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Development of 2A-CHYSEL technology based multicistronic expression systems for imparting fungal tolerance

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ABSTRACT

Multigene transfer is an approach for development of transgenic crops simultaneously expressing many genes. With an aim to impart necrotrophic fungal tolerance through transgenic approach, the present study describes the development of multigene construct bearing three antifungal genes as a single transcriptional unit capable of expressing at high levels and evading transgene silencing.

Keywords: CHYSEL technology, Multigene construct, Necrotrophic fungal resistance

Necrotrophic fungal infections are a severe threat to oilseed crop cultivation. Given the lack of resistant germplasm sources for most of these diseases, there is a necessity to introduce resistance through transgenic approach. Taking into account the multipronged approach of infection adopted by necrotrophic fungi, we hypothesized that simultaneous expression of multiple genes; each with a different mode of action against fungi, may provide better resistance. As a prerequisite, we describe the development of 2A-CHYSEL (2A based - cis acting hydrolase element) technology (Pablo de Felipe, 2004) based multi-cistronic gene constructs in the present study.

Based on several criteria, three antifungal genes *viz.*, *ech-42* (encoding chitinase from *Trichoderma*), *RsAFP2* (antifungal protein from radish) and *Ace-AMP1* (antimicrobial protein from onion) were chosen to be expressed simultaneously. Coordinated expression approach using CaMV35S promoter and VSP terminator was adopted to express all the three genes as a polyprotein using self-cleavable FMDV 2A linker peptide. Codon optimization of the chosen genes was carried out by “one amino acid –one codon approach”, and overlap extension PCR was used for synthesizing the optimized sequences. Software programs like Synthetic gene designer and DNA Works etc., were used for designing the oligonucleotides. Standard cloning procedures were employed for cloning of the genes and other regulatory elements.

All the three genes *ech-42*, *RsAFP2* and *Ace-AMP1* were codon optimized (Konda *et al.*, 2009; 2010) to exhibit relatively higher codon adaption index (CAI) values and altered GC content to suit the host. Three genes were synthesized using overlap extension and further confirmed by sequencing. The three optimized genes were subcloned as a single transcriptional unit under the control of E-CaMV35S promoter and VSP terminator. The transcript from the construct is expected to get translated

into a polyprotein with the start codon present in ECH-42 and stop codon in Ace-AMP1. Also, with the inclusion of 2A linker peptide, the polyprotein is expected to self-cleave in a co-translational process in such a way the ECH42 along with the first 19 amino acids of the first 2A sequence attached at the C-terminus would be released, *RsAFP2* peptide will be released with the last amino acid of the first 2A peptide attached at its N-terminal and first 19 amino acids of the 2nd 2A sequence attached at its C-terminus, while *Ace-AMP1* peptide will have the last amino acid of the second 2A attached at its N-terminal and a stop codon at its C-terminus (Fig. 1). The entire multi-cistronic polyprotein gene construct was sub-cloned into pCAMBIA-0390 to develop OCHN (‘O’-0390, ‘C’-E-CaMV35S, ‘H’-*hpt*, ‘N’-*nos*) binary vector. Thus, a coordinately expressing multi-cistronic gene construct (Fig. 1) bearing three antifungal genes interlinked by 2A linker sequence was developed for constitutive expression and subcloned into binary vector with flanking MARs regions within the T-DNA.

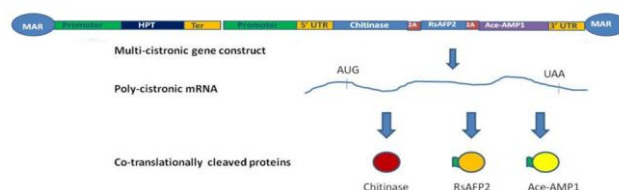


Figure 1: Schematic Representation of the multi-cistronic gene construct

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Morphological characterization of sesame germplasm

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ABSTRACT

The present study was done to characterize 110 germplasm accessions including 26 released varieties for 30 morphological characters and 10 agronomic characters. The qualitative data of morphological characters was subjected to estimate pair-wise dissimilarity co-efficient. The accessions got classified into 7 clusters. Seeds with brown and black coat colour got grouped exclusively in 3 clusters. An attempt was made to associate qualitative data based clustering to agronomic traits to aid selections in segregating population.

Keywords: Germplasm, Morphological traits, Sesame

Sesame (*Sesamum indicum* L.) is a highly valued oilseeds crops for its quality edible oil and direct confectionery uses. India has a rich diversity of cultivated sesame (Bhat *et al.*, 1999) and it has been proved that the domestication occurred on the Indian subcontinent (Bedigian, 2003; 2014). Characterization and classification of the germplasm into distinct groups and identification of the better performing ones is the primary step in plant breeding which will be followed by hybridization to create further variability and selection exercised among the variants for required characters.

Hundred and ten entries including 26 released varieties were evaluated in augmented design with 3 checks during summer 2018 and 2019 for agro morphological traits. The accessions were characterized qualitatively for 30 morphological characters based on descriptors of Bioversity International, Rome and 10 agronomic characters. The qualitative data was subjected to Rogers-Tanimoto method for calculating pair-wise dissimilarity co-efficient and clustering was done based on weighted neighbor joining method.

Morphological characterization of germplasm of sesame was taken up to identify genotypes with distinct traits. Variations for seed coat colour, seed coat texture, extra floral nectary size, capsule hair, flower colour and top leaf shape influenced the dissimilarity index. Seed coat colour was the major distinguishing character where the genotypes were grouped into white, light brown, dark brown and black out of 13 classes listed in the descriptors of Bioversity International. No specific trait associations with seed coat colour was observed. There were smooth, partially rough, radially rough and reticulately rough seed coat texture types. The texture of white seed coat was always smooth or partially rough, while all four textures were found in coloured seed coat types. Reticulately rough seed texture was found in black seed coat type only. Extra floral nectaries were prominently found in all the accessions. Glabrous, sparse, medium and strong hairiness were found in the capsules. Single flower at the node was found in all the accessions while the accessions had white,

white pink shade, white dark pink shade and violet coloured exterior corolla. The pigmentation intensity varied from few dots to flakes. The central leaf shape was linear, elliptic and lanceolate. Weighted neighbor joining

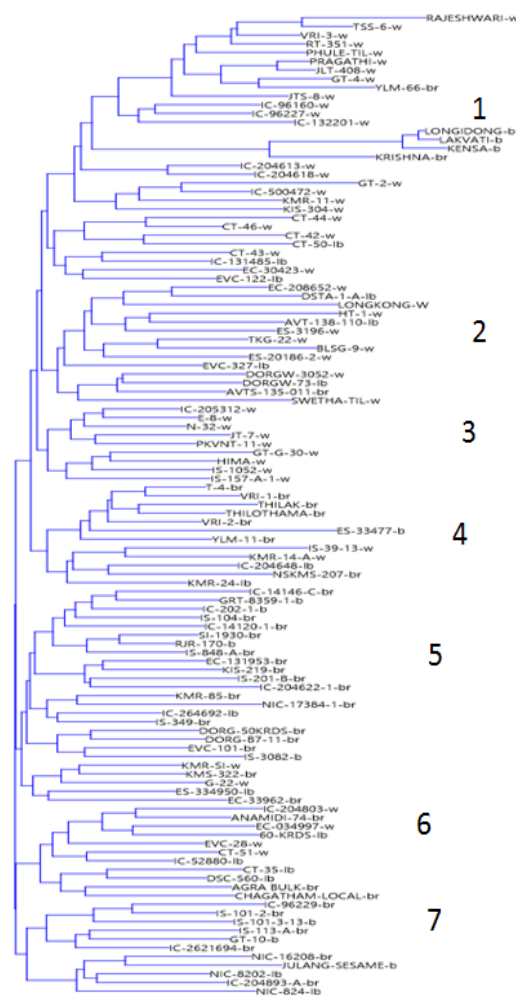


Figure 1: Dendrogram of 113 germplasm accessions clustered into 7 clusters

method resulted into 7 distinct clusters (Figure 1). Most of the released varieties clustered into one group and were earlier to flower and mature compared to other accessions. The percent of oil content (44%) and seed yield (9 gm/plant) was high in Cluster1 due to presence of improved cultivars. This study will be useful in selection of genotypes for breeding work.

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Morphological and biochemical mechanisms of resistance against powdery mildew (*Golovinomyces cichoracearum*) of sunflower (*Helianthus annuus* L.)

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ABSTRACT

Eighteen hybrids and two checks of sunflower were evaluated for their morphological and biochemical traits imparting tolerance/resistance to powdery mildew during *rabi*, 2015-16. The results revealed that sunflower hybrids *viz.*, LSFH-2026, LSFH-216, LSFH-3008 and LSFH-1225 exhibited moderately resistant to moderately susceptible reaction to powdery mildew. Moderately resistant hybrids exhibited least frequency and size of stomata and higher trichome density. The biochemical traits revealed that these hybrids had higher amounts of total phenols, total sugars and chlorophyll in healthy leaves. The rate of reduction of total phenols, total sugars and chlorophyll content was minimum in these three hybrids as compared to susceptible checks, after infection of powdery mildew pathogen.

Keywords: Biochemical, Physiological characterization, Powdery mildew resistance, Sunflower

Powdery mildew disease becoming a major disease in sunflower and under ideal conditions it causes substantial yield loss. Developing resistant genotype is the right choice considering the least damage such material causes for the environment. In the resistant genotypes, different mechanisms are known to operate in imparting the resistance against diseases and understanding the basis would help in manipulations as well.

In this study, 20 sunflower hybrids with two checks *viz.*, LSFH-35 and LSFH-171 were evaluated against powdery mildew in Randomized Block Design at College of Agriculture, Latur (Maharashtra State) during *rabi*, 2015-16. Observations on powdery mildew incidence and intensity were recorded at 60 days after sowing. Powdery mildew disease intensity on foliage was graded by applying 0-9 disease rating scale. Total sugars and phenols were determined from healthy and diseased leaves of sunflower. Structural and anatomical traits *viz.*, number and size (length and breadth) of stomata and trichome frequency in different hybrids were studied. Five plants per entry were randomly selected, from these second leaf on main stem was plucked, subjected to estimation of chlorophyll by SCMR technique and average chlorophyll content was computed. The data of various studies was subjected to statistical analysis.

On the basis of per cent powdery mildew intensity, test hybrids were categorized into five groups *viz.*, resistant (1 to 10%), moderately resistant (11 to 25 %), moderately susceptible (26 to 50 %), susceptible (51-

75%), and highly susceptible (76-100%). Morphological and anatomical features of the leaves of test entries varied substantially. Moderately resistant hybrids exhibited least frequency of stomata on adaxial and abaxial leaf surfaces, minimum stomata size (L x B) on adaxial and abaxial leaf surfaces and higher trichome frequency in comparison to moderately susceptible, susceptible and highly susceptible sunflower hybrids. Further, results indicated that stomatal frequency and their dimensions (LxB) were comparatively less on abaxial leaf surface than adaxial leaf surface. These results are in conformity with the earlier reports as observed in mulberry powdery mildew system by Chattopadhyay *et al.* (2011).

