatment of various body ailments. It has been used in Ayurvedic medicines and also in Chinese traditional medicine. Black pepper has innumerable claimed health benefits as well as theories. The most common therapeutic property studied on *piper nigrum* is protection against oxidative damage by inhibiting or quenching free radicals and reactive oxygen species i.e. anti-oxidant property. There are numerous researches and studies which support this claim. The other beneficial properties of black pepper are anti-microbial action, anti-inflammatory effects, anti-carcinogenic activity, enhanced bio-availability action on drugs and other compounds, assistance in digestive or gastrointestinal functions, fever-reducing or anti-pyretic effect, several neurological benefits, hepatoprotective functions by increasing bile secretion and rubefacient effects on skin. It is also claimed to have analgesic property. Cognitive brain functioning, anti-depressant effect and anti-diabetic activity are also said to be a property of black pepper but very few evidences are available to support the claim. Traditionally, black pepper is mainly used as an antidote for fever, cough, chest congestion, neuritis, cold pains and diseases of the throat.

Limitations of use of Black Pepper as a therapeutic medicine : Despite having numerous health benefits and therapeutic properties, black pepper has several limitations which restrict it from being used to its full potential. The main limitation of piperine, the bioactive compound of black pepper, is its low availability. The effects of piperine have been shown to be dose-dependent and tissue-specific. Toxicity is also a concern as black pepper in high doses is claimed to have harmful

effects similar to that of aspirin which reduces the secretion of healthy digestive juices and have negative effects on liver as well as male fertility. Low aqueous solubility of piperine also poses a great disadvantage as it is the major barrier for its development as a drug. Lack of human clinical trials is undoubtedly the weakest point of study of properties of black pepper which limits the accuracy and success of many research studies.

Conclusions

With emerging trends in nutraceuticals and functional foods, the current generation prefers medicinal products which are derived from natural sources. Black pepper (*Piper nigrum*) can be termed as one of those functional foods with its many favourable and natural therapeutic benefits and properties. The scope of its therapeutic and pharmacological potential is vast which is mainly contributed to its bioactive compound, piperine. Black pepper has been used in many researches and studies and has been approved of having anti-oxidant, anti-microbial, anti-inflammatory, anti-carcinogenic, anti-pyretic and analgesic effects. It is also found to have favourable effects on the digestive mechanism, neurological functions, bio-availability, hepatoprotective functions and rubefacient property. Essential oil extracted from Black pepper, BPEO, is responsible for its anti-microbial properties. Several evidences have proved the use of Black Pepper as a cure or relief for various ailments since time immemorial especially in Ayurvedic and Chinese medicine. However, black pepper has also been found to have its own share of constraints which restricts it from being developed from lab-to-clinical drug. It has dangers of toxicity, low bio-availability and low aqueous solubility which is related to various harmful health effects and is the root cause of low incidence of clinical human trial evidences. The scope on study of therapeutic properties of black pepper is vast and many researches are yet to be conducted. The currently available research materials and findings on therapeutic properties of black pepper are plenty but there is always room for more informative study.

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Documentation of Underutilized Fruits of North East India — A Review

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Abstract

North Eastern part of India is rich in actinorhizal plants diversity. The diverse agro-climate conditions, varied soil type, abundant rainfall and undulating topography of the region offer immense scope for evolution and development of different wild species specially the underutilized fruit trees. Wild fruits species have potential for economic, nutritional and other desirable traits. These wild indigenous edible fruit species are distributed in the foot hill tracts of the Eastern Himalayas, India inclusive eight states, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram. These underutilized foods possess potential natural colour, bioactive compounds and traditionally has been used in curing several ailments. In addition, these food crops also have potential for diversification such as value added product to increase the livelihood of the farmers. Thus there is a need to standardize a scientific crop production, protection, development of improved varieties and marketing channel. It is high time that the communities, researchers and the entrepreneurs all work together to make these minor and underutilized food crops a commercially viable food crop of future. The co-existence of these wild plants along with the commercial exotic crops will definitely help in achieving food security and eco-sustainability in the future.

Key Words : Underutilized, fruit crops, north eastern states, bioactive compound, utilization.

Introduction

The North Eastern parts of India is predominately mountainous and among the highest rainfall regions in the world. The economy of the region is basically rural based, with agriculture playing a predominant role, among which underutilized fruit crops contributes significantly in the livelihood security. The diverse agro-climate conditions, varied soil type, abundant rainfall and undulating topography of the region offer immense scope for evolution and development of different wild species specially the underutilized fruit trees. Wild fruits species have potential for economic, nutritional and other desirable traits. These wild indigenous edible fruit species are distributed in the foot hill tracts of the Eastern Himalayas, India inclusive eight states, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim (North East India).

Geographically, the region stretches between 21°50' and 29°34'N latitude and 85°34' and 97°50'E longitude, and altitude varies from near sea-level to over 7,000m a.s.l. this region represent an important part of Indo Myanmar bio-diversity hotspot, one of the 25 global biodiversity hotspot. Therefore, the region is considered to be a store house and reservoir of wild genetic resources, particularly of underutilized fruit crops occurring wildly in the forest. There are about 800 different species of underutilized edible crops in India, out of which about 300 species are used mostly by the tribal and rural population of the North Eastern region alone. These underutilized crops exist in the nature through

survival of the fittest, thus may possess several desirable traits such as resistance to biotic and abiotic stresses.

Objectives

To explore different underutilized foods of North East India.

Documentation of most two underutilized foods of different states of North Eastern states of India.

Review of Literature

According to Singh R.S and Preetinder (2009) evaluated the litchi juice concentrate for the production of litchi wine. The large amount of fermentable sugar (85.20 percent) and acid content (4.25 percent) present in litchi juice concentrate were found suitable for its use in wine making. The high quality wine should have a characteristics bouquet and taste which depends on the cultivar, maturity and phytosanitary condition of the litchi fruit, pedoclimatic conditions are most importantly, on yeast fermentation physiology. All these factors caused the differences of aroma, fragrance, composition and quality among all kinds of fruit wine.

Researchers also studied about the value addition of peach, plum and apricot fruits. Sharma KD *et.al.*, (2011) developed instant value added products from dehydrated peach, plum and apricots fruits. On the basis of sensory data the products viz., powder, ready-to-serve drink mix and chutney mix prepared from apricot were rated as the best product followed by plum and peach fruits while dried pickle from the plum halves was rated excellent followed by apricot and peach.

Aina JO *et.al.*, (2011) carried out the study to formulate jam from the plum fruit. It evaluates the physico-chemical properties, nutritional properties and consumer acceptability of the product. Plum jam was produced using traditional open kettle method.

Estimation of nutritional, phytochemical, antioxidant and antibacterial activity of dried fig was done by Soni and his co-worker (2014). The study analyzed the health benefits of fig fruits and its potential to be used as a functional food. Phytochemistry of fig fruit reveals the presence of various bio-active compounds and it is reported that figs are used in traditional medicines for its therapeutic benefits against various disorder.

Rymbai Heiplanmi *et.al.* (2015) conducted the study on several wild indigenous fruit crops which are rare in other parts of the world but are grown favourably and naturally in the North Easter India. Collection and evaluation of 11 naturally occurring potential wild edible fruit plants have been discussed including their habitat, distribution, morphological description, quality parameters, utilization potential, constraints and possible strategies like how to increase their population size, productivity, conservation and utilization.

Islam *et.al.*, (2015) conducted the study to analyze functional and chemical properties of jackfruit seed. Seed flour was utilized in composite flour biscuit. Biscuits were prepared with 10 percentage, 20 percentage, 30 percentage and 40 percentage jackfruit seed flour and were compared with the plain biscuit (0 percentage seed flour) based on chemical properties and sensory properties. Research revealed that the protein and carbohydrate contents of prepared biscuits decreased with higher replacement of jack seed flour. But moisture, fat, crude fibre and ash content increased with higher replacement of jack seed flour seed. The sensory parameter indicated that upto 20 percentage level incorporation biscuits were not significantly different with 0 percentage jackfruit seed flour (plain biscuit) biscuit based on all sensory parameters. But the higher level of jackfruit seed flour biscuit rejected by the panelist as it was dark colour and hard texture.

Study conducted by Koyel and Arkendu (2016) utilizes some of the underutilized fruit crops such as aonla, bael and jamun. These fruits were processed and developed into different food items such as aonla jam, aonla sauce, bael fruit squash, bael Ready- To -Serve and bael jam.

Piyali *et.al.*, (2016) conducted study on value addition of some underutilized fruit crops. The underutilized fruits which were studied were aonla, bael,

jamun, pomegranate, date palm, wood apple and carambola. Some of the value added products from aonla fruits were-aonla sauce, aonla jam, aonla chutney, aonla candy, aonla juice, aonla powder, aonla pickle, etc. value added products from bael fruits were – bael candy, bael fruit squash, bael RTS, dehydrated bael, bael jam, etc. value added products from wood apple were – wood apple jam and wood apple bar. Researchers developed different products, processing methods and marketing strategies for these underutilized fruits.

Labh and Shakya (2016) conducted study on medicinal importance of indigenous lapsi fruit. It was found that lapsi fruits with high vitamin C were mostly consumed fresh. But also the fruits processing were done in domestic, semi-commercial and commercial scale as well. Traditionally lapsi was processed to pickles, candy and titaura. The main marketable lapsi products were: candy, pickle, titaura, lapsi powder and lapsi squash.

Rinita (2017) studied the enterprises of Lapsi fruits production and its uses in market. The pulp of the Lapsi fruits was used for preparing Lapsi powder, candy and its seed stone was used for the preparation of activated carbons.

Sing SR *et.al.* (2017) conducted a study on variability of Burmese grape. From the investigation two types of morphotype could be identified in the region. Its different physical and quality parameters revealed that the sweetness ranges from 12.5 to 16.5 Brix and the fruit parameters like fruit weight, pulp weight, fruit juice, TSS, total sugar and acidity are found to be significant among the genotype.

Research Methodology

A secondary data was collected to enumerate the important potential wild edible fruits of North East India situated in the foot hills track of Eastern Himalayas. Several research papers were studied to gather the information on utilization of different potential underutilized fruit crops.

Discussion

From the research paper studied it was found that there were many different underutilized edible fruit genetic resources occurring naturally in the region. The current research review reports the two most underutilized fruit crops from different states of North Eastern India and their health benefits.

Underutilized fruits of Meghalaya-

a. Cane Fruit (*Calamus meghalayensis*)-

Cane Fruit (*Calamus meghalayensis*) belong to

Arecaceae family and native to Khasi Hills (Meghalaya) of the North Eastern India. The fruit is locally known as Sohthri in Khasi and Pnar, Sohml in Garo. It grows wildly as well as cultivated in warmer parts of the Khasi, Jaintia, Garo Hills and other areas of the region. Cane fruit contain protein, potassium and pectin, as well as nutrients like thiamine, iron, calcium and vitamin C. Cane fruits are also high in compounds such as Flavonoids, phenolic acids and tannins, which may be useful in the prevention of allergies, inflammation, and even ulcers and tumors.