The result on leaf bio-chemical parameters *viz.*, chlorophyll, phenols and total sugars revealed significant variations (Table 1). The SCMR values indicated drastic reduction in foliage chlorophyll content in the susceptible and highly susceptible hybrids compared to moderately resistant and moderately susceptible hybrids as has been reported. Similar results were reported earlier by Muhammad and Khan (2014) against pea powdery mildew. Higher content of total phenols were found in healthy leaves than powdery mildew infected leaves of sunflower hybrids, which later decreased significantly due to infection by powdery mildew. Post inflectional reduction in phenols was minimum in moderately resistant hybrids; whereas, it was maximum in susceptible hybrids. Phenolic compounds are well known to impart resistance against many plant diseases such as the one reported by

Muhammed and Khan (2014) against pea powdery mildew. Total sugar content was high in healthy leaves than the powdery mildew infected leaves of sunflower hybrids, which indicated the depletion of sugars during host-parasite interaction. Reduction in total sugars was maximum in highly susceptible hybrids as compared to moderately resistant hybrids. Nema (1989) reported higher

reduction in sugars during disease development in betelvine leaves after inoculation with leaf spot bacterium. Based on present study, it is concluded that sunflower hybrids viz., LSFH-2026, LSFH-216, LSFH-3008 and LSFH-1225 had moderately resistant to moderately susceptible reactions to powdery mildew disease, due to their structural and bio-chemical variations.

Table 1 Mean performance of sunflower hybrids for bio-chemical characters

Hybrid	P.M. Severity (%)	SCMR			Phenol (mg/g)			Total Sugar(mg/g)		
		H.	I.	R	H.	I.	R	H.	I.	R
LSFH-4913	28.90	39.37	33.73	14.3	3.14	2.99	04.8	18.42	16.78	08.9
LSFH-1044	82.87	38.63	28.16	27.1	1.64	1.34	18.6	19.14	13.38	30.1
LSFH-3008	42.73	40.40	34.90	13.6	3.13	2.99	04.5	18.55	16.88	09.0
LSFH-1225	27.99	36.16	31.97	11.6	3.55	3.34	06.1	18.68	15.76	15.6
LSFH-899	68.27	35.11	27.00	23.1	1.63	1.21	25.9	18.72	13.96	25.4
LSFH-3011	26.71	35.84	32.22	10.1	2.70	2.54	06.2	18.56	16.70	10.0
LSFH-3065	77.57	36.60	27.29	25.4	2.58	2.11	18.5	19.12	15.85	17.1
LSFH-1051	81.47	39.73	27.75	30.2	1.37	0.97	29.2	19.13	16.45	14.0
LSFH-3051	41.86	36.25	28.88	20.3	3.14	3.03	03.6	19.12	18.45	03.5
LSFH-2141	71.17	36.05	28.61	20.6	2.78	2.56	08.2	20.63	12.32	40.3
LSFH-4951	35.81	38.53	33.12	14.0	1.77	1.66	06.4	18.34	16.74	08.7
LSFH-2026	29.03	38.60	34.71	10.1	2.39	2.28	04.6	18.56	17.24	07.1
LSFH-3064	75.37	37.59	27.03	28.1	0.78	0.45	23.7	19.66	12.07	38.6
LSFH-35©	43.31	36.17	31.30	13.5	1.91	1.76	08.3	18.14	15.92	12.2
LSFH-3038	76.23	37.99	29.89	21.3	1.80	1.41	21.9	20.75	15.12	27.1
LSFH-2271	71.21	37.63	28.00	25.6	1.79	1.49	16.8	19.68	12.00	39.0
LSFH-1007	75.27	37.41	29.98	19.9	2.29	1.97	14.0	19.98	16.06	19.6
LSFH-1716	35.25	40.68	38.07	6.4	1.90	1.81	05.0	19.00	14.70	22.6
LSFH-216	24.52	38.36	33.88	11.7	2.75	2.53	008.3	19.44	15.45	20.5
LSFH-171©	39.13	39.84	33.11	16.9	2.20	2.03	7.7	18.27	14.08	22.9
Mean	52.73	37.8			2.26			19.09		
SE ±		1.02	0.32		0.16	0.16		0.27	0.22	
CD + 5%		3.02	0.96		0.49	0.49		0.80	0.66	

H= Healthy leaves, I= Infected leaves, R=Reduction (%)

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Variability for agro-morphological traits in safflower (*Carthamus tinctorius* L.) germplasm

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ABSTRACT

A set of 30 safflower germplasm accessions and two checks were evaluated to study the variability for nine agro-morphological traits. Based on better performance than the check varieties, accessions for seed yield (4), oil content (8) and bold capitula with high seed number (5) were identified for utilization in breeding.

The ICAR-Indian Institute of Oilseeds Research, Hyderabad holds more than 6900 accessions of safflower germplasm which are being systematically evaluated in *J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

different sets (Mukta, 2012; Mukta *et al.*, 2017). The collection exhibits a wide range of variability in agro-morphological characters which need to be assessed for

identification of trait specific accessions for utilization in safflower breeding. A set of 30 accessions found promising under initial evaluation were selected for evaluation during *rabi* season of 2014-15. The trial was conducted in randomised block design with net plot size of 9 sq m (4 rows x 5 m) with two replications and spacing of 45 cm x 20 cm. Observations on quantitative traits were recorded at maturity on five plants selected at random from each plot whereas seed yield was recorded on whole plot basis.

Wide variability was recorded for number of seeds/primary head, number of capitula/plant, seed yield/plant and oil yield/plant (Table 1). Among the accessions evaluated, GMU-1423-1 (36.93 g/plant), GMU-2758-1 (32.5g/plant), GMU-3101 (31.89g/plant),

GMU-2444 (31.74g/plant), were identified for high/on par seed yield in comparison to the check A-1 (31.74 g/plant). Accessions GMU-1437, GMU-1464, GMU-2039, GMU-2444, GMU-3530, GMU-3624, GMU-3781 and GMU-3965 recorded oil content of 33.09-33.86% whereas the check A-1 recorded 27.4% oil content.

In terms of oil yield, GMU-2444 (10.5g/plant), GMU-3101 (10g/plant), GMU-3966 (9.7g/plant), GMU-4907 (9.6g/plant), GMU-2968 (9.6g/plant), GMU-1423-1(9.5g/plant), GMU-1437 (9.2g/plant), GMU-3758 (8.8g/plant) and GMU-2830 (8.7g/plant) were identified. Five accessions with high number of seeds per capitula were also identified. The agro-morphological traits for the most promising accessions are presented (Table 2).

Table 1 Variation for agro-morphological traits among 30 safflower germplasm accessions

Characteristics	Mean	Minimum	Maximum	CV%
Days to 50% flowering	82.3	76.0	91	4.2
Plant height (cm)	95.5	77.1	115.7	9.6
No. of capitula/plant	37.3	15.0	67.9	29.1
Diameter of primary head (cm)	2.3	1.77	3.4	15.6
No. of seeds/primary head	33.8	16.6	61.8	35.2
100-seed weight (g)	4.1	2.9	5.0	15.2
Seed yield/plant (g)	24.6	11.6	36.9	24.7
Oil content (%)	30.5	24.5	33.9	9.2
Oil yield (g/plant)	7.4	3.5	10.5	22.9

Table 2 Agro-morphological traits for promising trait specific accessions identified

Accessions	Days to 50% flowering	Plant height (cm)	No of capitula/plant	Diameter of primary head	Seeds/ primary head	Seed yield/ plant (g)	100 seed weight (g)	Oil content (%)	Oil yield (g/pl)
High seed yield									
GMU-1423-1	91	113.1	50	2.3	41	36.9	3.4	25.9	9.5
GMU-2444	80	94.2	43	2.2	33	31.7	4.6	33.1	10.5
GMU-3101	76	77.1	39	2.0	22	31.9	4.9	31.4	10.0
High number of seeds/primary capitula									
GMU-472-1	86	111.2	23	3.3	62	26.5	4.6	28.0	7.4
GMU-2758-1	84	99.3	25	3.4	60	32.5	5.0	24.5	8.0
GMU-1810-2	84	100.2	39	2.8	50	30.2	3.6	26.4	8.0
GMU-7303	81	89.2	15	2.6	48	20.6	3.7	32.3	6.6
GMU-4907	79	104.9	43	2.5	38	30.6	4.9	31.4	9.6
A-1(Check)	83	106.4	37	2.3	31	31.7	5.6	27.4	8.7

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Development and evaluation of diverse wilt resistant monoecious lines in castor

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ABSTRACT

Since 1990s, development of wilt resistant and high yielding hybrids has played an important role in increasing the productivity of castor from around 320 kg/ha to 1700 kg/ha. Eleven elite monoecious lines having wilt resistance were developed by hybridization using five germplasm and seven elite monoecious lines. The elite lines *viz.*, ICS-303, ICS-304, ICS-315 and ICS-318 had better yield traits like spike length, seed weight and seed yield per plant. ICS-320 and ICS-321 derived from 48-1 and RG-2991 had the highest oil content (>50%) than the checks 48-1 and DCS-107. These elite lines will help in development of wilt resistant and high yielding hybrids and varieties in castor.

Keywords: Castor, Monoecious lines, Wilt resistance

Castor is an important commercial, industrial and non-edible oilseed crop suitable for both rainfed and irrigated cultivation in tropical and sub-tropical climatic conditions. *Fusarium* wilt (caused by *Fusarium oxysporum* f.sp. *ricini*) causes 39-77% yield loss (Pushpavathi *et al.*, 1997). Hence development of wilt resistant varieties is critical for sustainable crop yields (Dubey, 2016). We report here the development of wilt resistant lines in castor using diverse germplasm lines.

A total of 21 diverse germplasm lines were crossed with 9 proven monoecious lines and their F₁s were selfed or backcrossed with the proven parents, according to the desirability of traits. Atleast, 200 F₂ plants from each cross were subjected to agromorphological evaluation and selection in *kharif/rabi* seasons. 10-20 best progenies were selected and selfed in each F₂ population based on the

desirable traits like days to 50% flowering, proportion of maleness, longer spike length, larger capsule size, spines on capsules, branching pattern etc. 40 plants were evaluated from each of the selected progenies in F₃, F₄, F₅ and F₆ generations. 142 selected and stabilized lines were further evaluated for agronomic and morphological traits in ARBD (2 rows of 10 plants each, spacing 90 x 60 cm), along with checks 48-1 and DCS-107 under rainfed conditions during *kharif* 2017-18 season at ICAR-IIOR. Of these, 11 monoecious lines with desirable agromorphological traits and wilt incidence <10% were identified as elite lines from a total of 44 lines screened for wilt reaction (resistant check 48-1 and susceptible check JI-35) in wilt sick plot at ICAR-IIOR during 2017-18 as per the standard procedure (Santha Lakshmi *et al.*, 2014).

Table 1. New monoecious lines, their pedigree, agro-morphological characters and wilt reaction

ICS No.	Pedigree of ICS Lines	Colour & Bloom	PNN	DF50	EPSL (cm)	SW (g)	OC%	SYPP(g)	Wilt% @150 days
ICS-303	(RG-799 X DCS-96) X DCS-96	G2SP	12-16	63	49	30.5	46.9	128	0
ICS-304	(RG-799 X DCS-96) X DCS-96	G2SP	14-16	64	58	32.5	47.7	153	0
ICS-305	(RG-799 X DCS-106) X DCS-106	G2SP	13-15	65	38	28	47.9	116	7.8
ICS-312	DCS-97 X DCS-94	R2SP	11-15	58	69	26	47.4	118	5.6
ICS-314	RG-1582-3 X PCS-43	G2SP	10-14	64	42	30	47	107	2.2
ICS-315	RG-1582-5 X JC-3	G2SP	15-17	66	47	34	46.3	99	0
ICS-316	DCS-94 X RG-3105	G2SP	15-16	61	63	33.5	42	89	3
ICS-318	DCS-94 X RG-3105	G2SP	15-17	64	46	37.5	48	150	0
ICS-319	DCS-9 X RG-2672	R2SP	14-15	58	55	27	46.5	101	8.8
ICS-320	48-1 X RG-2991	R2SP	14-17	64	45	28.5	51.7	114	4.4
ICS-321	48-1 X RG-2991	R2SP	14-17	62	38	27.5	51	146	4.8
DCS-107 ©	-	G2SP	16-18	63	39	28.0	47.50	128	
48-1©	-	R2SP	16-18	65	38	27.7	49.50	112	2.20
JI-35	-	-	-	-	-	-	-	-	89.7

G2- Green and Double bloom, R2-Red, double bloom, M3- Mahogany Triple bloom, SP-Spiny capsules, PNN-Primary node number range, DF50-Days to 50% flowering
EPSL-Effective primary spike length, SW-100 seed weight, OC %- Oil content %, SYPP-Seed yield per plant

Agromorphological traits and wilt reaction of identified elite lines is given in Table 1. These lines had 5 diverse germplasm lines and 7 elite lines in their pedigree. ICS-303, ICS-304, ICS-315 and ICS-318 not only had zero wilt incidence but also better yield traits like longer effective spike length, higher 100 seed weight and seed yield per plant. These elite monoecious lines would be a good source for development of high yielding and wilt resistant varieties and hybrids in castor.

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Linkage between stem colour and pigmentation in young leaves of castor

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ABSTRACT

Development of superior cultivars in any crop including castor requires knowledge on inheritance of various traits to handle the segregating generations in various breeding methods. In the present study, inheritance of anthocyanin pigmentation in younger leaves was studied in three F₂ populations. The results revealed that the presence of anthocyanin in emerging leaves inherited as monogenic dominant and it showed tight linkage with red stem colour.

Keywords: Anthocyanin, Castor, Leaf colour, Linkage, Stem colour

In castor, morphological traits such as stem colour, waxy coatings (bloom), capsule spinyess, plant type, leaf shape and branching pattern show qualitative nature of inheritance (either monogenic or oligogenic) among which plant type, leaf shape, type of nodes and branching pattern are tightly linked (Lavanya *et al.*, 2018). Characters having qualitative inheritance not only serve as major descriptors for DUS testing but also play important role in handling segregating populations. Presence of pigmentation in emerging leaves is one of the 30 descriptors used in DUS testing of castor genotypes. In the present study, an attempt was made to study the inheritance pattern of pigmentation in young leaves.

Five inbred lines *viz.*, RG-1149 (green stem with presence of pigmentation in young leaves), RG-2874 and 48-1 (red stem with presence of pigmentation in young leaves) and RG-1673 and RG-2685 (green stem with absence of pigmentation in young leaves) were used to generate three F₂ populations *viz.*, RG-1149 × RG-1673, 48-1 × RG-1673 and RG-2685 × RG-2874 segregating for pigmentation in young leaves. Data for stem colour and presence of pigmentation in young leaves was recorded before flowering on F₂ plants in the experimental farm of ICAR-IIOR during *kharif* 2019-20.

The segregation pattern for stem colour and presence of pigmentation is presented in Table 1. Appearance of F₁

in all three crosses indicated the dominant nature of presence of pigmentation. The segregation for pigmentation in F₂ populations revealed monogenic inheritance. In two F₂ populations (48-1 × RG-1673 and RG-2685 × RG-2874), in which the parents differed for stem colour and pigmentation, the red stem and presence of pigmentation were dominant over green stem and absence of pigmentation. Recombinants having red stem with absence of pigmentation or green stem with presence of pigmentation were not found indicating strong linkage between the two traits in castor genotypes studied. In a panel of more than 280 castor germplasm lines studied for different traits, lines with combination of red stem and absence of anthocyanin and green stem with presence of pigmentation were very less in frequency (data not shown). This trend in germplasm panel supports the hypothesis that stem colour and pigmentation in young leaves are tightly linked in castor.

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Table 1 Segregation pattern for stem colour and pigmentation in young leaves in castor

Cross	F ₁	F ₂ population			
		Red/Present	Red/Absent	Green/Present	Green/Absent
48-1 (red/present) × RG-1673 (green/absent)	Red/ Present	143	0	0	49
RG-2685 (green/absent) × RG2874 (red/present)	Red/ Present	159	0	0	68
RG-1149 (green/present) × RG-1673 (green/absent)	Green/Present	-	-	136	51

Development of breeding lines with high oil content in safflower using exotic germplasm sources

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ABSTRACT

Safflower breeding lines with high oil content (36-44%) were developed through Indian × exotic germplasm crosses by pedigree method of selection. A promising line, F5-55 showed high oil content (38.5%) and high yield (10.7 g/plant) with comparable seed yield with the checks. The results indicated that selection for high oil content can be successful in early segregating populations; however, significant improvement in seed yield could not be achieved.

Keywords: Exotic germplasm, High seed oil content, Safflower

Low oil content in the Indian safflower cultivars is a major concern. Exotic safflower varieties and germplasm possess > 40% oil content (Mündel and Bergman, 2009), which could be valuable donors for improving oil content under Indian conditions (Kadirvel *et al.*, 2017a; 2017b). In this study, our aim was to develop superior breeding lines with high oil content (>35%) using exotic safflower genotypes from USA and Mexico.

Indian varieties (A-1, Bhima, PBNS-12 and NARI-57) were crossed with high oil accessions (EC-736487, EC-736500, EC-736501, EC-736516, EC-755660, EC-755664 and EC-755675) and pedigree method of selection was followed. The promising selections were evaluated in field trial (Plot size: 3 rows; Alpha Lattice Design; 3 replications). Seed yield/plant (g), oil content (%) and oil yield/plant (g) were measured.

A set of 30 selections (F3) with oil content ranging from 36.12% to 44.19% were identified from eight crosses. Eight progenies were further evaluated for yield

performance in field trial (Table 1). The results indicated that selection for high oil content can be successful in early segregating populations in safflower; however, significant improvement in seed yield could not be achieved.

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Table 1 Performance of high oil selections

Selection	Pedigree	Seed yield/plant (g)	Oil content (%)	Oil yield/plant (g)
F4-8	Bhima x EC755660	23.0	38.7	8.9
F4-55	Bhima x EC755675	27.7	38.5	10.7
F4-125	PBNS12 x EC755664	24.6	36.6	9.0
F4-157	PBNS-12 x EC-736501	24.5	38.2	9.5
SAF-20A	NARI-57 x EC-736500	17.6	36.4	6.4
SAF-20B	NARI-57 x EC-736500	23.1	38.7	9.0
SAF-39A	NARI-57 x EC-736500	24.5	39.8	9.8
F5-86-2-1-THS	PBNS-12 x EC-736487	19.8	39.6	7.9
A-1	-	24.6	29.8	7.4
Bhima	-	28.3	32.1	9.0
PBNS-12	-	32.5	30.2	9.9
NARI-57	-	15.3	37.2	5.8
F value	-	NS	19.6**	NS
LSD	-	-	2.3	-

Combining ability and heterosis of untested inbred lines in sunflower (*Helianthus annuus* L.)

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ABSTRACT

An investigation was carried out to estimate the combining ability and heterosis of 12 fertile sunflower hybrids, 12 parents and checks *viz.*, KBSH 44 and KBSH 53 in augmented design during *kharif* 2018. The lines CMS 903A, NDCMS 2A and the tester K 3 were identified as good general combiners for seed yield and its component traits. The cross combinations CMS 903A × GMU 411, CMS 135A × GMU 411 and NDCMS 2A × GMU 411 exhibited highest significant *sca* effects and high heterosis over checks for seed yield.

Keywords: Combining ability, Heterosis, Inbreds, Sunflower

Exploitation of heterosis is the chief method of crop improvement in sunflower. The potentiality of any line to be used as a parent in hybridization programme depends on its *per se* performance and the performance of the hybrid derived from it and its own *gca* effect. Hence in the present investigation, an attempt was made to study the combining ability of 17 new inbred lines, three CMS lines and heterosis of F₁ fertile hybrids over standard check.

The experiment material comprised of 17 new inbred lines *viz.*, GMU-327, GMU-336, GMU-342, GMU-362, GMU-376, GMU-379, GMU-400, GMU-411, GMU-423, GMU-426, GMU-428, GMU-441, GMU-450, K-3, K-7, K-8, A-7 and three cytoplasmic genetic male sterile lines, CMS 903A, CMS 135A and NDCMS 2A. In *kharif* 2018 an experiment was laid out for evaluating the resulted 51 hybrids along with 17 inbreds, corresponding three CMS B lines and two hybrid checks *viz.*, KBSH 44 and KBSH 53 in a Randomized Complete Block Design consisting of three replications. All the plants in the F₁ progenies at flowering were evaluated for restoration of fertility and maintenance of sterility. The data was recorded from five randomly selected plants from each genotype for seven characters. The combining ability analysis was carried out

according to Kempthorne (1957) and percent heterosis of derived F₁ over standard check hybrid was estimated as per Hayes *et al.* (1955).

Out of 17 new inbred lines tested with three CMS lines, 4 inbred lines *viz.*, GMU 411, GMU441, K3 and A7 were effective restorers for all three CMS lines. Among the 51 crosses, 12 hybrids were fertile. The cross combinations *viz.*, CMS 903A × GMU 411, CMS 135A × GMU 411 and NDCMS 2A × GMU 411, were promising for yield. Lines CMS 903A, NDCMS 2A and the tester K 3 were identified as good general combiners for seed yield and its component traits. However, the restorers and maintainers and the hybrids must be further evaluated for stability and G × E interaction.

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Trichoderma mediated induced systemic resistance in castor against seedling blight

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ABSTRACT

Colonization of castor roots by *Trichoderma* induced resistance to seedling blight disease. When compared with untreated seedlings, *Phytophthora* disease severity was reduced by 93% in *Trichoderma* (Th4d strain)-treated ones. Induced systemic resistance (ISR) by *Trichoderma* was confirmed by the expression profiling of a few signature genes known to be up-regulated during ISR.