Fruit pulp inside the outer woody skin is aril and are edible, very juicy, little acidic but very delicious and relished by the indigenous population. The fruit can also be processed to different products such as juice, squash and candy.



b. Silver Berry (*Elaeagnus latifolia* L.)-

It belongs to family Elaeagnaceae, genus *Elaeagnus* commonly known as Bastard oleaster and the vernacular name is Sohshang in Khasi Hills, Slangi in Jaintia Hills and Muslerhi in Sikkim (Rymbai Heiplanmi *et.al*, 2015). The species grows well in forest openings, swamps, to elevations between 1500 and 2600 m a.s.l in the Himalayas.

Chemical analysis recorded TSS (11.9 percentage), acidity (2.8 percentage), vitamin C (1619.2 mg/100g pulp), total sugar (6.1 percentage), -carotene (1.1 µg/100g pulp), anthocyanin (16.2 mg/100g) and antioxidants (10.1 g moltolox/g). Fruit is fairly rich in minerals and essential fatty acids (Patel *et al*, 2008) All parts of the fruit are edible including seed, and at all stages of fruit growth. They are usually consumed raw with salt or used in pickle preparation by the indigenous tribes. Pulp is used for making jam, jelly and refreshing drink. The extracted juices possess attractive reddish or pinkish colour.



Underutilized Fruits of Arunachal Pradesh

a. Box myrtle fruit (*Myrica esculenta*)-

This fruit crop belongs to family Myricaceae, commonly known as box myrtle. It is locally known as Buching in Apatani (Arunachal Pradesh). The species is distributed in the temperate and sub-tropical regions (India and China) of both hemispheres. In India, it is confined in subtropical Himalayas and quite common in North Eastern India (Kumar, 2002).

Fruits are eaten fresh at all stages of its growth, and are one of the tastiest and preferred wild fruits of the region. In Himachal Pradesh this fruits are consumed fresh because of their taste and juiciness. This fruit can be used for making refreshing drink and pickle. The fruit can also be processed to syrup (Abhimanyu, 2017). The bark has medicinal properties and is used as aromatic, stimulant for rheumatism, astringent, carminative, asthma, toothaches, diarrhoea, lung infection, fever, cough, bronchitis, dysentery, antiseptic indigenous medicine and in the preparation of yellow dye (Heiplanmi *et.al*, 2015).



b. Wild Apple (*Docynia indica*)-

Wild apple (*Docynia indica*) belongs to the Rosaceae family and locally known as Pecha in Apatani (Arunachal Pradesh). The species prefers moist soil and open places up to elevations of 700-3000 m a.s.l. It is native of the Eastern Himalayas. The species is distributed from East Asia to China, Nepal, Bhutan and North Eastern India. It naturally grows in the forest (Heiplanmi *et.al*, 2015).

Studies on chemical content of fruits showed that pH 3.25, moisture 80.31-85.14 percentage, vitamin C 14.8-17.5 mg/100g pulp, protein 1.81-2.76 mg/100g pulp, potassium 140mg/100g, magnesium 20.60 mg/100g and micro elements such as iron, copper, cobalt, manganese and zinc.

Utilization

The fully ripe fruit is eaten as fresh, while the half ripe are consumed as fresh with salt or boiled with sugar, sundried and consumed (Rymbai Heiplanmi *et.al*, 2015). Fruits are also used for preparation of pickles and jelly. It was reported that the natural products extracted from the fruit consist of polyphenol compounds, especially flavonoids

and alkaloids which are found to reduce the blood glucose concentration, and in turn have anti-obese effects in mice.



Underutilized Fruits of Assam-

a. Crude Stalk thick Plum (*Padus napulensis*)-

Crude stalk thick plum (*Padus napulensis*) is a member of Rosaceae family which is commonly known as Sohiong in Assamese (Assam). It is also known as Khasi cherry or Sohiong in Khasi (Meghalaya). It is a wild growing fruit found in temperate Himalayan regions at altitudes between 800 and 3000m a.s.l. It starts occurring from Kumaon hills of Indian upto Bhutan and North East India. It is quite common in Khasi and Jaintia Hills of the Indian state of Meghalaya and Assam where it is cultivated.

According to the size and quality the chemical contents also varies. Bigger fruit type recorded higher content of acidity (3.32 percentage), ascorbic acid (58.38 mg/100g), total sugar (8.75 percentage), pectin (2.00 percentage), moisture (in fruit 61.84 percentage and seed 33.33 percentage) as compared to smaller fruit types. However, higher content of TSS (20.15 percentage), β -carotene (2.76 mg/100g), and fibre (2.5 percentage) was obtained in smaller fruits of Sohiong.

Sohiong are usually consumed in raw form. Fruits are eaten raw and used for wine making due to its imparting purple colour to the wine. Cherry sauce can also be prepared from Sohiong fruits. It has observed that its colour added to squash and jam last longer of around one year. RTS and cheery wine are prepared from pulp and juice of the fruit to impart purple colour to the wine.



b. Bael fruit (*Aegle marmelos*)-

Bael fruit (*Aegle marmelos*) belongs to family Rutaceae and is commonly known as Bael, Bengal Quince, Indian Bael, Wood Apple, Matoom, etc. This fruit bearing tree is found in dry forest, hills and plains of Myanmar, Pakistan, Bangladesh, Nepal and India. The tree, which is the only species in the genus *Aegle*, grows upto 18m tall with the

thorns and fragrant flowers. It grows in all types of soil, climate and require little care when established.

The bael fruit pulp contains many functional and bioactive compounds such as carotenoids, phenolics, alkoids, coumarins, flavonoids, terpenoid and other antioxidants which may protect us against chronic disease. The bael fruit is of considerable medicinal value when it just begins to ripen.

The fruits are mostly eaten as raw both in unripe and ripe stages. The fruits can be processed to juice, jam, candy, preserve, panjiri and toffee.

The pulp can be used to prepare delicacies like murabba and pudding. All the part of bael plant such as stem, bark, root, leaves and fruits has medicinal value. The ripe fruit is aromatic, astringent, cooling and laxative. It is useful in preventing scurvy and it also strengthens the stomach and promotes its action (Kartikar and Basu, 1935).



Underutilized Fruits of Manipur-

a. Plum (*Prunus domestica*)

Plum (*Prunus domestica*) is one of the important fruit crops cultivated in temperate regions of the world. Plums are a drupe fruit of the subgenus *Prunus* of the genus *Prunus* (Family Rosaceae) and locally it is known as "Heikha" in Manipuri language.

Plums have abundance of bioactive compounds such as phenolic acids, anthocyanin, carotenoids, minerals and pectins).

Plums constitute a valuable component of our diet, both in terms of their nutritive and dietary value. They have low calorie content and relatively high nutritive value. They contain carbohydrates, such as sucrose, glucose and fructose, organic acids, e.g., citric and malic acids, fibre (pectins), tannins, aromatic substances and enzymes. Contents of minerals in plums increases as fruits ripen. These substances determine nutritive value and taste of plum.

Utilization

Plums with high sugar content and firm flesh dried without removal of stone are called prunes. Plums are processed as plum juice, plum paste, plum jam and jelly. In different

parts of India plums are used for preparing different recipes such as plum sauce and as a substitute for prunes. Plums also offer several health benefits having high in Vitamin K which helps in proper blood clotting. The phenols present provide antioxidant benefits.



b. Apricot (*Prunus armeniaca* L.)-

Apricot (*Prunus armeniaca* L.) belongs to family Rosaceae and the vernacular name is “Malhei” in Manipur. It is a temperate fruit and grown in climates with well-differentiated seasons. It requires a fairly cold winter and moderately high temperatures in the spring and early summer (Gani et al, 2018).

Botanically, apricots are drupes like peaches, plums, cherries and mangoes in which the outer fleshy part surrounds a hard stone with a seed inside. Fruit colour ranges between orange to orange red and some cultivars are cream white to greenish white (Sharma et al, 2011).

Among stone fruits, apricot is a carbohydrate rich and is good source of fibres, minerals and vitamins. Carbohydrates concentration in fresh apricots ranges from 11-13 percentage and provides 50 KCals of energy per 100g. It is also rich in bioactive phytochemicals that have certain roles in the biological system and effective in preventing oxidative stresses. Apricots contains varied amounts of essential minerals such as potassium, phosphorus, calcium, magnesium, iron and selenium, while sodium, manganese, zinc and copper are also present in small quantities. Similarly vitamins found in apricots are pro-vitamin A, vitamins C, K, E, thiamine (B1), riboflavin (B2), niacin (B3), pyridoxine (B6), Folic acid (B9) and pantothenic acid.

Mostly apricots are consumed in fresh form by the people. Apricots can also be used for the preparation of jam, jellies and marmalades. Most common processed product of apricot is dried apricot so that it can be available throughout the year. Apricots have a number of widely lauded health benefits either in its fresh or dried form. The high Vitamin A in apricots helps maintain eye health and reduces the risk of cataract formation.



Underutilized Fruits of Mizoram-

a. Passion Fruit (*Passiflora* L.)-

Passion Fruit (*Passiflora* L.) belongs to family Passifloraceae with its major centre of diversity in Brazil (Vera Edwin et al, 2003). In India it is found to be growing in many North Eastern states such as Manipur, Nagaland and Mizoram. In Mizo language it is known as “Sapthei”. There are two recognized forms of edible passion fruit; purple (*Passiflora edulis* Sims) and yellow (*Passiflora f. flavicarpa* Deg).

It is rich source of Vitamin A and contains fair amounts of Sodium, Magnesium, Sulphur and Chlorides. Commercial processing of yellow passion fruits yields 36 percentage juice, 51 percentage rinds and 11 percentage seeds (Carlos et al., 2015).

Locally the fruit is mostly consumed in its raw form. But it can also be processed to juice, squash. It can also be used in the preparation of cakes, pies and ice-cream. To enhance the flavour of the final produce, passion fruit juice is often mixed with juices of pineapple, mango, ginger, etc. The leaf of passion fruit is used as a vegetable in the hills of North Eastern India. Apart from its consumption as food the passion fruit is also highly valued for its medicinal use. In Kerala, doctors recommend passion fruit for dengue patients since it is believed that passion fruit helps in increasing the platelet count. The leaf of the fruit is believed to bring down blood sugar. And also the fruit is rich in antioxidants and other reserve phenols (Padree, 2018).



b. Litchi (*Litchi chinensis* Sonn.)-

Litchi (*Litchi chinensis* Sonn.) is a nourishing and flavourful fruit that grows in tropical and sub tropical area (Xin et al., 2008). Litchi is the sole member of the genus Litchi in the Soapberry family, Sapindaceae. It was introduced in India about 100 years ago. Litchi is nonclimacteric fruit and has a limited distribution. In India it is grown in the States of Bihar, Tripura, West Bengal, Meghalaya and Mizoram (Singh et al, 2009).

Litchi pulp contains protein, lipids, carbohydrates, vitamins (mainly Vit C, Vit B-Complex) and phytonutrient Flavonoids and minerals like manganese, magnesium, copper, iron, folate, anthocyanins and tannins.

In Mizoram, litchi is commonly consumed in its raw form. Litchi can be processed into different products such as juice, squash, syrup, cordial, wine, jam, jelly, candy and toffee. Most recently there has been an increasing trend of switching simple food towards functional food and therefore litchi juice is used which has got natural antioxidants, which can further be increased by adding probiotics. Probiotics benefits the host by acting as living microbial supplements (Prakash et.al., 2017). Litchi having ample amount of bioactive compounds like Flavonoids, Vitamin B-Complex and ascorbic acid confers significant health benefits. The health benefits due to these active compounds include disease- fighting ability, better heart health and blood regulation and free radical scavenging capacity.