Keywords: Castor, Induced systemic resistance. *Trichoderma*, Seedling blight

Seedling blight disease, caused by *Phytophthora parasitica* var *nicotiana*, is a major disease of castor (*Ricinus communis* L.) that results in yield reduction up to 30 to 77%. *Trichoderma*, a bio-control agent that can colonize root system of host plants is known to impart resistance against diseases through ISR as well as exert direct action against phyto-pathogens (Romera et al., 2019). Our studies examined the ISR in castor against seedling blight induced by different *Trichoderma* strains.

Seeds of DCS107, a susceptible genotype for seedling blight were treated with three strains of *T. asperellum* viz., TaDOR-N13, -TV5, -7316 and one strain, Th4D of *T. harzianum*. After the appearance of cotyledonary leaves, 10 day old discs of *Phytophthora parasitica* were placed on the abaxial side, of one of the two leaves. Leaf wetness, temperature (25°C) and humidity (about 70%) were maintained. Necrosis caused by the pathogen was measured at 48, 72 and 96 hours post infection (hpi) in three replicates each. In a modified experiment, a booster dose of *Trichoderma* suspension was given to the seedlings. To validate *Trichoderma*- mediated ISR within 24 hpi, total RNA isolated from the cotyledonary leaves (un-inoculated) of 12 day old castor seedlings treated with Th4d strain for 0, 1, 2, 3, 4, 6, 12, 16 and 24 h were subjected to RT-PCR and semi-quantitative RT-PCR using primers specific to PR1, PR2, PDF1.2a, OPR3 and Actin genes.

When compared with untreated seedlings, disease severity was reduced to 85.7% in Th4d treated seedlings. *Trichoderma* strains TaDOR7316 and N13 showed 50% and 42.9% of disease reduction over check (data not shown). In the 'booster' dose experiments, leaf blight size was considerably reduced when seedlings were given *Trichoderma* boost (Table 1). Th4d seed treated + 'booster' displayed better control of leaf blight (0.39cm), and N13 seed treated + 'booster' displayed infection diameter of 0.48cm when compared with control

(1.53cm). RT-PCR analysis indicated up-regulation of the signature genes within two hpi, which continued until 24 hpi and by 48 hpi the expression levels started attenuating. These results indicated that ISR is initiated very early after interaction of *Trichoderma* with the castor roots. RT-PCR analysis with samples from the booster dose experiments, indicated increased expression after 'booster' dose of the *Trichoderma* on the roots of castor seedlings pre-treated with *Trichoderma* (seed treatment). The expression of the signature genes reached the maximum level within 6 hpi and maintained at that level even after 48 hpi indicating the prolonged ISR.

Table 1 Disease severity in different *Trichoderma* treatments

Treatments	Disease severity (%)	Reduction over check (%)
N13 seed treatment (ST)	47	41.25
N13 ST+ re-inoculation	14	82.5
Th4d ST	14	82.5
Th4d ST+ re-inoculation	5	93.75
TV5 ST	35	56.25
TV5 st+TV5 re-inoculation	60	25.00
7316 ST	40	50.00
7316 ST+ re-inoculation	40	50.00
No ST+Th4d re-inoculation	40	50.00
Check	80	0.00

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Robust and informative microsatellite markers for genetic improvement of Indian sesame (*Sesamum indicum* L.)

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ABSTRACT

Quality of sesame seed oil is superior but seed yields have stagnated at abysmally low levels. Marker-assisted genetic improvement holds key to break the yield-barrier. Robust molecular markers are the indispensable prerequisites of marker-assisted breeding. Microsatellites are the easy-to-use and codominant molecular markers widely used across crop species. In the present study, a set of 180 robust and informative SSR markers have been identified from about 400 SSR based primers tested and thus adding more markers for utilization in different marker assisted breeding programmes of sesame.

Keywords: SSR Markers, PCR optimization, Sesame, Molecular markers

Sesame (*Sesamum indicum* L.), is a nutritionally, economically, agronomically, and culturally important oilseed crop that is yet to be explored at molecular levels and in general, yield levels of the crop are almost stagnated for decades (Akhtar *et al.*, 2009). Intervention with biotechnological tools such as molecular marker-assisted breeding is a significant modern approach to break yield barriers in sesame, as is accomplished in other field crops (Verma *et al.*, 2019). Since the second-half of the previous decade genomic resources in sesame are increasingly becoming available (Dossa *et al.*, 2017). Microsatellite markers are available in the public domain from various sources. However, most of them are not ready-to-use in Indian genotypes. Therefore, it is necessary to make them useful for genetic improvement of Indian sesame genotypes. With this motivation, the present study was conducted to develop robust and informative microsatellite markers for Indian sesame.

Publicly-available primer sequences were downloaded from various published works and databases (Dossa *et al.*, 2017). Primers were synthesized and template DNA of Indian sesame genotypes were utilised. Two-dimensional gradient PCR, with respect to MgCl₂ concentration and annealing temperature, was performed on a thermocycler having gradient temperature facility. PCR-amplicons were run on 4% agarose electrophoresis and size-based alleles were ascertained.

Robustness and informativeness of microsatellite markers are determined by PCR parameters and allelic variations, respectively. Out of 400 microsatellite markers attempted, 180 markers showed consistent amplification in a panel of 50 morphologically diverse (data not given) Indian sesame genotypes with specifically optimized PCR parameters. Optimum annealing temperature ranged from 55°C to 63°C and MgCl₂ concentration varied between 1.5 mM and 2.5 mM. A representative electropherogram of a set of 7 primers with one genotype is shown in Fig 1. Polymorphism-information-content (PIC) of 80 markers

ranged between 0.32 and 0.65 with an average of 3.5 alleles per marker locus.

In conclusion, upon ensuring robustness by meticulously optimizing PCR parameters, microsatellites were made to reveal prevalent allelic spectrum of their respective loci in a given panel of Indian genotypes. A set of 180 robust and informative markers have been developed that could be used in Indian sesame genetic improvement programs.

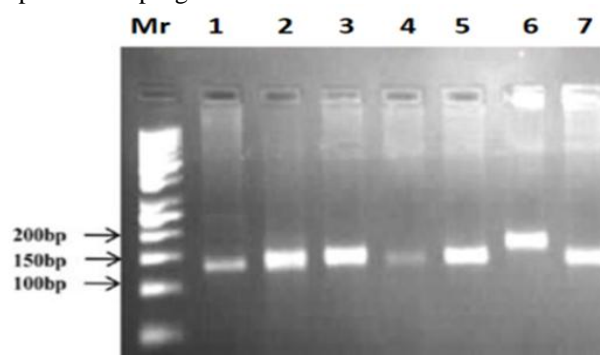


Fig. 1. Electropherogram showing amplicons of markers. Mr: marker; SSR markers: 1. SIM030, 2. SIM034, 3. SIM051, 4. SIM055, 5. SIM059, 6. SIM065, 7. SIM072, amplifying their respective loci in a IIOR sesame genotype NIC-16426-IS.

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Screening of new inbreds for their sterility and fertility reaction against new CMS lines in sunflower (*Helianthus annuus* L.)

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ABSTRACT

Sunflower, an important oilseed crop in the state of Andhra Pradesh witnessed a sharp decline in area during the recent past and the lack of diversity in CMS lines and inbreds is attributed as one of the major reasons. To address this issue, a set of new CMS lines (NDLA 2,3,4,5,6,7,8) and inbreds (CPI 1,6,8,10, NDI 1, 2, 12, 13, 14) of sunflower were tested. The results revealed that NDI 2 showed maintainer action whereas NDI 14, 15 segregated for fertility. CPI 1, 6, 8, 10 and NDI 1, 13 restored fertility. The identified restorers can be exploited either to strengthen the future hybrid breeding or in the synthesis of new restorers.

Keywords: CMS lines, Inbred lines, Fertility restoration, Sterility maintenance, Sunflower

Sunflower, an important oilseed crop cultivated in varied climatic and soil conditions throughout the year. It's cultivation in Andhra Pradesh witnessed a sharp decline in area during recent past. Thus, it has become imperative to choose diverse CMS and restorer lines which combine well to yield superior hybrids excelling the standard checks. To address this, AICRP sunflower scheme working at RARS, Nandyal during 2008-13 has come up with a series of newly developed cytoplasmic male sterile lines in PET-1 background. Simultaneously, a set of new inbreds have also been developed.

Crosses were made between seven new CMS lines (NDLA 2, 3, 4, 5, 6, 7, 8) developed in PET I background over years and new inbreds (CPI 1, 6, 8, 10 and NDI 1, 2, 12, 13, 14) during *rabi* 2014-15. Evaluation for restorer/maintainer action was studied in a non-replicated trial of 2 rows of 3 m length with a spacing of 60 cm between rows and 30 cm within the row along with two checks, NDSH 1012 and DRSH 1 during *kharif* 2015. The F₁s were assessed critically at anthesis for anther exertion and pollen shedding by observing individual flowers and inbreds were segregated as restorers, maintainers and partial restorers. Those inbreds restored fertility in the CMS lines were evaluated for mean seed yield and its related traits.

Inbred, NDI 2 showed maintainer action with all the CMS lines tested and it can be used to develop three way hybrids or new CMS line after testing for per se agronomic performance and combining ability. NDI 14 and 15 segregated for fertile action with all the CMS lines. The incomplete segregation for fertility in NDI 14 and 15 inbreds to the tested CMS lines can be ascribed to presence of restorer genes in heterozygous condition (Virupakshappa *et al.*, 1991) and purification of these lines is required. The present study also came up with new restorers like CPI 1, 6, 8, 10 and NDI 1, 13 which showed fertile reaction with all the CMS lines. A preliminary evaluation of the 42 fertility restoring hybrids was done in the same year using two checks NDSH 1012 and DRSH 1. Nine hybrids excelled in seed yield over the best check, NDSH 1012 (1557 kg/ha). The top performing hybrids are NDLA 3 x CPI 8 (2335 kg/ha), NDLA 3 x CPI 10 (2224 kg/ha) and NDLA 8 x CPI 1 (2085 kg/ha).

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Combining ability for seed yield and its component traits in castor (*Ricinus communis* L.)

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ABSTRACT

Combining ability analysis was carried out using five pistillate lines as female and 13 monoecious lines as male for seed yield and component traits in castor. The result indicated that both *gca* and *sca* variances were important in the expression of all the traits. Non-additive gene action was predominant for seed yield and oil content, while additive gene action was more important in the expression of length of main spike, number of capsules on main spike, number of effective spikes/plant and 100-seed weight. Three pistillate lines, JP-96, JP-106 and SKP-84 and five male lines, JI-454, JI-455, JI-456 and JI-457 were good general combiners for yield and its contributing traits.

Keywords: Castor, Combining ability, Pistillate lines, Monoecious lines

Combining ability for seed yield and its component traits in castor (*Ricinus communis* L.) was undertaken using line x tester design. Crosses were generated during *kharif* 2017-18 using five pistillate lines as females and 13 inbred lines as males. The resultant 65 crosses and their 18 parents with one check hybrid (GCH-9) were evaluated in RBD with three replications during *kharif* 2018-19 at Main Oilseeds Research Station, JAU, Junagadh. Observations were recorded for length of main spike (cm), number of capsules on main spike, number of effective spikes/plant, 100-seed weight (g), oil content (%) and seed yield (qt/ha).

Analysis of variance for combining ability revealed that both additive as well as non-additive genetic variance was important in the inheritance of various traits. These results are in accordance with those obtained by Patel *et al.* (2012) and Patel and Chauhan (2013). The estimates of components of variance and their ratios ($\sigma^2_{gca}/\sigma^2_{sca}$) indicated the preponderance of additive type of gene action in the expression of length of main spike, number of capsules on main spike, number of effective spikes/plant and 100-seed weight while, non-additive type of gene action was predominant in the expression of seed yield and oil content. The predominant role of non-additive gene

action in the inheritance was observed by Patel and Chauhan (2013) and Aher *et al.* (2015) for seed yield.

Based on estimates of general combining ability effects for various characters, three females, JP-96, JP-106 and SKP-84 and five males, JI-454, JI-455, JI-456 and JI-457 were found to be good general combiners for yield and its contributing traits (Table 1), therefore, were noted as good source of favourable genes for increasing seed yield through various yield contributing characters. The estimates of *sca* effects revealed that none of the hybrids was consistently superior for all the traits. Five crosses, JP-96 x JI-457, JP-96 x JI-462, SKP-84 x JI-455, DPC-15 x JI-454 and JP-96 x JI-455 expressed high *per se* performance and good or average *sca* effects for seed yield. A good agreement was observed between *sca* effects and *per se* performance of crosses for seed yield indicating that selection of crosses based on *per se* performance

would be rewarding. The best performing crosses involve atleast one good general combiner in the cross combination and also possesses good *per se* for atleast one yield contributing trait.

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Table 1 General combining ability effects of the parents for seed yield and its contributing traits in castor

Parents	Seed yield/plant (q/ha)	Length of main spike (cm)	Number of capsules on main spike	Number of effective spikes/plant	100-seed weight (g)	Oil content (%)
Females						
DPC-15	-4.74**	-9.95**	-11.18**	2.70**	-2.94**	0.037
DPC-9	-7.18**	-1.64**	2.05*	-2.11**	0.64**	-0.269**
JP-106	1.10*	5.71**	8.32**	-0.03	-0.70**	0.034
JP-96	8.21**	0.67	-2.02*	0.59**	1.52**	0.280**
SKP-84	2.61**	5.21**	2.82**	-1.15**	1.48**	-0.082*
S.E. (gi)±	0.82	0.67	1.36	0.24	0.14	0.052
Males						
JI-453	-0.74	4.74**	-1.35	-0.84*	1.10**	0.066
JI-454	3.04*	2.34*	3.15	-0.84*	-0.21	0.270**
JI-455	4.56**	-3.36**	-7.75**	1.66**	0.00	0.238**
JI-456	3.01*	3.04**	4.25	-0.14	-2.84**	0.287**
JI-457	8.65**	4.34**	3.15	-0.04	0.62**	0.206*
JI-458	-0.09	-3.86**	-7.45**	0.36	-0.13	0.002
JI-459	-3.44*	2.04	1.85	-0.44	-1.62**	0.545**
JI-460	-2.28	-4.56**	-2.05	2.16**	-3.78**	0.112
JI-461	-3.29*	5.14**	8.65**	-2.14**	2.56**	-0.971**
JI-462	0.14	-4.16**	-8.35**	-0.14	5.60**	-0.759**
JI-463	0.07	-4.26**	-0.75	0.66	0.08	0.066
JI-464	-4.97**	-2.16*	5.45*	-0.24	1.01**	-0.275**
JI-465	-4.65**	0.74	1.15	-0.04	-2.38**	0.212*
S.E. (gj)±	1.33	1.07	2.19	0.39	0.22	0.084

Correlation and path analysis in relation to seed yield and its components in Indian mustard (*Brassica juncea* L. Czern and Coss)

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ABSTRACT

Sixty diverse genotypes of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] were evaluated for 17 quantitative and qualitative traits. Association analysis revealed that seed yield/plant was significantly correlated with plant height, number of branches/plant, number of siliqua/plant, seeds/siliqua, length of siliqua, 1000-seed weight, oil content, linolenic acid and erucic acid. Days to flowering and days to maturity was negatively correlated

with seed yield/plant. Path coefficient analysis indicated the highest positive direct effect on seed yield/plant by oil content followed by days to flowering, linoleic acid, number of branches/plant, 1000-seed weight, length of siliqua, days to maturity and stearic acid. The character oleic acid exerted the highest negative direct effect on seed yield/plant.

Keywords: Indian mustard, Path coefficient analysis, Quantitative and qualitative traits

Understanding the association between yield and its attributing characters is of paramount importance for making the best use of these relationships in selection. It is well known that correlation mainly does not fulfill the purpose of the researcher because it does not detect the characters having indirect or direct effects on seed yield. In such situation, path coefficient analysis helps breeders to explain direct and indirect effects and hence been extensively used in breeding experiments in different crop species.

In this study, 60 genotypes of Indian mustard were sown in *rabi* 2017-18 in a Randomized Block Design with three replications at Castor-Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Each plot consisted of single row of 5.0 meter length. The inter row and intra row spacing was 45 cm and 15 cm, respectively. The experiment and other post-sowing operations were carried out in accordance with the practices recommended for the mustard crop. The data were recorded from five randomly selected plants from each entry in each replication for seventeen characters. Correlation coefficient both at genotypic and phenotypic level was analysed as suggested by Johnson *et al.* (1955). Path coefficient as suggested by Dewey and Lu (1959).

The seed yield/plant was highly significant and positively correlated with plant height, number of branches/plant, 1000-seed weight and linolenic acid at both

genotypic and phenotypic levels, while seeds per siliqua, length of siliqua, oil content and erucic acid at genotypic level. Days to flowering and oleic acid were highly significant and negatively correlated with seed yield per plant at both the levels.

Path analysis revealed that the oil content showed highest direct effect followed by days to flowering, linoleic acid, number of branches/plant, 1000-seed weight, length of siliqua, days to maturity and stearic acid. The negative direct effects were recorded for oleic acid followed by erucic acid, seeds/siliqua, number of siliqua/plant, plant height, linolenic acid, palmitic acid and eicosenoic acid. From the study it could be concluded that for improving seed yield in *Brassica juncea*, an ideal plant type would be early flowering and maturity, with more number of branches, number of siliqua/plant, 1000-seed weight with bold seed, and high oil content. Hence, these characters could be utilized as selection criteria for improving seed yield in Indian mustard.

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Efficiency of alpha lattice design in crop evaluation trials

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ABSTRACT

In large field experiments, the precision of randomized complete block (RCB) design is reduced because of the heterogeneity in field condition. Alpha lattice design (ALD) provides better control on experimental variability among the experimental units under field conditions. Each replication is divided into incomplete blocks and that blocks with in replication error will be eliminated from total error, so that the precision will be increased. The data from an experiment conducted in ALD with 22 entries, three replications and each replication divided in to two blocks was used for this study. The results indicated that RCBD should be replaced by alpha lattice when more than 10 treatments were compared.

Keywords: Experimental design, RCBD, Alpha Lattice Design

The most commonly used design in field experiments is RCBD. The precision of the experiments will be increased by maintaining homogeneity within the blocks.

If the treatment number exceeds 10, maintaining homogeneity will be difficult. To overcome this Alpha Lattice Design (ALD) has been recommended for

unlimited entries (Masood *et al.*, 2006). Alpha designs introduced by Patterson and Williams (1976) are now routinely used for field trials and are also widely used for breeding as well as varietal evaluation trials (Patterson and Silvey, 1980). They are resolvable incomplete block designs that can accommodate any number of treatments and more flexible than lattice designs. In the AICRP Sorghum, ALD has been used for multi-location testing of coordinated trials. Rajendra Prasad *et al.* (2007) published monograph on alpha designs giving the lay out of the design so that the experimenters make use of these important designs in their experiments.

The data from AICRP Mustard (2017-18) trial at ICAR-IIOR was used for this study. Yield (kg/ha) and per cent oil content was subjected to ALD ANOVA and RCBD ANOVA. The efficiency of the design was calculated using the following formula:

$$\text{Relative efficiency} = \frac{\text{Standard Error of ALD}}{\text{Standard Error of RCBD}}$$

Relative efficiency less than one indicates that a ALD is more efficient design while the value nearly equal to one suggests that the two designs yield similar

results and the value of greater than one suggests that RCBD is more efficient design than ALD. The data were analyzed by RCBD and ALD using SAS software.

The results indicated that alpha lattice design provides better control on experimental variability among the experimental units under field conditions. The coefficient of variation (CV) for oil content was 1.8 for alpha lattice and 2.5 for RCB designs respectively (Table 1). The value of relative efficiency (0.71) indicated that the use of alpha lattice design instead of randomized complete block design (RCBD) increased experimental efficiency.

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Table 1 ANOVA- Oil content (%)

Source	DF		TSS		Mean Square		F Value		Pr > F		R-Square		CV	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
T	21	21	34.80	36.39	1.65	1.73	4.89	3.80	<.0001	0.0001	0.77	0.68	1.8	2.5
R	2	2	9.52	8.92	4.76	4.46	13.03	9.83	<.0001	0.0003	-	-	-	-
Block(Rep)	3	-	4.82	-	1.60	-	4.40	-	0.009	-	-	-	-	-

1-ALD, 2-RCBD

Early events of root colonization in castor by the biocontrol agent *Trichoderma*

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ABSTRACT

The colonization of castor roots by the biocontrol agent *Trichoderma* has been studied in a time series experiment. The results showed penetration and colonization of castor roots by *Trichoderma* within 48 hours post inoculation. Microscopy studies established that the colonization was restricted to cortical cells of the roots and during this interaction there were architectural changes in the cell wall of the host cells.

Keywords: *Trichoderma*, Colonization in roots, ISR, Microscopy

Interaction between host plant and *Trichoderma* is reported to enhance plant fitness in response to biotic and abiotic stresses (Hermosa *et al.*, 2012; Brotman *et al.*, 2013) as well as increase the plant health by increasing its

growth (Contreras *et al.*, 2009) by enhancing the nutrient uptake and fertilizer use efficiency and increased photosynthetic rates. The present investigation involved studying the early event of colonization of castor roots by

Trichoderma. This study includes the systematic study with respect to the penetration and colonization of the biocontrol agent - *Trichoderma* in the roots of castor.

To understand the mode of penetration and subsequent colonization of the fungi in the roots of castor seedlings (DCS-9 variety) maintained under axenic conditions in a hydroponic system. The roots of were treated with *Trichoderma harzianum* (Th4D) germlings @ 105/ml concentration. Penetration of the roots by the germinating spores and colonization was checked at 24, 48, 72 and 96 hours post inoculation (hpi) by plating the sap obtained by crushing the surface sterilized roots on *Trichoderma* selective medium (TSS). Surface adherence of mycelium to the root tissue was studied through scanning electron microscopy (SEM) and the spread of the fungal mycelium inside the root tissue was evaluated through tunneling electron microscopy (TEM) as well as Aniline blue staining of root cross section. Confocal microscopy was carried out to understand the internalization of *Trichoderma* mycelium in the intercellular spaces of the root cortical cells after staining the root sections with WGA-FITC fluorescent dye.