Underutilized Fruits of Nagaland-

a. Fig (*Ficus carica* L.)-

Fig (*Ficus carica* L.) belongs to Moraceae family, and are cousins to the Artocarpus species breadfruit and jackfruit (Ken et al, 2007). In Nagaland, fig is locally known as “Mbuithi”. Figs of various types can be cultivated from sea level to over 5000 feet. The plant is tolerant of most soils with good drainage. It tolerates drought and some soil salinity but not highly acidic soil (Ken et al, 2007). In India, fig is considered to be a minor fruit crops and the commercial cultivation of the fruit is very confined.

There are about 20 popular varieties of fig that are being grown in different parts of the world. Figs are high in natural sugars, minerals and soluble fibre. Figs are rich in minerals and vitamins including potassium, calcium, magnesium, iron, copper, vitamin A, vitamin C and vitamin K (Soni et al, 2014).

Figs are mostly consumed freshly or dried forms (Soni et al, 2014). Figs can also be processed into juice, smoothie, jam and jelly. Different plant parts like fruits, seeds, leaves, tender, bark, shoots and latex have numerous medicinal applications. In folk medicine, figs were used for arthritis, stomach upsets and headache. In South America, fig extracts are used to treat puffy gums, abnormal tissue growth and tumours. The book “Indian Medicinal Plants” explains that cluster figs treated diarrhoea, dyspepsia and haemorrhages. Figs are also used as skin protective against different derma toxic effects.



b. Tree Tomato (*Cyphomandra betacea* Sendt.)-

Tree Tomato (*Cyphomandra betacea* Sendt.) belongs to Solanaceae family, also commonly known as Tamarillo (Ken et al, 2007) . The tamarillo is native to the Andes of Colombia, Peru, Argentina and Bolivia. In India it grows in the hilly regions of West Bengal, Maharashtra, Assam, Uttaranchal, Nagaland and Himachal Pradesh. Tamarillo is locally known as “Begenā” in Sumi tribe (Nagaland). The tamarillo prefers subtropical climate, with rainfall between 600-4000 mm and annual temperatures between 15-20°C. It grows best in light, deep and fertile soils.

Tree tomatoes contain the following values per 100g according to “Nutritive Value of Indian Foods”: moisture (82.6g), protein (1.5g), fat (2g), CHO (6.7g), calcium (12mg), iron (1.0mg), potassium (539mg) and carotene (324ig).

Tree tomatoes are commonly consumed as chutney by the locals. It can also be processed to jam as the fruit has high pectin content. It can substitute the tomatoes in salads and sandwiches. It can be used in cooking as both fruit and vegetables. They can be processed eaten raw or cooked in sauce, jams, chutneys, sambar, rasam and other savoury dishes. Some of the successful recipes made from tamarillo are juice, puree, ketchup, chutney and sauce. National Institute of Health, India found that tree tomatoes have high levels of anthocyanins, which protects the body from diabetes, symptoms of ageing, certain cancers and neurological disease. It also contain lycopene which boosts heart health and the skin ability to withstand UV radiation.



Underutilized Fruits of Sikkim-

a. Laurel Cherry Spices (*Prunus undulate*)-

Laurel Cherry Species (*Prunus undulate*) belongs to Rosaceae family. The species is rare and grows wild in mountainous or hilly forests or river valleys. It is well distributed from Asia-temperate to tropical including Indian Subcontinent such as Bangladesh, Bhutan, Nepal,

India- Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim, Uttar Pradesh and West Bengal at elevations of 500-3600 m a.s.l.

The plant (especially the seed and young shoots) contain cyanogenic glycosides, especially amygladin and prunasin. When ingested, these compounds break down the digestive tract to release cyanide. Used in small quantities, this exceedingly poisonous compound has been shown to stimulate respiration, improve digestion and promote well being. In larger concentration, however cyanide can cause gasping, weakness, excitement, pupil dilation, convulsion and respiratory failure leading to death. In general, it can be considered safe to eat any fruit or seed that either have a sweet or slightly bitter flavour, but if the flavour is moderately to very bitter great caution should be taken .

It is mostly found as fresh fruit in local markets. The fruit can also be used for making marmalades, jam and cakes. It is also consumed in its dry form by the locals. Its decoction stimulates respiration and improves digestion. Fruit extract gives dark grey to green dye (Heiplanmi *et.al*, 2015).



b. Lapsi (*Choerospondias axillaris*)-

Lapsi (*Choerospondias axillaris*) is a wild, large, deciduous, dioecious fruit tree belonging to family Anacardiaceae. Lapsi is native to Nepal also known as Nepali hog plum in English. The tree is largely known for its delicious fruit in Nepal, for timber in China and for medicine in Vietnam (Chhetri and Gauchan, 2006).

Lapsi fruit is extremely rich in vitamin C so, even at full ripe stage they are extremely sour. The calorie of lapsi fruit is around 380Kcal per 100g. The pulp is rich in amino acids (Joshi, 2017).

Utilization-

Fruits are eaten raw, pickled, processed into titaura or sometimes used for alcohol production in different level (Chhetri and Gauchan, 2006).



Underutilized Fruits of Tripura-

a. Jackfruit (*Artocarpus heterophyllus*)-

Jackfruit (*Artocarpus heterophyllus*) , also known as jack tree, is a species of tree in the fig and mulberry family (Moraceae). In India it is found in Western Ghats of southern India and North Eastern states such as Arunachal Pradesh, Assam, Meghalaya and Tripura. It is well suited to tropical lowlands. The vernacular name is “Kathal” in Tripura (Ashima, 2018).

The edible pulp is 74 percentage water, 23 percentage CHO, 2 percentage protein and 1percentage fat. The CHO component is primarily sugars and is a source of dietary fibre. In 100g portion, raw jackfruits provides 400 KJ and is a rich source of vitamin B6 , vitamin C and potassium (Ashima, 2018).

Ripe jackfruit is naturally sweet and is used to make variety of dishes such as custards, cakes, ice-cream and chips. The seeds from the ripe fruits are edible, and are said to have a milky and sweet taste. They are eaten as boiled, baked or roasted. The seed of the jackfruit can be processed to fine powder and can be used in the preparation of bakery product such as cakes, biscuits and cookies (Islam *et.al*, 2015).



b. Burmese Grape (*Baccaurea ramiflora* Lour)-

Burmese Grape (*Baccaurea ramiflora* Lour) is a species of flowering plant belonging to the Phyllanthaceae family. The genus comprises about 80 species, distributed from Indo-Malaysia to the West Pacific (Heiplanmi *et al*, 2015).

Chemical analysis of fruits revealed that TSS was 8.2-14.1percentage, acidity 1.93percentage; reducing sugar 5.10percentage and total sugar 13.69percentage besides, fruits are also rich in protein and iron.

Arils of ripened fruits are eaten very deliciously by the tribal population. Fruits are mainly used for preparation of squash, RTS, wine and jam. Fruits and leaf also yields dye of chocolate colour which can be used as colorants for many processing products. The rinds of the fruits are occasionally used for making pickle. Traditionally fruit juice is either stewed or used to prepare wine, and is also used for the treatment of arthritis, abscesses and injuries. In Arunachal Pradesh, the young leaves are used as vegetable or flavouring agent for

curries. The fresh bark of the plant chewed or juice taken orally for complaints of constipation. The seeds produce a valuable dye called “annatto” which is used for colouring silk, cotton and other textile materials in orange.



Conclusions

North Eastern part of India is rich in actinorhizal plants diversity. Wild edible fruit genetic resources possess valuable nutrients, medicinal and importance sources of desirable genes. There is a possibility of adopting these underutilized food crops over a wide range of agro-climatic conditions due to their hardy in nature. Similarly, food availability can be extended almost throughout the year for nutritional security among the tribal population. It has been that these underutilized foods possess potential natural colour, bioactive compounds and traditionally has been used curing several ailments. In addition, these food crops also have potential for diversification such as value added product to increase the livelihood of the farmers. Thus there is a need to standardize a scientific crop production, protection, development of improved varieties and marketing channel. It is high time that the communities, researchers and the entrepreneurs all work together to make these minor and underutilized food crops a commercially viable food crop of future. The co-existence of these wild plants along with the commercial exotic crops will definitely help in achieving food security and eco-sustainability in the future.

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Economic Analysis of Credit Flow through District Central Co-operative Banks in Southern Rajasthan

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Abstract

The economic analysis of short and medium term credit flow in District Central Co-operative Banks (DCCBs) of five districts (Udaipur, Banswara, Dungarpur, Bhilwara and Chittorgarh) in Southern Rajasthan from 2000-01 to 2017-18 was conducted. The average short term credit flow during this period ranged from Rs. 7917.6 lakhs per year in Dungarpur district to Rs. 36080.8 lakhs per year in Chittorgarh district. The average medium term credit flow during this period ranged from Rs. 787.8 lakhs per year in Dungarpur district to Rs. 2808.1 lakhs per year in Bhilwara district. The Coefficient of Variation (CV) for medium term credit flow was low (32.2 to 72.5%) compared to short term credit flow (74.9 to 103.4%). There was more variation in Gini concentration ratio for medium term credit flow (0.159 to 0.431) when compared to the short term credit flow (0.147 to 0.2) during the study period. However, the Gini concentration ratio were closer of zero (than one) indicating less inequality. The Gini ratio and Lorenz curve for short and medium term credit flow showed inequality in short and medium term credit flow in all DCCBs within the district (over the years) and among the districts during the study period.

Key words : Inequality, credit flow, coefficient of variation, cooperative bank, gini ratio, lorenz curve.

Introduction

The co-operative credit system in India comprises the short term (ST) or production credit structure and the long term (LT) investment credit structure. The ST structure has at its base the Primary Agricultural Credit Societies (PACS), which are affiliated to District Central Co-operative Banks (DCCBs) at the district level, which in turn, are affiliated to State Co-operative Banks (SCB) at the state level. The DCCBs deposit for investment in agricultural and non-agricultural sectors through co-operative societies. The State Co-operative Banks are connected to the RBI and provides the finance to Co-operative Banks. In three tier structure of short and medium term credit, the DCCBs play a pivotal role in providing credit to agriculture/allied sectors and act as a balancing centre for rural finance. One of the significant functions of DCCBs is to mobilize local funds from various sources and to utilize them for providing adequate agricultural finance through its constituent primary societies, so as to accelerate the pace of agricultural development and to extend rural banking facilities. These banks act as friend, philosopher and guide to the entire co-operative movement in the district.

The progress of Co-operative movement in Rajasthan from 1953 to 2019 showed that in 1953 total branches were 16 comprising 5 regional offices (Jaipur, Udaipur, Jodhpur, Kota and Bikaner) and 11 branches

handled from Jaipur. During 2019 total branches of District Central Co-operative Banks in India and Rajasthan were 363 and 29, respectively (DES, Rajasthan 2019). The objective of this research paper is to assess the trends in short and medium term credit flow in DCCBs in Southern Rajasthan from 2000-01 to 2017-18 and to estimate the extent of inequality.

Materials and Methods

Southern Rajasthan comprises seven districts namely; Udaipur, Rajsamand, Chittorgarh, Bhilwara, Pratapgarh, Dungarpur and Banswara. Out of these, five districts were selected randomly selected viz. Udaipur, Dungarpur, Banswara, Bhilwara and Chittorgarh. Five branches each from these five districts were selected on the basis of highest loan disbursement. The information on credit flow from 2000-01 to 2017-18 was obtained from the published data of the National Federation of State Co-operative Banks Ltd. (NAFSCOB), annual reports of DCCBs, progress reports and other records of banks. The time series data on gross cropped area, net cultivated area, area under cereals and average rainfall were collected from the published reports/ bulletins of Government of Rajasthan.

The district wise inequality in disbursement of short term and medium term loans by DCCBs was assessed with the help of Coefficient of Variation, Gini ratio and Lorenge Curve techniques. The district wise CV was

Table-1 : Trends in inequality in short term credit flow by DCCBs (2000-01 to 2017-18). (Amount Rs. in lakhs)

S. No.	Year	Udaipur	Banswara	Dungarpur	Bhilwara	Chittorgarh	Total
1.	2000-01	1861	2261	1305	3096	4492	13015
2.	2001-02	1861	2261	1305	3096	4492	13015
3.	2002-03	1861	2261	1305	3096	4492	13015
4.	2003-04	1972	2565	1305	3331	4998	14171
5.	2004-05	1980	2565	2577	5608	9373	22103
6.	2005-06	2120	4381	2608	6896	11093	27098
7.	2006-07	7020	4958	2791	8945	15392	39106
8.	2007-08	9075	5225	4001	10321	22708	51330
9.	2008-09	4835	5459	2452	10321	24116	47183
10.	2009-10	7622	6066	2271	8948	26273	51180
11.	2010-11	12313	10137	6273	16563	32812	78098
12.	2011-12	19229	13593	9418	27786	44324	114350
13.	2012-13	19229	22241	14513	46535	59150	161668
14.	2013-14	19229	34484	14513	69639	90736	228601
15.	2014-15	19229	31690	21113	71856	83060	226948
16.	2015-16	19229	31690	21339	74414	78438	225110
17.	2016-17	19229	31690	22296	74414	66753	214382
18.	2017-18	19229	31690	11132	65478	66753	194282
	Total	187123	245217	142517	510343	649455	1734655
	Mean	10395.72	13623.17	7917.611	28352.39	36080.83	96369.2
	SD	7785.40	12865.59	7663.037	29315.29	30316.33	86510.29
	CV%	74.89	94.44	96.78	103.40	84.02	89.76

Table-2 : Trend in inequality in medium term credit flow by DCCBs (2000-01 to 2017-18). (Amount in Rs. lakhs)

S. No.	Year	Udaipur	Banswara	Dungarpur	Bhilwara	Chittorgarh	Total
1.	2000-01	1866	704	719	2755	2768	8812
2.	2001-02	1866	704	719	2755	2768	8812
3.	2002-03	1866	704	719	2755	2768	8812
4.	2003-04	1972	153	719	846	1182	4872
5.	2004-05	1980	153	1415	1573	1133	6254
6.	2005-06	2120	610	469	1278	1401	5878
7.	2006-07	2253	960	1125	2867	1253	8458
8.	2007-08	1544	1305	1403	949	1257	6458
9.	2008-09	824	628	618	949	1510	4529
10.	2009-10	2607	655	1404	1985	1957	8608
11.	2010-11	2687	2702	817	6527	6548	19281
12.	2011-12	1218	1279	1030	2720	2902	9149
13.	2012-13	1218	1263	546	4460	4526	12013
14.	2013-14	1218	1290	546	3891	3687	10632
15.	2014-15	1218	430	278	4370	3904	10200
16.	2015-16	1218	430	331	3622	3112	8713
17.	2016-17	1218	430	473	3622	3700	9443
18.	2017-18	1218	430	849	2622	2642	7761
	Total	30111	14830	14180	50546	49018	158685
	Mean	1672.83	823.89	787.78	2808.11	2723.22	8815.83
	SD	537.90	597.60	356.66	1472.43	1421.98	3266.93
	CV%	32.15	72.53	45.27	52.43	52.22	37.05

Table-3 : Gini concentration ratio of inequality in short-term and medium-term agricultural credit flow by DCCBs (2000-01 to 2017-18).

Year	Gini Concentration Ratio	
	Short term agricultural credit	Medium term agricultural credit
2000-01	0.171	0.159
2001-02	0.168	0.161
2002-03	0.163	0.163
2003-04	0.165	0.364
2004-05	0.200	0.431
2005-06	0.173	0.396
2006-07	0.170	0.185
2007-08	0.186	0.213
2008-09	0.159	0.354
2009-10	0.150	0.284
2010-11	0.175	0.214
2011-12	0.181	0.212
2012-13	0.178	0.250
2013-14	0.156	0.302
2014-15	0.179	0.294
2015-16	0.179	0.283
2016-17	0.182	0.261
2017-18	0.147	0.268

calculated for a period of 18 years (2000-01 to 2017-18) and Gini ratio was estimated (Grewal, 1987). Higher the value of Gini ratio (L), more is the inequality in distribution of credit and vice versa. The Gini ratio ranges from 0 to 1. Lorenz curve technique is the graphical representation of cumulative proportion of number of DCCBs in Southern region on horizontal X-axis and cumulative proportion of agricultural credit flow per hectare of gross cropped area by DCCBs on the vertical Y- axis. The line of equal distribution is the straight line at 45° angle joining (0, 0) and (100, 100) points. The degree to which a line Lorenz curve deviates from the line of equal distribution is a measure of the inequality of distribution of a loan. Further, more the curve moves away from the equality line, the greater is the inequality. Both Gini ratio and Lorenz curves were obtained for the base year (2000-01), mid-year (2008-09) and terminal year (2017-18) of the study period.

Results and Discussion

Short term credit flow : District wise trends in inequality in short term credit flow by DCCBs during 2000-01 to 2017-18 in five districts of southern Rajasthan is presented in Table 1. The loan disbursement during the entire period was highest in Chittorgarh district (Rs. 649455 lakhs) and lowest in Dungarpur district (Rs. 142517 lakhs). The CV in loan disbursement during the period varied from 74.9% (in Udaipur district) to 103.4% (in Bhilwara district). This wide variation was due to the

fact that each DCCB finalized the scale of finance every year independently and the short term loans were disbursed to farmers in each district. Various studies have reported that there was inequality in short term agricultural credit flow (Arrora and Tiwari, 1978; Giri and Dasgupta, 1988).

Medium term credit flow : Trends in inequality in medium term credit flow by DCCBs during 2000-01 to 2017-18 is presented in the Table 2. The loan disbursement during the entire period was highest in Bhilwara district (Rs. 50546 lakhs) and lowest in Dungarpur district (Rs. 14180 lakhs). The CV in medium term loan disbursement during the period varied from 32.2% (in Udaipur district) to 72.5% (in Banswara district). The inequality in medium term credit flow was low compared to short term credit flow. Similar results were reported by Zeratsion *et al.* 2001.

Inequality in credit flow : Gini concentration ratio of inequality in short-term and medium-term agricultural credit flow by DCCBs during 2000-01 to 2017-18 is presented in the Table 3. For short term credit flow, the Gini concentration ratio varied from 0.171 during the base year to 0.159 during the mid-year and 0.147 during the terminal year. The Gini concentration ratio varied from 0.147 to 0.2 during different years of the study period.

For medium term credit flow, the Gini concentration ratio varied from 0.159 during the base year to 0.354 during the mid-year and 0.268 during the terminal year. The Gini concentration ratio varied from 0.159 to 0.431 during different years of the study period. There was more variation in Gini concentration ratio for medium term credit flow when compared to the short term credit flow during the study period. However, the Gini concentration ratio were closer of zero (than one) indicating less inequality. Similar results were reported by Jadhav *et al.* (2007) and Jadhav (2009).

Conclusions

The economic analysis of credit flow through DCCBs in five districts in southern Rajasthan from 2000-01 to 2017-18 indicated wide variation over the years and among the districts. The average short term and medium term credit flow during this period in all the districts was Rs. 96369.2 lakhs and 8815.8 lakhs respectively. The Coefficient of Variation (CV) for medium term credit flow was low (37.05%) compared to short term credit flow (89.8%) in all districts. There was more variation in Gini concentration ratio for medium term credit flow (0.159 to 0.431) when compared to the short term credit flow (0.147 to 0.2) during the study period. However, the Gini concentration ratio were closer of zero (than one) indicating less inequality. The Gini ratio and Lorenz curve

for short and medium term credit flow showed inequality in short and medium term credit flow in all DCCBs within the district (over the years) and among the districts during the study period.

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Factors Influencing of Short Term Agricultural Credit Flow through District Central Co-operative Banks in Southern Rajasthan

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Abstract

The economic analysis of factors influencing of short term of Agricultural credit in District Central Co-operative Banks (DCCBs) of five districts (Udaipur, Banswara, Dungarpur, Bhilwara and Chittorgarh) in Southern Rajasthan from 2000-01 to 2017-18 was conducted. In Udaipur DCCB, the coefficient of total deposits (X_3) and average rainfall (X_5) were significant and the coefficient of net cultivated area (X_1) found to be positive but turned out to be non-significant. Other coefficients of this district were found negative i.e. area under cereal crops (X_2) and short term agriculture loan recovery (X_4). It can be indicated that these five regressors jointly explained 94 per cent of the variation in the disbursement of ST credit in Udaipur and Banswara DCCBs. Banswara DCCB, total deposits (X_3) was observed to be significant and other four factors found to be non-significant in the disbursement of short term credit. Dungarpur DCCB, total deposits (X_3) was found to be significant and others four coefficients were non significant. The five regressors jointly explained 80 per cent of the variation. Bhilwara, net cultivated area (X_1), total deposits (X_3) and short term agriculture loan recovery (X_4) were observed to be positively significant and other two factors found to be negative and non-significant. It was estimated that these factors together explained 95 per cent of the total variation. Chittorgarh, it was observed that the coefficient of variables viz; area under cereals crops (X_2) and total deposits (X_3) were positive and significant. Coefficient of determination suggested that 91 per cent variation in ST loan was explained by the five independent variables selected for this study.

Key Words : Factors, credit flow, short term, cooperative bank, total deposit, net cultivated area, rain fall, crops and regression coefficient.

Introduction

Agricultural credit plays vital role in the agro-socio economic development of the nation both at micro and macro level. It strengthens the farm business and enhances the productivity of scarce resources. If these necessities are fulfilled, the institutional credit, which is an instrument of agricultural and economic development of the country, will serve its desired proposes very well (Hatai *et al.* 2006).

District central co operative banks (DCCBs) are infact the link between State Cooperative Banks and Primary Agricultural Cooperative Societies (PACS). They are basically meant to meet the credit requirements of PACS. The DCCBs are most important institutions in the entire co-operative credit structure. The success of cooperative credit structure depends on working of the DCCBs. These banks not only safeguard the interest of PACS, but also help various types of credit and non credit societies in the district (Venkateswaralu and Bhalerao, 1980).