The plating technique showed that *Trichoderma* strain Th4D colonized the roots of castor and increased in number with time up to 96 hpi and subsided later. These results were further confirmed by SEM and TEM techniques which established the presence of *Trichoderma* on the roots as well as in the intercellular spaces of the cortical cells within 48 hpi (Fig. 1). This study also showed that during this interaction there were

morphological changes in the host cells as well with the formation of cell wall appositions which perhaps did not permit intracellular penetration by fungus and restricted the fungal mycelium within the intercellular spaces. The confocal studies indicated that the colonization was restricted to the cortical cells of the root and the fungus did not enter the pith cells of the root. Once the colonization of roots by *Trichoderma* was established with microscopy, ISR in the host was studied by analyzing the up-regulation of signature defense related genes that are known to be implicated in ISR. These results further established ISR due to colonization of the roots.

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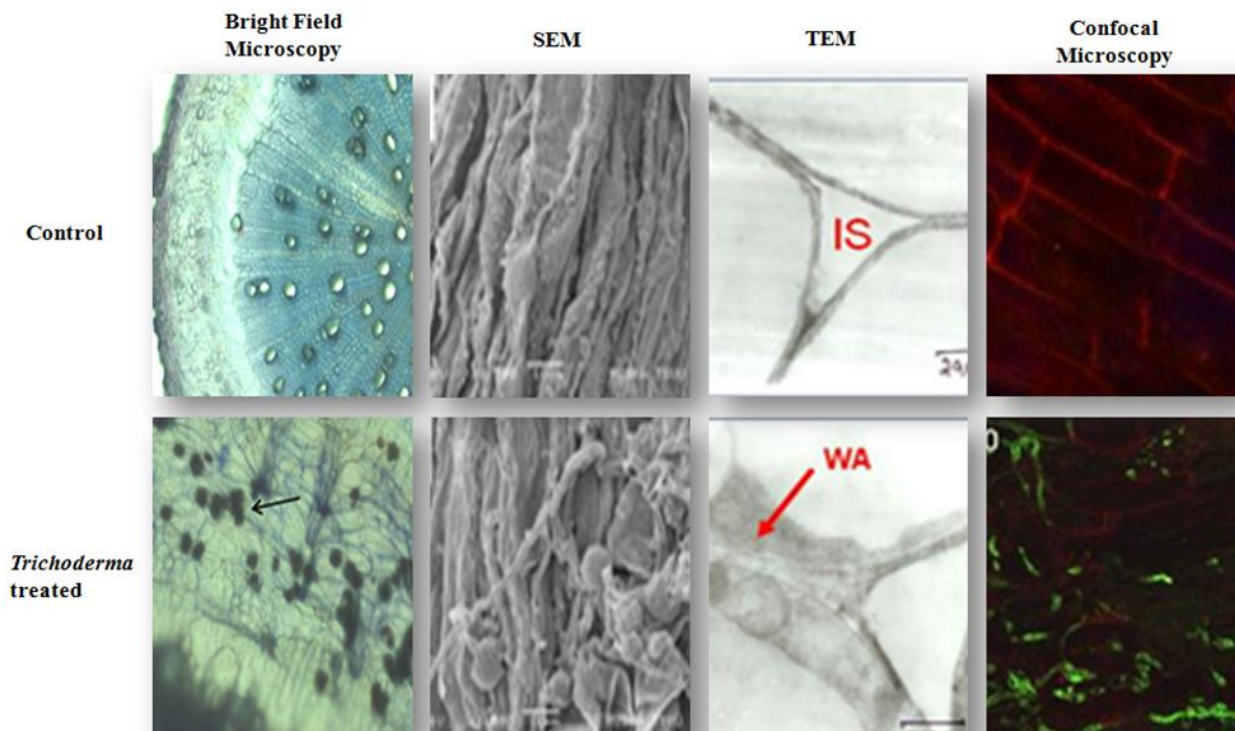


Fig. 1. A snapshot of *Trichoderma* colonizing the cortical cells of castor roots

Comparison of Start Codon Targeted (SCoT) and EST-SSR markers in sesame

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ABSTRACT

Expressed sequence tag (EST)-SSR markers and Start codon targeted (SCoT) markers were compared to estimate genetic diversity among thirty sesame genotypes. To achieve this goal, the available sesame database was used as a resource for the development of novel microsatellite (SSR) and Start codon targeted (SCoT) markers. EST-SSR markers detected a mean of 4.34 alleles with a mean polymorphic information content (PIC) of 0.84, against SCoT markers with a mean of 9.6 alleles and a mean PIC of 0.79. SCoT markers amplified more null alleles than EST-SSRs. Geographical diversity did not corroborate with genotypic diversity as the cluster composition revealed that genotypes belonging to different geographical origin grouped in the same cluster.

Keywords: SCoT markers, EST-SSR markers, PIC value, Sesame, Diversity

Sesame (*Sesamum indicum* L.) is the fifth important edible oilseed crop in India. In spite of its high nutritional value, research on this valuable oilseed crop is neglected. Genetic diversity is one of the key issues in upgrading of genetic materials. Several methodologies have been used to characterize genetic diversity in sesame germplasm but the use of molecular markers is very limited. A number of molecular markers such as RAPD, Amplified Fragment Length Polymorphism (AFLP), Inter-Simple Sequence Repeat (ISSR), Simple Sequence Repeats (SSR) and Expressed Sequence Tagged-SSR (EST-SSR) have been used for genetic evaluation of diversity in sesame (Bhattacharjee *et al.*, 2019). A method for generating plant DNA marker system based on conserved regions flanking the ATG regions of the start codon in plant genes, called as SCoT (Start Codon Targeted) has been developed by Collard and Mackill (2009). This marker system does not require any prior knowledge about the sequence under study. The objective of the present study was to investigate strength and potentiality of SCoT marker v/s EST-SSR markers in determining genetic diversity of sesame cultivars.

Thirty diverse genotypes were collected from the Department of Genetics & Plant Breeding and employed in this study as experimental materials. DNA was isolated from the leaves of young seedlings (2-4 leaf stage) from each genotype using CTAB method. EST-SSR were selected from dbEST/Gene Bank (<http://www.ncbi.nlm.nih>) and SCoT markers selected from the studies by Bertrand *et al.* (2008). The size of amplified DNA was estimated by using the DNA ladder that produced the expected size (50/100–1000 bp). The dendrogram was generated through using the software NTSYS Pc Ver. 2.20.

The size of SCoT markers ranged between 200–1500 bp whereas the amplified product of EST-SSR marker varied from 100 bp to 440 bp. This is comparable to the number of markers typically generated by RAPD and ISSR techniques in sesame. EST-SSR markers detected a mean of 4.34 alleles with a mean polymorphic information content (PIC) of 0.84, against SCoT markers with mean 9.6 alleles and a mean PIC of 0.79. SCoT markers amplified more null alleles than EST-SSRs. Both cluster analysis based on EST-SSR and SCoT markers grouped the 30 sesame genotypes into five main groups. The dissimilarity distance showed that the highest distance value was estimated between the genotypes RT 351 and Prachi. Thus, the present study indicated that, the SCoT marker analysis was effective for evaluating the genetic relationships among sesame genotypes like that of EST-SSR and therefore, could be a useful marker system for investigations in population genetics, genetic diversity and improvement of genotypes.

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***In vitro* regeneration of castor (*Ricinus communis* L.)**

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ABSTRACT

Standardization of a reliable regeneration protocol is important in castor to develop transgenics conferring resistance to biotic and abiotic stresses. An attempt has been made to develop an *in vitro* regeneration protocol using the hypocotyl explants derived from seedlings obtained from decoated seeds. Out of 60 different hormonal combinations tried, three combinations showed better shoot induction and the rooting was better with IBA 1.0 mg/L.

Keywords: Castor, tissue culture, TDZ, BAP, shoot induction, callus, rooting

Grey mold disease has become a serious threat to castor cultivation, especially in peninsular India. Various approaches adopted for control of this disease in castor have met with limited success necessitating host plant resistance. Developing transgenic plants with resistance to grey mold is one of the feasible options and a prerequisite for adopting this strategy is the availability of a reliable and reproducible regeneration and transformation protocol.

Embryos were excised from the surface sterilized decoated castor seeds and germinated on Murashige and Skoog (MS) medium supplemented with 0.25 mg/L Thiadiazuron (TDZ). Hypocotyl explants (~2 cm) derived from the 15 days old seedlings were cultured on 60 different media combinations in petriplates. Cultures were incubated at 25±2°C and 16 hours/day light. Explants were sub-cultured twice onto the same media at 15 days interval. For elongation of the shoots, explants were sub-cultured on half strength MS medium supplemented with 0.2 mg/L, 0.5 mg/L, 1.0 mg/L GA₃ and without or with 0.2 mg/L and 0.5 mg/L BAP. Shoots of ~2.5 cm length, were cultured on the half strength MS basal medium supplemented with 1.0 mg/L indole-3-butyric acid (IBA) for rooting.

In the present study, an attempt has been made to develop such a protocol. Out of 60 different hormonal combinations tried for regeneration using embryo axes derived hypocotyls, three combinations *viz.*, BAP at 3 mg/L + 0.5 g/L 2-N-Morpholinoethane sulphonic acid (MES), BAP 4.5 mg/L + 0.5 g/L MES and BAP 6 mg/L + IAA 1 mg/L, showed better shoot induction with about 4-5 shoots per explant. Responding explants were sub-cultured on to the same media after every 15-20 days. Shoot induction for the explants have been shown in Figure 1. BAP at 4.5 mg/L + 0.5 g/L MES produced the best response with about 85% explants showing shoot induction, length of shoots, and number of leaves per *in vitro* induced shoots. Medium with BAP alone @0.5 mg/L

or along with GA₃ @ 1 mg/L showed better elongation of the shoots (3 cm). Elongated shoots were transferred for root induction on MS medium supplemented with 1 mg/L IBA. Alam *et al.* (2010) observed BAP at 3.0 mg/L induced the highest frequency of shoot induction as well as maximum number of shoots per explant. The rooting was better with IBA 1 mg/L. Similar to our results, Alejandro *et al.* (2019) found highest percentage of rooted plants in the medium supplemented with IBA. As shoot elongation and rooting were sporadic, further fine tuning of this protocol with better regeneration frequencies could be achieved.