Credit is said to be the lifeblood of agriculture for increasing agricultural production. Agricultural credit is very important instrument in facilitating the process of

agricultural development and thereby initiating the growth of rural economy. In recent years agriculture is being modernized. Adoption of modern technology calls for the diversification of agriculture, which involves the use of crucial and productive inputs such as HYVs, irrigation, fertilizers and pesticides, and therefore additional investment in the agriculture sector has become imperative (Jadhav *et al.* 2007).

The crop loan system became an instrument for agricultural development and the Apex bank accepted its responsibility in directing and developing the system through co-operative societies in the villages for the farmer since 1966. During this period the State Government authorized all central co-operative banks to extend medium term loans for repairs to old wells, purchase of electric motors and for other agriculture purposes (Borude, 1993).

The present study was taken with objective to find out factors responsible for inequality in flow of short term agricultural credit.

Materials and Methods

Southern Rajasthan comprises seven districts namely; Udaipur, Rajsamand, Chittorgarh, Bhilwara, Pratapgarh,

Dungarpur and Banswara. Out of seven districts, five districts were selected randomly and their five branches selected on the basis of highest loan disbursement. The selected districts were Udaipur, Dungarpur, Banswara, Bhilwara and Chittorgarh. The primary data were obtained from the loanee farmers. List of loanee farmers of selected DCCBs was prepared from the selected bank branch of five districts in Southern Rajasthan and then 500 farmers were selected randomly consisting 100 farmers from each branch randomly.

Multiple linear regression analysis involving total short term agricultural credit disbursed (Rs.) as dependent variable and net cultivated area in lakh hectares (X_1), area under horticultural crops (X_2), total deposits in lakhs of rupees (X_3), short term agricultural loan recovery in per cent (X_4) and average rainfall in mm (X_5) as independent variables were attempted. This analysis was carried out district wise as well as for the region as a whole. The regression coefficients were estimated with zero intercept. The form of the equation used for the analysis is given as $Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + u$ Where, Y = Total short term credit disbursed (Rs.), $b_1, \dots, b_5$ = Regression coefficient, X_1 = Net cultivated area (lakh hectares) X_2 = Area under horticultural crops (lakh hectares), X_3 = Total deposits in lakhs of rupees, X_4 = Short term agricultural loan recovery (per cent), X_5 = Average rainfall (mm) and u = Error term.

Results and Discussion

The flow of credit to agriculture is supposed to be associated with the social, economic and natural factors related to agricultural activities. The selection of variables was based on some of a priori expectations so that these variables would provide sufficient economic explanations. Net cultivated area was taken as a proxy for agricultural infrastructure including irrigation, and area under cereal crops was taken as indicator of annual crops, total deposits and recovery per centage of short term credit represented amount of funds available for reutilization and rainfall was taken as a proxy for climate in this analysis.

The results of the multiple linear regression analysis for factors influencing the inequality in short term credit flow are presented in Table 1 for all the selected districts and southern region as a whole. It was observed that at the regional level, the per hectare short term credit flow was influenced significantly by the factor total deposits (X_3) during the period under study. The results of multiple regression analysis showed a positive and significant influence by one variable and other four variables found negative and non-significant. The R^2 value suggested

that the above said five factors have jointly explained 96 per cent of the variation in the disbursement of ST credit in Southern region.

In Udaipur DCCB, the coefficient of total deposits (X_3) and average rainfall (X_5) were significant and the coefficient of net cultivated area (X_1) found to be positive but turned out to be non-significant. Other coefficients of this district were found negative *i.e.* area under cereal crops (X_2) and short term agriculture loan recovery (X_4). This has, therefore, indicated that the factors viz; net cultivated area, deposits and average rainfall, has played an important role in determining the disbursement of short term credit in Udaipur DCCB. It can be indicated that these five regressors jointly explained 94 per cent of the variation in the disbursement of ST credit in Udaipur DCCB.

In Banswara DCCB, regression coefficient of the factor total deposits (X_3) was observed to be significant and other four factors found to be non-significant in the disbursement of short term credit. It was estimated that these factors together explained 94 per cent of the total variation in the disbursement of the ST credit in Banswara DCCB.

In Dungarpur DCCB, it was noted that the coefficient of the factor total deposits (X_3) was found to be significant and others four coefficients were non significant. Only two factor total deposits (X_3) and net cultivated area (X_1) have shown their influence in disbursement of ST credit in the Dungarpur DCCB. The other three factor's viz; area under cereals crops (X_2), short term agriculture loan recovery (X_4) and average rainfall (X_5) had negative and non-significant effects. The five regressors jointly explained 80 per cent of the variation in the disbursement of ST credit in Dungarpur DCCB.

In Bhilwara DCCB, regression coefficient of the factors viz; net cultivated area (X_1), total deposits (X_3) and short term agriculture loan recovery (X_4) were observed to be positively significant and other two factors found to be negative and non-significant. It was estimated that these factors together explained 95 per cent of the total variation in the disbursement of the ST credit in Bhilwara DCCB.

As regards Chitorgarh DCCB, it was observed that the coefficient of variables viz; area under cereals crops (X_2) and total deposits (X_3) were positive and significant. Thus, these variables do have the significant role in increasing the disbursement of ST credit in the Chitorgarh DCCB. The influence of net cultivated area (X_1), short term agriculture loan recovery (X_4) and average rainfall (X_5) on ST credit disbursement were found negative and non-significant. Coefficient of determination suggested

Table-1 : Factors influencing per hectare short term credit disbursement in Southern region.

S. No.	Independent Variable		Udaipur	Banswara	Dungarpur	Bhilwara	Chittorgarh	Southern Region
1.	Net cultivated area (ha)	X ₁	5.9240 (2.4529)	-1.3941 (3.1648)	9.6474 (1.0971)	1.7786* (1.0445)	-1.1103 (8.2896)	-3.4748 (2.6226)
2.	Area under cereals crops (ha)	X ₂	-1.1187 (3.9928)	1.0899 (3.2471)	-9.3227 (1.2336)	-3.3013 (1.7263)	2.1588* (2.30807)	-6.4096 (4.1905)
3.	Total deposits in ` Lakhs	X ₃	2.0939* (5.1083)	2.3778* (1.1345)	4.0015* (2.4141)	3.2704* (9.8106)	3.4784* (1.4867)	7.7897* (1.5728)
4.	Short term agril Loan recovery (%)	X ₄	-1.2109 (0.00134)	-0.000454 (0.00224)	-0.000104 (0.00225)	0.00694* (0.00499)	-3.4901 (1.7453)	-3.7527 (1.9494)
5.	Av. Rainfall (mm)	X ₅	2.3729* (7.1399)	0.000125 (0.00022)	-6.6300 (0.00246)	-3.0713 (0.00012)	-1.5046 (2.9469)	-1.5926 (9.8430)
6.	Coefficient of Determination	R ²	0.94	0.94	0.80	0.95	0.91	0.96
7.	Adjusted R Square		0.92	0.92	0.71	0.93	0.88	0.94

Note: Figures in the parentheses indicate standard errors of respective coefficient

* Indicates significance at 5 per cent level of significance

that 91 per cent variation in ST loan was explained by the five independent variables selected for this study.

In summing up, it looks that the total deposits was observed to be most important factors influencing the district inequality in the disbursement of per hectare ST credit in all the districts during the period under study. Similar results were found in their study conducted by Asfawet *et al.* (2016) and Bhosale *et al.* (2013).

Conclusions

The economic analysis of short term of Agricultural credit flow through DCCBs in five districts in southern Rajasthan from 2000-01 to 2017-18 indicated wide variation over the years and among the districts. Five districts (DCCBs) in southern Rajasthan, the coefficient of total deposits (X₃) was significant. These five regressors jointly explained 95, 94, 91 and 80 per cent of the variation in the disbursement of ST credit in Bhilwara followed by Udaipur, Banswara, Chitorgarh and Dungarpur District Central Cooperative Banks.

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Effect of Different Soilless Growing Media Combinations on Yield, Quality and Cost-Benefit Ratio of Gynoeceous Cucumber (*Cucumis sativus* L.) under Polyhouse Conditions

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Abstract

The research investigation, titled "Effect of different soilless growing media combinations on yield, quality, and cost-benefit ratio of gynoeceous cucumber (*Cucumis sativus* L.) under polyhouse conditions" has been conducted during the 2020-21 kharif season. The study is being carried out at the Centre of Excellence for Protected Cultivation (CEPC), Horticultural Research Station, Dr. Y. S. R. Horticultural University, situated in Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was structured based on a randomized block design (RBD) with three replications, encompassing a total of 14 treatment combinations. Out of various combinations of growing media, T₁₃ achieved the highest yield per vine (2.46 kg), yield per plot (24.68 kg), estimate yield tons per hectare (49.36), TSS (3.50 °B), ascorbic acid (3.79 mg/100g), whereas, the minimum titratable acidity was recorded in T₁₃ and T₃ (0.31 % and 0.32 %). T₁₃ was found to be the best with highest gross returns (Rs 12,34,000 /-), net returns (Rs 3,63,000 /-) and benefit: cost ratio of 1.41:1.

Key words : Cocopeat, soilless media, grow bags, vermicompost, fym, neem cake, gynoeceous cucumber, polyhouse.

Introduction

One of the most extensively cultivated vegetable crops in the world, Cucumber (*Cucumis sativus* L.) with a chromosome count of $2n = 14$ belongs to the Cucurbitaceae family, which encompasses 120 genera and 825 species. (Gangadhara *et al.*, 2019). Its origins are believed to trace back to Southern Asia. It thrives in warm temperatures and is susceptible to frost, as indicated by Bacci *et al.* (2006), with its optimal growth occurring within a temperature range between 22°C to 27°C indicates a moderate to warm environmental condition. Elevated temperatures during the crop's growth phase led to the formation of male flowers, whereas during the fruit development stage, it causes bitterness in the fruit, as reported by Singh *et al.* (2017). Essentially, it is a trailing or ascending monoecious vine characterized by stiff hairs or have a coarse texture are described as hirsute or rough. Triangular-ovate leaves with mostly sharp curves, typically exhibiting three lobes, are observed. The small and thin pedicels of the staminate blooms are grouped together. The pistillate blooms often have robust, short pedicels and are solitary. The environment often has an impact on sex expression. During short days and in conditions of reduced light intensity, female flowers tend to predominate, whereas staminate blooms are more common during long days and high light intensities (Yadav *et al.*, 2020). In botanical terminology, the fruit is classified as a pepo.

The term "soilless culture" refers to the practice of growing plants in systems that do not involve traditional soil in situ. (Gruda, 2009). Soilless culture is a method of cultivating plants that involves growing them without utilizing soil as the primary growth medium, in which irrigation water is used to supply the inorganic nutrients received by the roots. These systems frequently rely on using solid rooting material to grow plants. They are frequently referred to as substrates or growth mediums. When major water and soil issues make conventional soil-based production impossible, (This includes avoiding challenges such as soil-borne pests, nematodes, soil and water salinity, chemical residues in the soil, fertility issues, and water shortages) Soilless culture provides an alternative to traditional soil-based cultivation. The key benefits of soilless culture encompass the utmost precision in regulating water supply, nutrient levels, pH, and root temperature; enhanced productivity via easier and more precise management of production parameters; a decrease in labor requirements; a lack of a demand for soil sterilization; and the ability to grow more crops each year *etc.*, (Tuzel *et al.*, 2008). Container farming is the practice of growing plants in tiny containers rather than in the ground, such as pots, grow bags, and polybags. In the current study, an effort was made to determine the ideal growing media combination for gynoeceous cucumber soilless production in a polyhouse conditions.

Materials and Methods

The study was conducted between 2020 and 2021 at the Horticultural Research Station, Centre of Excellence for Protected Cultivation (CEPC), Dr. Y.S.R. Horticultural University, situated in Venkataramannagudem, West Godavari District, Andhra Pradesh. The research employed a randomized block design (RBD) with three replications, involving a total of 14 treatment combinations, denoted as T1 to T14. The treatments included various proportions of cocopeat with different electrical conductivity (EC) values, along with additional components such as vermicompost, FYM (Farm Yard Manure), and neem cake. The combinations aimed to assess their impact on the cultivation environment and plant growth. In accordance with the treatments, diverse volumetric mixtures of cocopeat, vermicompost, farmyard manure, and neem cake were prepared as media and incorporated into the grow bags. In order to control weeds and prevent dirt from coming into touch with grow bags and media, the ground within the polyhouse was leveled and covered with a 110 GSM weed mat, leaving no exposed soil. The grow bags are spaced 50 to 60 cm apart. The variety Pusa Parthenocarpic Cucumber – 6, parthenocarpic gynoecious cucumber variety improved by IARI, New Delhi, was employed in the experiment. The twelve days old seedlings were transferred into grow bags that had already been prepared. As per standard procedures, at every harvest yield data per vine and per plot has been recorded, Fruit sample of cucumber was collected from the field at second and third harvesting for estimating TSS, ascorbic acid and titratable acidity of fruits. TSS was estimated in ° Brix with the help of hand refractometer, ascorbic acid (Vitamin C) content was estimated by the dichlorophenol indophenols dye method, and expressed in mg/100 g and titratable acidity of the fruits was determined by titrating the sample with sodium hydroxide (NaOH) and using phenolphthalein as an indicator and expressed in percentage. BC ratio was obtained by dividing gross returns with total costs ha⁻¹.

Treatment details :

- T₁ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹
- T₂ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹
- T₃ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 75 % + Vermicompost @ 25 % (v/v)
- T₄ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 75 % + Vermicompost @ 25 % (v/v)
- T₅ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 75 % + FYM @ 25 % (v/v)

T₆ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 75 % + FYM @ 25 % (v/v)

T₇ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 90 % + Neem cake @ 10 % (v/v)

T₈ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 90 % + Neem Cake @ 10 % (v/v)

T₉ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 75 % +Vermicompost @ 15 % + Neem Cake @ 10 % (v/v)

T₁₀ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 75 % + Vermicompost @ 15 % + Neem Cake @ 10 % (v/v)

T₁₁ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 75 % + FYM @ 15 % + Neem Cake @ 10 % (v/v),

T₁₂ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 75 % + FYM @ 15 % + Neem Cake @ 10 % (v/v)

T₁₃ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹ @ 75 % + Vermicompost @ 10 % + FYM @ 10 % + Neem Cake @ 5 % (v/v)

T₁₄ - Cocopeat with EC 1.00 ± 0.10 dS m⁻¹ @ 75 % + Vermicompost @ 10 % + FYM @ 10 % + Neem Cake @ 5 % (v/v).

Data collection and analysis : Cucumber growth parameters and cucumber yield were measured and recorded. Quality parameters such as total soluble solids (°Brix), titratable acidity (%), and ascorbic acid content (mg/100g) were also evaluated. The collected data underwent statistical analysis following the procedures outlined by Panse and Sukhatme (1985). The results for growth, yield parameters, yield, and quality parameters, along with their statistical interpretations, are presented and discussed.

Results and Discussion

Impact of various combinations of soilless growing media on crop yield : The data related to the yield per vine, yield per plot and yield per hectare demonstrated a notable variation across various combinations of soilless growing media (Table-1). Within the array of soilless growing media combinations, T₁₃ recorded highest yield per vine (2.46 kg), yield per plot (24.68 kg) and yield tons per hectare (49.36). Greater growth and yield parameter values in T₁₃ may be because of the combination of favorable conditions in the media and increased availability of vital nutrients. This promoted improved drainage, improved aeration, and increased nutrient uptake. Nutrition was more readily available when lower electrical conductivity cocopeat was used.

More nitrogen-fixing, phosphate-solubilizing, and other helpful microorganisms, as well as vitamins,

Table-1 : Impact of various combinations of soilless growing media on yield of gynoecious cucumber (*Cucumis sativus* L.) polyhouse conditions.

Treatment combinations	Yield per vine (kg)	Yield per plot (kg)	Estimated Yield (t/ha ⁻¹)
T ₁	2.04	20.40	40.80
T ₂	1.10	11.00	22.00
T ₃	2.09	20.90	41.80
T ₄	2.02	20.20	40.40
T ₅	2.01	20.10	40.20
T ₆	1.83	18.30	36.60
T ₇	2.05	20.50	41.00
T ₈	1.96	19.60	39.20
T ₉	2.35	23.50	47.00
T ₁₀	1.87	18.70	37.40
T ₁₁	2.16	21.60	43.20
T ₁₂	1.90	19.00	40.92
T ₁₃	2.46*	24.68*	49.36*
T ₁₄	1.85	18.50	37.00
SE(m) +	0.03	0.32	0.50
C.D. (0.05)	0.08	0.92	1.47
C.V. %	5.42	6.78	6.20

Table-2 : Impact of various combinations of soilless growing media on Quality characters of parthenocarpic cucumber (*Cucumis sativus* L.) polyhouse conditions.

Treatment combinations	TSS (°B)	Ascorbic acid (mg/100 g)	Titrateable acidity (%)
T ₁	3.10	2.89	0.38
T ₂	2.01	1.50	0.46
T ₃	3.00	3.00	0.32*
T ₄	2.80	3.20	0.35
T ₅	2.90	2.10	0.41
T ₆	3.02	3.45	0.39
T ₇	3.31	2.20	0.41
T ₈	3.20	3.60	0.35
T ₉	3.34	2.79	0.31
T ₁₀	2.80	2.61	0.36
T ₁₁	3.20	2.90	0.43
T ₁₂	3.10	2.81	0.40
T ₁₃	3.50*	3.79*	0.31*
T ₁₄	3.10	2.83	0.36
SE(m) +	0.04	0.04	0.01
C.D (0.05)	0.13	0.12	0.02
C.V %	4.52	4.45	3.47

hormones, and enzymes, are present in vermicompost, and these microbes have a better impact on plant growth and yield. Besides enhancing the physical and chemical attributes of the media combinations, vermicompost and neem cake helped the plants receive an adequate supply of nutrients. This may have encouraged the plants to grow as much as possible vegetatively and to produce more food, which was then portioned out to sink. Which is to the observation of Bairwa *et al.* (2009) in Okra, Lata *et al.* (2018) in cucumber, Arunesh *et al.* (2020) in gerbera,

Deogade *et al.* (2020) in calendula, Kala *et al.* (2020) in chrysanthemum and Yadav *et al.* (2020) in cucumber (Table-1).

Impact of various combinations of soilless growing media on cucumber quality : Cucumbers and other vegetables have quality characteristics that are crucial because they affect the produce's processing and nutritional value. Soilless culturing has generally been reported to significantly improve the quality of cucumber

Table-3 : Impact of various combinations of soilless growing media on Benefit cost ratio of parthenocarpic cucumber (*Cucumis sativus* L.) polyhouse conditions.

Treatment combinations	The total cost (Rs/ha)	Income total (Rs/ha)	Net profits (Rs/ha)	Benefit : Cost ratio
T ₁	821030	1020000	198970	1.24:1
T ₂	711630	550000	-161630	0.77:1
T ₃	871530	1045000	173470	1.19:1
T ₄	795830	1010000	214170	1.26:1
T ₅	733230	1005000	271770	1.37:1
T ₆	656430	915000	258570	1.35:1
T ₇	931130	1025000	93870	1.10:1
T ₈	840230	980000	139770	1.16:1
T ₉	869630	1175000	305370	1.39:1
T ₁₀	789830	935000	145170	1.08:1
T ₁₁	859480	1080000	220520	1.25:1
T ₁₂	783340	1023000	239660	1.30:1
T ₁₃	870310	1234000	363690	1.41:1*
T ₁₄	789130	925000	135870	1.17:1

fruits worldwide. In the current study, quality characteristics like TSS, ascorbic acid, and titratable acidity varied amongst growing soilless media combinations. T₁₃-grown cucumbers had the highest TSS (3.50 °B) and ascorbic acid (3.79 mg/100 gm), but T₁₃ and T₃ had the lowest titratable acidity (0.31 % and 0.32 %) (Table 2).

Benefit: Cost : Growing media's effect on a benefit-cost ratio in cucumber cv. Pusa Parthenocarpic Cucumber-6 under protected conditions has been employed in privileged circumstances. Therefore, Soilless growing media treatment combinations have been analyzed economically by examining their gross return, net return, and B:C ratio. Table 3 presents the pertinent statistics. During the current study, the highest B:C ratio was 1.41:1 obtained in T₁₃. whereas, least B: C ratio (0.77:1) was resulted from the treatment T₂ Cocopeat with EC 1.00 ± 0.10 dS m⁻¹. The benefit cost ratio can be increased from succeeding cultivation of cucumber by reducing total costs. The investigation's findings demonstrated that the T₁₃ growing media combination produced the best cucumber growth and yield characteristics, as well as the benefit-cost ratio. It is attributable to the improved soilless media structure that organic growth media produce, both in terms of structure and biology, in addition to the plants' consistent and reliable nutrition supply (Table 3).

Conclusions

Drawing from the findings of this attempt, It is possible to say that parthenocarpic cucumber cultivated in growbags, treatment-13 recorded highest yield (49.36 t/ha), TSS (3.50 °B), Ascorbic acid (3.79 mg/100 gm) and B:C ratio of 1.41:1. The study's conclusions can be beneficial to

growers involved in protected cultivation of cucumber for utilizing locally sourced growing media, conserving water and nutrients, and increasing output. Gynoecious cucumbers can be grown soillessly in a polyhouse setting using the growing media combination previously mentioned.

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Investigations on the Effects of Various Growing Media Combinations and its Nutrient Content on Yield of Parthenocarpic Cucumber (*Cucumis sativus* L.) in Polyhouse

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Abstract

The present investigation entitled "Investigations on the effects of various growing media combinations and its nutrient content on yield of parthenocarpic cucumber (*Cucumis sativus* L.) in polyhouse" was carried out during 2020-21 at Centre of Excellence for Protected Cultivation (CEPC), Horticultural Research Station, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was laid out in randomized block design (RBD) with 3 replications comprising 14 treatment combinations. Among different combinations of growing media, T₁₃ recorded maximum fruit yield per plot (24.68 kg), estimated fruit yield (49.36 t ha⁻¹) and pH and EC of the media after harvest was 7.38 and 0.75 dS m⁻¹. Highest nutrient content of media before harvest recorded in T₁₃ i.e., N (1.47%) on par with T₉ & T₁₁ (1.40 and 1.36 %) and P, K, (1.3 & 1.12%), after harvest minimum NPK recorded in T₁₃ (0.78, 0.60 and 1.12%) which is on par with T₉ (0.99, 0.73 and 1.25%), after harvest plant nutrient content was maximum in T₁₃ i.e., N, P (3.18 and 1.89%) which is on par with T₉ (3.60 and 1.84%), no significant difference observed in K. whereas, T₂ showed least performance in all the parameters of cucumber.