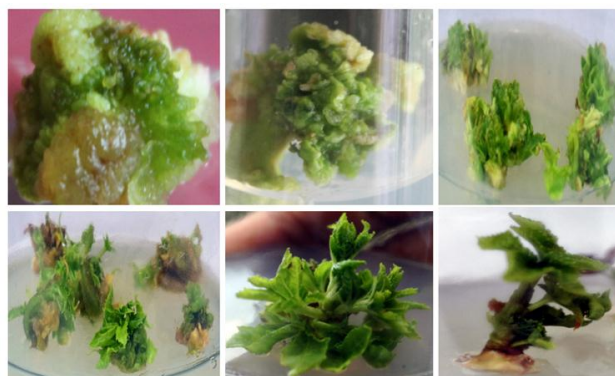


Fig 1: Multiple shoot induction on the media BAP 4.5 mg/L

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Screening for *Alternaria* leaf blight disease in breeding lines of sunflower (*Helianthus annuus* L.)

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ABSTRACT

Several pathogens attack sunflower crop and among them sunflower leaf blight disease caused by *Alternaria helianthi* is major one in *kharif* season infecting from seedling to seed filling stage. The screening of 75 sunflower breeding lines revealed that PM6, PM160, PM26, PM163 recorded resistant reaction with PDI (percent disease index) of 4%, 3.3%, 3.1% and 7% respectively. These breeding lines can be used as resistant source in developing resistant hybrids for *Alternaria* leaf blight after confirming the resistance in artificial epiphytotic conditions.

Keywords: *Alternaria*, Leaf blight, PDI, Resistance, Screening, Sunflower, Susceptible

Sunflower *Alternaria* leaf blight is severe in rainy season and may cause yield losses upto 80% if the conditions are favorable for the pathogen (Balasubramanyam and Kolte, 1980). Occurrence of natural epiphytotics during rainy season has threatened both sunflower cultivation and further expansion in India. The disease initially appears as small circular brown spots on lower leaves which later on become irregular and concentric rings. Resistance sources to *Alternaria helianthi* infection are not available in cultivated sunflower but there exists a differential reaction among sunflower genotypes. In the present study, an attempt was made to screen sunflower breeding lines for *Alternaria* leaf blight and identify the resistant sources.

The experimental material consisted of 75 sunflower breeding lines along with susceptible check Morden. The screening against *Alternaria* leaf blight was done under field conditions during *kharif* 2018 at MARS, Raichur. The *Alternaria* leaf blight disease severity was scored in each entry by following 0-9 scale given by Mayee and Datar (1986). Observations were converted to per cent disease index (PDI) using following formula:

$$\text{PDI} = \frac{\text{Sum of disease rating}}{\text{Number of plants rated} \times \text{Highest rating}} \times 100$$

Based on their reaction (0, 1-10, 11-25, 26-50, >50 percent disease index) inbred lines were categorized into

immune, resistant, highly resistant, moderately resistant, susceptible and highly susceptible.

Among 75 sunflower breeding lines evaluated, PM6, PM7, PM160, PM26, PM8, PM163 with PDI of 4%, 6.2%, 3.3%, 3.1%, 5.5%, 7% respectively, showed resistance to *Alternaria* leaf blight at flowering stage. However, PM7 (PDI=15) and PM8 (PDI=13.6) showed medium resistance reaction at post flowering whereas PM6 (PDI=6.6), PM160 (PDI=5.4), PM26 (PDI=6) and PM163 (PDI=9.6) remained resistant to *Alternaria* leaf blight in later part of their growth stages where susceptible check Morden registered highly susceptible reaction of 59.8% PDI.

Thus, a total of 12 lines showed moderate resistance for the disease. Out of them PM8 (13.6%), PM7 (15%), PM11 (16.2%), PM33 (17.7%), PM73 (19%) and PM133 (21.3%) recorded 11-25% PDI even after flowering stages. Whereas, 30 and 29 breeding lines recorded 25-50% and more than 50% PDI, respectively indicating susceptible and highly susceptible response to *Alternaria* leaf blight.

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Evaluation of new castor pistillate lines for agro-morphological characters and sex expression in different seasons

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ABSTRACT

A total of 41 new castor pistillate lines along with three checks were evaluated in two sets during *rabi* and late *kharif* under irrigated and rainfed conditions to study the variability for nine agro-morphological traits and sex

expression. Based on better performance than the checks, both for seed yield and pistillate expression, ten pistillate lines were identified for further studies on heterosis and combining ability.

Keywords: Castor, Evaluation for traits, Pistillate lines, Sex expression

A spectacular rise in production and productivity of castor from 2.1 to 10.03 lakh tonnes and 220 to 1334 kg/ha, respectively during the last six decades (Lavanya and Varaprasad, 2012) was mainly possible through development of VP-1 and several other pistillate lines (Lavanya *et al.*, 2018). Castor, being a monotypic genus, diversification of pistillate source is mainly through intra-specific, inter varietal hybridization and mutation breeding followed by stringent selection pressure through pedigree method of selection (Lavanya *et al.*, 2019). The present study was aimed at identification of new pistillate lines through evaluation for agro-morphological characters and sex expression.

A set of 15 and 26 new pistillate lines along with three pistillate checks, DPC-9, M-574 and SKP-84 were evaluated for agro-morphological characters during *rabi* 2017-18 and late *kharif* 2018-19 under irrigated and rainfed conditions, respectively. Both the trials were conducted in a randomised block design with a net plot size of 10.8 sq.m (2 rows x 6 m) and three replications. All standard agronomic practices and prophylactic plant protection measures were adopted to raise a good crop. Observations on quantitative traits were recorded at maturity on five plants selected at random from each plot whereas seed yield was recorded on whole plot basis.

Among the first set of 15 lines, IPC-33 recorded 13% yield increase over the best check, M-574 (3092 kg/ha). IPC-30, IPC-38 and IPC-37 recorded significantly higher oil content (48.5-49.4%) compared to the highest seed yielding check, M-574 (45.6 %) (Table 1). IPC-37, IPC-38

and IPC-39 were promising for stable pistillate expression and yield components.

Among the second set of 26 pistillate lines evaluated during late *kharif* of 2018-19 under rainfed conditions, DPC-23 (33%), DPC-21 (31%), DPC-24 (28%), DPC-17 (14%) and IPC-35 (12%) were promising compared to the best check, M-574 (551 kg/ha) (Table 2). Lines DPC-23, DPC-21, DPC-19 recorded oil content on par with that of checks SKP-84 (47.5%) and DPC-9 (47.4%). On the whole, 10 promising pistillate lines have been identified for seed yield, yield components and stable sex expression.

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Table 1 Promising pistillate lines for seed yield and yield components under irrigated conditions (Rabi, 2017-18)

Entry	Plant height up to primary raceme (cm)	Number of nodes to primary raceme	Effective spike length (cm)	Number of capsules per primary	100-seed weight (g)	Seed yield (kg/ha)	Oil (%)
IPC-33	54	11	59	87	36	3507	46.4
IPC-34	61	11	64	102	25	2553	47.2
IPC-35	44	10	43	35	24	3189	46.1
IPC-36	46	11	49	75	30	2218	45.5
IPC-37	47	11	39	55	39	2763	48.5
IPC-38	63	14	58	79	26	2382	48.8
IPC-39	41	10	56	79	33	2280	44.5
DPC-9 ©	52	12	45	83	32	2704	47.8
M-574 ©	43	13	64	87	32	3092	45.6
SKP-84©	58	20	71	136	32	1947	47.3
Mean	54	12.1	51.6	82	30.8	2518	46.9
CD(P=0.05)	12.0	1.8	8.1	24.2	3.5	620	1.6
C V (%)	13	9	10	18	7	15	2

Table 2 Promising pistillate lines for seed yield and yield components in late *kharif* under rainfed conditions (2018-19)

Pistillate lines	Plant height up to primary raceme (cm)	Number of nodes to primary raceme	Effective spike length (cm)	100-seed weight (g)	Oil (%)	Seed yield (kg/ha)
DPC-23	38	8	22	27.1	47.1	735
DPC-21	78	19	74	30.7	47.0	722
DPC-24	79	19	76	27.7	46.3	706
DPC-17	96	16	52	44.5	46.6	627
IPC-35	64	11	49	30.7	45.0	618
DPC-19	88	18	71	29.3	47.0	573
IPC-38	70	15	47	28.1	46.7	572
M-574 ©	45	17	56	29.6	46.1	551
DPC-9 ©	61	14	32	28.1	47.4	543
SKP-84 ©	80	18	42	30.1	47.5	351
Mean	73	15	46	28.7	45.3	479
C.D. (p=0.05)	14.5	2.12	5.97	6.31	11.97	112.3
C.V. (%)	15.9	8.6	7.9	13.4	16.11	14.3

Genetic variation in sesame genotypes (*Sesamum indicum* L.) grown in Telangana

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ABSTRACT

The genotypic and phenotypic variability, genetic advance and heritability in a broad sense were estimated in 22 genotypes. Highest GCV and PCV was observed for seed yield/plant followed by number of capsules/plant and number of branches/plant. Among 22 entries tested, JCS 3202 and JCS 2701 cultures recorded significantly higher yield as compared to check, Hima.

Keywords: PCV, GCV, Sesame, Yield and component traits

Sesame is an important oilseed and cash crop production in India. In India, sesame is being grown over an area of 19.50 lakh hectares with production of 8.50 lakh tonnes and productivity of 436 kg/ha (www.indiastat.com, 2016). In Telangana, it is grown over an area of 0.14 lakh hectares with an annual production of 0.03 lakh tonnes and productivity of 214 kg/ha (www.indiasta.com, 2016). Major sesame growing states in India are West Bengal, Madhya Pradesh, Uttar Pradesh, Punjab and Gujarat. Today, white seed sesame is a product with high international demand because of its versatile uses in human and animal consumption as well as use in industries. It is often referred to by the epithet “the queen

of oilseeds” because it is highly valued not only for its nutritive value but also for the quality and quantity of its oil ranging from 40 to 62.7%. Sesame is an important oilseed crop successfully grown in tropical and sub-tropical climates from 25°N to 25°S. The objective of this study was to estimate the extent of genetic variability in genotypes of sesame (*Sesamum indicum* L.) under summer conditions.

In the present study, the genotypic and phenotypic variability, genetic advance and heritability in a broad sense were estimated in 22 genotypes. Experiment was laid out in a randomized block design with 3 replications at Regional Agricultural Research Station, Polasa, Jagtial

during Summer 2017-18. Different genetic estimates were carried out as per the standard procedures as followed by other workers (Chung and Liang, 1970; Abhijatha *et al.*, 2018).

The highest GCV and PCV was observed for seed yield/plant followed by number of capsules/plant and number of branches/plant. The heritability estimates were high for seed yield, test weight and number of capsules/plant. High heritability coupled with high GAM was observed for seed yield, test weight and number of capsules/plant indicating that these characters are controlled by additive gene effect and phenotypic selection of these characters would be effective for further breeding purpose. Among 22 entries tested, JCS 3202 (1018 kg/ha) and JCS 2701 (1003 kg/ha) cultures recorded significantly

higher yield as compared to check, Hima (831 kg/ha). Among these, JCS 3202 showed consistent performance in the last two years.