Key words : Soilless growing media, cocopeat, vermicompost, FYM, neem cake, grow bags, polyhouse, NPK, EC, pH.

Introduction

Cucumber (*Cucumis sativus* L.) (2n = 14), a member of the Cucurbitaceae family with 120 genera and 825 species, is among the most widely cultivated vegetable crops worldwide. Its origin is traced to Southern Asia (Gangadhara *et al.*, 2019). It exhibits thermophilic and frost-sensitive characteristics, preferring a temperature range of 22°C - 27°C for optimal growth. High temperature affects its reproductive development, causing male flower production during crop growth and fruit bitterness during fruit development (Singh *et al.*, 2017). It is a monoecious vine with either trailing or ascending habit and hirsute or rough stems. Its leaves are triangular-ovate, mostly three-lobed, and have sharp curves. The staminate flowers have small and thin pedicels and are clustered, while the pistillate flowers have robust, short pedicels and are solitary. The environmental conditions influence its sex expression, with female flowers dominating under short days and low light intensities and staminate flowers prevailing under long days and high light intensities. Its fruit is classified as a pepo in botanical terms. (Yadav *et al.*, 2020).

"Soilless culture" refers to the cultivation of plants in systems that do not use soil in situ as the growth medium (Gruda, 2009). In this technique, irrigation water provides the inorganic nutrients that the roots absorb. These systems often employ solid rooting materials to support

plant growth. These materials are commonly called substrates or growth mediums. Soilless culture is an alternative to soil culture when soil and water problems render conventional soil-based production unfeasible, such as soil born pests, nematodes, soil and water salinity, chemical residues in soil, lack of fertility, water shortage, etc. Soilless culture has several advantages, such as the most precise control over water, nutrient, pH, and root temperature supply; increased productivity through easier and more accurate management of production parameters; reduced labor requirements; no need for soil sterilization; and the possibility of growing more crops per year, etc. (Tuzel *et al.*, 2008). Container farming is a method of growing plants in small containers instead of in the ground, such as pots, grow bags, and polybags. The current study aimed to identify the best growth media combination for cucumber container production in a naturally ventilated polyhouse.

Materials and Methods

The current experiment was conducted from 2020 to 2021 at the Horticultural Research Station, Dr. Y. S. R. Horticultural University, Centre of Excellence for Protected Cultivation (CEPC), Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was laid out in randomized block design (RBD) with 3 replications comprising of 14 treatment combinations i.e., T₁ - Cocopeat with EC 0.50 ± 0.10 dS m⁻¹, T₂ - Cocopeat

with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$, T₃ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 25 % (v/v), T₄ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 25 % (v/v), T₅ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + FYM @ 25 % (v/v), T₆ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + FYM @ 25 % (v/v), T₇ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 90 % + Neem cake @ 10 % (v/v), T₈ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 90 % + Neem Cake @ 10 % (v/v), T₉ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 15 % + Neem Cake @ 10 % (v/v), T₁₀ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 15 % + Neem Cake @ 10 % (v/v), T₁₁ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + FYM @ 15 % + Neem Cake @ 10 % (v/v), T₁₂ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + FYM @ 15 % + Neem Cake @ 10 % (v/v), T₁₃ - Cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 10 % + FYM @ 10 % + Neem Cake @ 5 % (v/v), T₁₄ - Cocopeat with EC $1.00 \pm 0.10 \text{ dS m}^{-1}$ @ 75 % + Vermicompost @ 10 % + FYM @ 10 % + Neem Cake @ 5 % (v/v). According to the treatments, various volumetric mixtures of cocopeat, vermicompost, farmyard manure, and neem cake were made as media and added to the grow bags. In order to control weeds and prevent dirt from coming into touch with grow bags and media, the ground within the polyhouse was leveled and covered with a 110 GSM weed mat, leaving no exposed soil. The grow bags are spaced 50 to 60 cm apart. The variety Pusa Parthenocarpic Cucumber – 6, improved parthenocarpic gynoecious cucumber variety improved by IARI, New Delhi, was employed in the experiment. The twelve-day-old seedlings were transferred into grow bags that had already been prepared.

Physio-chemical properties of the media used in the experiment :

Media	pH	EC (dS m^{-1})	N (%)	P (%)	K (%)
Cocopea (Reused)	7.2	0.5 ± 0.10	0.35	0.25	0.33
Cocopeat blocks (Un used)	6.6	1.0 ± 0.10	0.22	0.18	0.14
Vermicompost	7.02	0.62	1.31	0.56	2.10
FYM	5.6	1.5	0.73	0.50	0.25
Neem cake	8.2	1.25	2.64	0.51	1.01

I. Estimation of nutrient content

Media pH : The media p^H was measured before planting and after harvest using digital p^H meter.

Electrical conductivity (dS m^{-1}) of media : Electrical conductivity (dS m^{-1}) of media was measured before planting and after harvest using digital EC meter. Media and water in 1:2.5 ratio was taken and kept overnight after

stirring. The supernatant liquid was used to determine EC with digital EC meter.

Estimation of Nitrogen : Nitrogen was determined by Kjeldhal's method. Half gram digested plant sample was distilled using micro-Kjeldhal unit and the liberated ammonia was trapped in boric acid containing mixed indicator and titrated against 0.01 N H_2SO_4 (Jackson, 1973). The nitrogen content in the leaves was expressed in per cent.

Estimation of Phosphorus : Diacid digested plant sample was used for the determination of total phosphorus by developing Vanado-molybdo phosphoric yellow color as per Jackson (1973). The intensity of yellow color was read in spectrometer (Systronics UV-VIS Spectrophotometer 118) at 470 nm. The phosphorus content in the leaves was expressed in per cent.

Estimation of Potassium : Potassium content was determined by a microprocessor based flame photometer using specific filter and LPG flame. Diluted diacid digest was fed to atomizer through capillary tube and concentration was directly read on the display monitor. Per cent potassium content on dry weight basis was calculated as per Chapman and Pratt (1961). The potassium content in the leaves was expressed in per cent.

II. Statistical analysis :

The data was subjected to statistical analysis as per the methods out lined by Panse and Sukhatme (1985). Statistical significance was tested by F value at 5 percent level of significance.

Results and Discussion

Nutrient content of growing media before planting (%)

: The data on NPK status of media before planting (%) showed significant difference among different growing media combinations are presented in Table 1. Among different combinations of growing media T₁₃ recorded maximum N status of media (1.47 %) which are on par with T₉ (1.40 %) and T₁₁ (1.36 %). Highest P and K percent was recorded in T₁₃ (1.30 %, 1.12 %) followed by T₉ (0.93 % and 0.95 %) and the least NPK content of the media before planting was observed in T₂ (0.22 %, 0.18 % and 0.14 %). Addition of vermicompost, FYM, neem cake to the cocopeat with EC $0.50 \pm 0.10 \text{ dS m}^{-1}$ might have improved the NPK % of the media combination.

Nutrient content of media after harvest (%) : The data on NPK status of media after harvest (%) showed significant difference among different growing media combinations are presented in Table 2. Among different combinations of growing media T₁₃ was recorded

Table-1 : Effect of different growing media combinations on nutrient content of growing media before planting in soilless cultivation of polyhouse.

Treatment combinations	Nutrient content of media before planting (%)		
	N (%)	P (%)	K (%)
T ₁	0.35	0.25	0.33
T ₂	0.22	0.18	0.14
T ₃	0.72	0.72	0.92
T ₄	0.58	0.54	0.77
T ₅	0.68	0.70	0.49
T ₆	0.58	0.43	0.82
T ₇	1.04	0.67	0.56
T ₈	0.78	0.40	0.41
T ₉	1.40	0.93	0.95
T ₁₀	1.32	0.64	0.79
T ₁₁	1.36	0.82	0.58
T ₁₂	1.07	0.55	0.45
T ₁₃	1.47	1.30	1.12
T ₁₄	1.34	0.89	0.85
SE(m) +	0.05	0.03	0.05
C.D (0.05)	0.14	0.09	0.08
C.V %	7.65	8.60	7.38

Table-2 : Effect of different growing media combinations on nutrient content of growing media after harvest in soilless cultivation of polyhouse.

Treatment combinations	Nutrient content of media after harvest (%)		
	N (%)	P (%)	K (%)
T ₁	1.65	0.97	2.43
T ₂	3.07	1.58	2.88
T ₃	1.98	1.33	2.05
T ₄	2.46	1.23	2.02
T ₅	2.04	1.07	2.35
T ₆	2.10	1.05	2.27
T ₇	2.95	1.08	2.08
T ₈	2.90	0.91	2.34
T ₉	0.99	0.73	1.25
T ₁₀	2.72	0.95	2.67
T ₁₁	1.72	0.79	1.53
T ₁₂	2.63	1.10	1.93
T ₁₃	0.78	0.60	1.12
T ₁₄	2.38	1.00	2.36
SE(m) +	0.57	0.18	0.46
C.D (0.05)	1.55	0.59	1.05
C.V %	5.11	3.85	6.00

minimum NPK status of 0.78 %, 0.60 % and 1.12 % which is on par with T₉ (0.99 %, 0.73 % and 1.25 %) and the maximum NPK status of the media after harvest was recorded in T₂ (3.07 %, 1.58 % and 2.88 %).

The minimum NPK status of growing media T₁₃ was

Table-3 : Effect of different growing media combinations on plant nutrient content after harvest in soilless cultivation of polyhouse.

Treatments	Nutrient content of plant (%)		
	N (%)	P (%)	K (%)
T ₁	2.40	1.60	3.93
T ₂	1.21	0.30	2.60
T ₃	2.60	1.14	3.40
T ₄	3.10	1.00	4.00
T ₅	2.10	1.51	3.02
T ₆	3.30	1.20	3.60
T ₇	1.98	1.62	3.61
T ₈	3.40	1.82	2.84
T ₉	3.60	1.84	4.05
T ₁₀	1.90	0.61	3.90
T ₁₁	3.50	1.18	4.05
T ₁₂	2.60	0.89	2.94
T ₁₃	3.81	1.89	4.10
T ₁₄	2.20	1.31	3.80
SE(m) +	0.16	0.04	0.41
C.D (0.05)	0.47	0.09	NS
C.V %	9.97	4.04	5.26

Table-4 : Effect pH and EC on different growing media combinations after harvest in soilless cultivation of polyhouse.

Treatment combinations	pH	EC (dS m ⁻¹)
T ₁	8.08	1.09
T ₂	8.14	1.55
T ₃	7.99	0.71
T ₄	7.97	1.26
T ₅	7.60	0.76
T ₆	8.06	1.41
T ₇	8.10	0.85
T ₈	8.06	1.47
T ₉	7.52	0.71
T ₁₀	8.06	0.94
T ₁₁	7.71	0.76
T ₁₂	7.90	0.94
T ₁₃	7.38	0.75
T ₁₄	7.93	1.03
SE(m) +	0.23	0.05
C.D (0.05)	0.67	0.14
C.V %	4.98	9.12

due to higher yields. The nutrients present in the media have been sufficiently utilized by the plants which resulted in increased plant growth and yield. The results obtained in present investigation are in close conformity with those of Singh *et al.* (2015) in chrysanthemum.

Table-5 : Effect of different growing media combinations on yield of parthenocarpic cucumber in soilless cultivation of polyhouse.

Treatments	Yield /plot (kg)	Estimated Yield (t/ha)
T ₁	20.40	40.80
T ₂	11.00	22.00
T ₃	20.90	41.80
T ₄	20.20	40.40
T ₅	20.10	40.20
T ₆	18.30	36.60
T ₇	20.50	41.00
T ₈	19.60	39.20
T ₉	23.50	47.00
T ₁₀	18.70	37.40
T ₁₁	21.60	43.20
T ₁₂	19.00	40.92
T ₁₃	24.68	49.36
T ₁₄	18.50	37.00
SE(m) +	0.32	0.50
C.D (0.05)	0.92	1.47
C.V %	6.78	6.20

Plant nutrient content after harvest : The data pertaining to NPK content of the plant after harvest (%) has shown a significant difference among different growing media combinations are presented in Table 3. Among different combinations of growing media T₁₃ recorded maximum N and P levels (3.81 % and 1.89 %) which is on par with T₉ (3.60 % and 1.84 %). No significant difference was observed among different growing media combinations in K percentage after harvest and the least NP content of the plant after harvest was observed in T₂ (1.21 % and 0.30 %).

The maximum NPK content of the plant after harvest (%) observed in T₁₃ might be due to heavy nutrient uptake by the plant and strong root system which resulted in high NPK content in the plant. These results are in congruence with the studies of Lata *et al.* (2018) in cucumber and Abbey *et al.* (2012) in Swiss chard.

pH and EC of the media : The data pertaining to p^H and EC of the media after harvest has shown a significant difference among different growing media combinations are presented in Table 4. Among different combinations of growing media T₁₃ was recorded minimum p^H and EC of the media after harvest (7.38 and 0.75 dS m⁻¹) which is on par with T₉ (7.52 and 0.71 dS m⁻¹) and the highest was recorded in T₂ (8.14 and 1.55 dS m⁻¹).

Optimum p^H and EC levels of the media helped to better nutrient uptake by the plant in T₁₃ which led to better growth and yield of the plant. These results are in congruence with the studies of Kala *et al.* (2020) in chrysanthemum and Singh *et al.* (2015) in chrysanthemum.

Yield of cucumber : Among different combinations of growing media T₁₃ was recorded highest fruit yield per plot (24.68 kg) followed by T₉ (23.50 kg) and estimated fruit yield (49.36 t ha⁻¹), T₉ (47.00 t ha⁻¹). The positive influence of the media on better root development might have improved nutrient uptake along with good aeration thus forming greater root system which may have promoted shoot nutrient uptake leading to increased yield. These results are in congruence with the studies of Maher *et al.* (2020) in strawberry, Thakur and Shylla (2018) in strawberry, Nagaraj *et al.* (2015) in sweet pepper and Chauhan *et al.* (2014) in gerbera Table-4.

Conclusions

Based on results obtained in the present experiment, it can be concluded that parthenocarpic cucumber grown in growbags containing 75 % of cocopeat with EC 0.50 ± 0.10 dS m⁻¹ + 10 % Vermicompost + 10 % FYM + 5 % Neem Cake (volume/volume) (T₁₃) recorded highest yield (49.36 t/ha), nutrient content of media before and after harvest, plant nutrient content and required levels of EC and pH. Hence the above growing media combination can be utilized for cultivation of parthenocarpic cucumber in soilless cultivation in polyhouse.

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A New Record of *Fusarium incarnatum equiseti* Species Complex Causing Stem Splitting, Gummy Ooze Secretion in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl]

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Key words : Bark splitting, *Fusarium incarnatum equiseti* species complex, Gummy ooze secretion.

Bottle gourd (*Lagenaria siceraria*) native to tropical low lands of Africa is an important cucurbitaceous vegetable widely grown in Asia, Africa, America and European countries under tropical climatic conditions for hard shelled and bottle shaped fruits. In India, the crop is cultivated in an area of 1, 87,000 Ha with an annual production of 30, 11,000 MT. In Andhra Pradesh, an area of 2,380 hectares of land is under cultivation with an annual production of 50, 940 metric tonnes (NHB, 2018-19). The crop is attacked by many economically important fungal diseases like gummy stem blight, powdery mildew, downy mildew, and anthracnose. Among them, gummy stem blight also called as black rot or alligator skin results in 20.0 per cent losses to the crop under field conditions (Thakare, 2014). Gummy stem blight is a cucurbit rot disease, it can affect the host at any stage of growth during the crop development and affects all plant parts including leaves, stems and fruits. Symptoms generally consist of circular dark tan lesions appearing on the margins of the leaves (Fig 1a) which later spread towards the inner side of the leaf resulting in blighting (Fig 1b), bark splitting, amber coloured gummy ooze secretion (Fig 1c, 1d), necrotic streaks on stem and finally resulting in wilting of the plant (Fig 1e). Though symptoms of marginal necrotic lesions, amber coloured ooze secretions were first observed during the month of September 2020, the diseased plants remained unaffected. However, due to congenial conditions of continuous rains for a week in the first fortnight of October, 2020 blighting of leaves, stem splitting, wilting and death of the plants occurred in week duration.



Fig.-1b : Blighting of leaf.



Fig.-1c : Bark splitting and gummy ooze on stem.



Fig.-1d : Wilting of the vine.



Fig.-1a : Dark necrotic lesions on margin of the leaf.



Fig.-1d : Complete drying of vine.

Different pathogens were reported to incite the disease in different locations of the country. The causal agent was reported as *Didymella bryoniae* and *Fusarium* species in Hyderabad region of Telangana, *Aspergillus glaucus* in Kalyanpur, mixed infection of *Fusarium oxysporum*, *Fusarium verticilloides* and *Rhizoctonia solani* in Indian Institute of Vegetable Research, Varanasi, Uttarpradesh, India and *Didymella bryoniae* and *Fusarium* species in Hesaraghatta. (Annual report of All Indian Coordinated Research Project (Vegetable Crops) 2018-19). As per the current literature, three casual agents were reported for inciting gummy stem blight (GSB) in bottle gourd. They are *Didymella bryoniae* (Chiw W.F., Walker J.C. 1949, Roy, 1967, Schenck, 1968; Keinath *et al*; 1995) *Fusarium roseum* Link (Thakare and Gaikwad, 2014) and *Fusarium verticilloides* (Gurpreet Singh *et al.*, 2018). The disease has become a major constraint for cultivation of cucurbits in the country including Andhra Pradesh.

The pathogenic fungus was isolated from the diseased samples of bottle gourd showing characteristic symptoms of gummy stem blight. The collected plant tissues were surface sterilized with 0.1% mercuric chloride for 1 min, rinsed thrice in sterilized distilled water and cultured on potato dextrose agar (PDA) at 25 °C for 7 days. The pure culture of the pathogen isolated from diseased samples produced white aerial fluffy mycelium.



Fig-2 : Pure culture of isolated pathogen.



Fig-3 : Macroconidia of *Fusarium* sps with staining by Lacto phenol cotton blue.

The pathogenicity of the fungus was tested *in vivo* in open shade net conditions. The methods followed for inoculation are soil inoculation of pathogen multiplied on sorghum grains, micro droplet inoculation method and

mycelial bit inoculation method. (Thakare and Gaikwad, 2014)

(a) Soil inoculation of pathogen multiplied on sorghum grains : Pure culture of the isolated fungus was mass multiplied on sorghum grains by inoculating them with 5mm of mycelial discs of the pure culture. (Fig:4) After seven days of inoculation the entire surface of the sorghum grains was covered with mycelium. It was then transferred to 25 x 10 x 10 cm sized polybags containing healthy bottle gourd seedlings sown in sterilized soil. Inoculum was not added to some polybags which were kept for control.



Fig-4 : Pathogen multiplied on sorghum grains for soil inoculation.

(b) Micro droplet inoculation technique (MDIT) : Five healthy, disease free seeds of bottle gourd were sown in poly bags (25 x 10 x 10 cm) containing sterilized soil, vermiculite and perlite (2:1:1) mixture. The inoculation was done on 30 days old healthy plants. Spore suspension was prepared at a concentration of 10^6 spores/ml and sprayed on leaves, at the collar portion and on nodes and internodes by slight injury with the help of sterilized needles. Congenial condition for disease development was maintained by placing polythene covers over the inoculated vines for 24 and 48 hours before and after inoculation, respectively. The injured vines with inoculation of sterile distilled water were also maintained for comparison.

(c) Mycelial bit inoculation method (MBIM) : The bottle gourd seedlings were grown in polythene bags (25 x 10 x 10 cm). The inoculation was done on different plant parts, viz. collar, nodes and leaves by placing mycelial bits of 5 mm size from 10 days old pure culture grown on PDA on injured areas. The sterilized wet cotton swabs were covered on inoculated portions.

Pathogenicity studies conducted by inoculating the test pathogen by various inoculation methods resulted in the development of marginal necrotic lesions on the leaves, streaks on vines, wilting and death of the vines by three weeks post inoculation. Among them, soil inoculation method (86.7%) and MBIM (53.3%) has shown highest per cent of incidence on disease

development. Symptoms were observed when there are untimely continuous rains for a week during the month of November, 2020. Incessant rains with humid climate favoured the disease development. The isolated pathogen and re-isolated pathogen were same thus proving Koch's postulates.

The test pathogen was morphologically identified as *Fusarium* species by visual observation of macroconidia under the microscope (Fig 3). For species level identification by molecular methods, the sample was sent to National Centre for Microbial Resource, Pune, Maharashtra, India. The isolated culture was deposited in National Centre for Microbial Resource (NCMR), Pune culture collections. Fungal DNA was isolated by C-TAB method. The pathogen was characterized by amplification and sequencing of the internal transcribed spacer (ITS) region of rDNA gene by using universal primers (ITS1:5'TCCGTAGGTGAACCTGCGG3'/ ITS4:5'TCCTCCGCTTATTGATATGC3'). which annealed to the flanking 18S and 28S rDNA genes. PCR products were visualized on 1.0 % agarose gel along a 1-kb DNA ladder. To edit and align the ITS sequences, Molecular Evolutionary Genetic Analysis software, ver. 7.0 (MEGA7.0; <http://www.megasoftware.net>) was used. The aligned sequence was subjected to BLASTn analysis in NCBI website and it was found that, the pathogen has shown 100% homology with *Fusarium equiseti*. When the sequence was analysed by using *Fusarium* ID and Mycobank database, the derived sequence has shown 100% homology with *Fusarium incarnatum-equiseti* species complex. This is the first report of *Fusarium incarnatum-equiseti* species complex causing gummy stem blight in bottle gourd as per our knowledge. *Fusarium incarnatum equiseti* species complex infecting muskmelon, *Eucommia ulmoides*, rice, rock melon was recently reported by different workers (Cao et al. 2019; Fang et al. 2020; Ismail et al. 2021; Thirumalaisamy et al. 2019).

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