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Selection of castor germplasm for drought tolerance

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ABSTRACT

Nine germplasm lines selected for root traits (volume, dry weight) along with checks were screened for drought tolerance in field by imposing drought stress from 30-90 DAS. Genotypes RG 373 and RG 1582 recorded >50g/pl. seed yield with <30% reduction in seed yield under drought stress along with low (<1.0) drought susceptibility index (DSI). These selected germplasm lines can be used in breeding for rainfed conditions.

Keywords: Drought tolerance, Castor, Germplasm, Drought susceptibility index

India ranks first in castor area and production in the world. But it is grown in less fertile alfisols without supplemental irrigation as rainfed crop in southern India resulting in huge yield gap between irrigated and rainfed states. The productivity needs to be improved especially in rainfed areas to sustain the first position in world. So, breeding for drought tolerance is a major objective to maximize yield levels. Hence, an experiment was conducted to select germplasm lines with drought tolerance.

A set of 12 genotypes (9 germplasm lines selected for better root traits, along with three checks that included one germplasm line with poor root, one variety and one hybrid) were evaluated during 2015-16 for drought tolerance. Drought stress was imposed from 30-90 DAS. Data on crop growth, relative water content (RWC), specific leaf area (SLA), total dry matter (TDM), total seed yield was recorded. Drought susceptibility index (DSI) was calculated based on the formula given by Fischer and Maurer (1978) to select genotypes with drought tolerance.

Data recorded just before relieving stress showed significant reduction in crop growth *viz.*, plant height, leaf number, branch production and TDM. RWC increased and SLA decreased with stress. Spike number, effective spike length, capsule number per spike, spike weight, seed weight and test weight of different spike orders reduced with drought stress. Genotypes with less per cent reduction (<30%) in total seed yield along with low DSI (<1.0)

included RG 373, RG 1582 (Table 1). RG 272, RG 289, RG 373, RG 1582, RG 1759 recorded good seed yield even under stress (>50g/plant). RG 272, RG 289, RG 373, RG 1582, RG 1667, RG 1759 and RG 1963 showed low DSI (<1.0). As there was water scarcity, very limited irrigations with less quantity of water were given even to control plots, so most of the genotypes recorded low DSI values.

Table 1 Total seed yield, percent reduction in seed yield and DSI of studied castor genotypes

Genotypes	Total Seed Yield (g/plant)		% reduction in seed yield	DSI
	Control	Stress		
RG 272	87.8	57.2	34.8	0.78
RG 289	87.3	51.6	40.8	0.92
RG 373	77.7	73.5	5.4	0.12
RG 2058	100.0	42.6	57.4	1.29
RG 1582	81.2	57.4	29.3	0.66
RG 1667	70.0	44.5	36.4	0.82
RG 1759	92.8	52.2	43.7	0.98
RG 1922	57.6	29.3	49.2	1.10
RG 1963	45.3	31.0	31.6	0.71
RG 1520 (C)	79.7	37.8	52.7	1.18
48-1 (C)	104.8	31.3	70.2	1.58
DCH 519 (C)	112.5	45.2	59.8	1.34
Mean	83.1	46.1	42.6	

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Genetic divergence and character association studies in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Correlation studies conducted in groundnut revealed that the genotypic correlations were higher than their corresponding phenotypic correlation for all the characters. Pod yield/plant was significantly and positively correlated with number of mature pods/plant, kernel yield/plant, shelling percent and days to 50% flowering whereas kernel yield/plant, number of mature pods/plant exhibited high and positive direct effects on pod yield/plant. The formation of eleven clusters in the present study suggested the presence of wide genetic diversity among the 40 genotypes studied. Test weight followed by shelling percent, kernel yield/plant, 100 kernel weight, plant height and days to 50% flowering contributed maximum towards total divergence.

Keywords: Diversity, Groundnut, Yield and yield related traits

Choosing genetically diverse parents and intercrossing between them will enable the expansion of genetic base and development of superior genotypes. Therefore, the present study was carried out to ascertain the nature and magnitude of genetic variability and divergence among 40 groundnut genotypes which will help to plan better hybridization programmes in future.

The experimental materials were sown in a Randomized Block Design with three replications during Summer 2015-16 at Niger Research Station, Navsari Agricultural University, Vanarasi, Tal-Vansda, Dist-Navsari. Each entry was accommodated in a single row of 3.0 m length with a spacing of 45 x 15 cm. The recommended agronomical practices and plant protection measures were followed for the successful raising of the crop. The observations were recorded on five randomly selected plants in each entry and replication for ten characters.

The results indicated that the pod yield per plant had highly significant and positive correlations at both genotypic and phenotypic levels with number of mature pods per plant, kernel yield per plant, shelling percent and days to 50% flowering, while oil content had significant but very poor association at genotypic level and also positive and non-significant correlation at phenotypic level. Plant height, days to maturity and 100 pod yield had negative and non-significant correlation at both genotypic and phenotypic levels. 100 kernel yield had positive and non-significant correlation at both genotypic and phenotypic levels with pod yield/plant. Thus, on the basis of correlations, number of mature pods/ plant, kernel yield/plant, day to 50% flowering and shelling out-turn proved to be the outstanding characters influencing pod yield in groundnut and they can serve as marker indicator characters for improvement in pod yield and need to be given importance in selection to achieve higher pod yield.

The path coefficient analysis revealed that the number of mature pods and kernel yield per plant exhibited high and positive direct effects on pod yield per plant. The character like days to 50% flowering, 100 kernel weight and plant height exhibited low and positive direct effects with pod yield/plant. While, days to maturity, 100 pod weights, shelling percent and oil content had low and negative direct effect towards pod yield/ plant. The kernel yield/plant trait exhibited positive indirect effects *via* days to 50% flowering, number of mature pods/plant, shelling percent and oil content. Shelling percent and oil content had negative indirect effect on pod yield/plant *via* number of mature pods/plant, kernel yield/plant and 100 pod weight whereas remaining characters *viz.*, days to maturity and plant height had negligible and positive indirect effects on pod yield/plant.

In the present study, D^2 -statistic (Mahalanobis, 1936) estimated on forty genotypes of groundnut for ten characters showed that the generalized distance ($\sqrt{D^2}$) between two populations varied from 2.81 to 16.65 which was an indicator of considerable diversity available in the material evaluated. On the basis of D^2 values, eleven clusters were formed from forty genotypes. The analysis of per cent contribution of various characters towards the expression of total genetic divergence indicated that 100 pod weight (38 %) followed by shelling percent (19.23%), kernel yield/plant (14.62%), 100 kernel weight (12.18%), plant height (6.15%) and days to 50% flowering (4.23%) contributed maximum towards divergence in the present study.

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Genetic variability and diversity studies in niger (*Guizotia abyssinica* L Cass.)

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ABSTRACT

A wide range of phenotypic variation was observed for most of the characters studied for genetic variability assessment in niger. Seed yield/plant showed highly significant and positive correlation with number of branches/plant, number of capsules/plant, capsule diameter, number of seeds/capsule, 1000 seed weight, leaf area and harvest index at both genotypic and phenotypic levels, while it was found to be positive and significant correlation at genotypic level with plant height. Among eleven traits studied for diversity, harvest index followed by number of seeds/ capsule, seed yield/plant, days to 50% flowering, number of branches/plant contributed maximum towards the total genetic divergence.

Keywords: Genetic diversity, Genetic distance, Niger, Variability, Yield traits

Niger (*Guizotia abyssinica* L Cass.) is one of the minor oilseed crops of India belonging to family compositae, which is cultivated extensively in tropical and sub-tropical countries for its importance in terms of oil content and oil quality. The effectiveness of selection is dependent upon the nature, extent and magnitude of genetic variability present in the material and the extent to which it is heritable and also knowledge of association among the seed yield and yield contributing characters would be of great help in constructing a suitable plant type and in planning breeding programme. Therefore, there is a need to study the genetic variability and divergence among

various niger genotypes in order to evaluate their usefulness in hybridization programme.

In this study, 55 niger genotypes were evaluated in RBD with three replications at NRS, NAU, Vanarasi. Crop was sown by keeping the distance of 30 x 10 cm, each genotypes consisted of three rows. Recommended agronomic practices were followed to raise good crop. Data were recorded on randomly selected five plants from each genotype and average value was used for the statistical analysis for sixteen characters. Analysis of genetic divergence using Mahalanobis's D^2 statistics was carried out. The data was also subjected to different statistical analysis as suggested by Burton (1952).

Table 1 Distribution of 55 genotypes of niger in eleven different clusters on the basis of Mahalanobis D^2 statistics

Clusters	No. of genotypes	Genotypes
I	16	ONS-109, DMN-2013, NRS-00-1, NRS-99-1, PMN-13, M15CA, NRS-00-5, GA-5, M12 L8, M6L2, VJO-1, A-8, NPS-1 PET, NM3, A-42, DH2-JK
II	26	A-11, A-23, PNS-6, V-5, ACH-91, A-4, A-1, A-5, VG-91, VK1-91, VT1-93, A-2, IGP-2004-1, VL1-91, SHLN-13, VJO-2, NRS-96-1, A-40, RCR-317, M7L3, JLN-13, VB1-93, A1 M5, VL3-91, M8L4, A-17
III	5	A-14, BKR-1, KBR, M18 H, VJ2-913
IV	1	VP-91
V	1	VJ3-91
VI	1	VL2-91
VII	1	VJ1-91
VIII	1	IGP-76
IX	1	Dhrl-1
X	1	A-41
XI	1	GN-1

A wide range of variation and highly significant varietal differences for all the traits were observed in the present experimental material. The values of PCV were higher than GCV due to interaction of the genotypes with the environment or other environmental factors influencing the expression of these characters. Narrow

differences observed between the PCV and GCV in certain cases like days to 50% flowering, plant height, number of branches/plant, capsule diameter, 1000 seed weight, and seed yield/plant indicated that these characters were less influenced by the environment suggesting that improvement by phenotypic selection would be possible.

The PCV and GCV in the present study was the highest for number of seeds per capsule followed by number of capsules per plant, harvest index, seed yield per plant and number of branches per plant. High magnitude of GCV indicated the presence of wide variation for the characters studied to allow further improvement by selection of the individual trait. High heritability estimates were observed for harvest index followed by number of seeds/capsule, seed yield/plant and number of branches/plant indicated that the characters were least influenced by the environmental effects and selection based on phenotypic value could be more reliable. Similar observations have been reported by others. The expected genetic advance was highest for number of seeds/capsule followed by

harvest index and plant height. The characters like days to 50% flowering, and number of capsules/plant had moderate values for genetic advance. Fifty five niger genotypes were divided into eleven different clusters as per Tocher's method (Table 1).

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Character association and path analysis studies for yield and morpho-biochemical characters in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

The present investigation studies the extent of correlation among morpho-biochemical characters in 18 groundnut genotypes including three checks. The interrelationships were negative and significant for phenol content with leaf thickness and total sugar, whereas, positive and significant with trichome frequency and leaf water content. Trichome frequency, leaf thickness and jassid incidence exerted negative direct effect on pod yield at genotypic level. The components *viz.*, trichome frequency through total sugar and thrips incidence; leaf thickness through SCMR, leaf water content, phenol content and total sugar; jassid incidence through leaf water content, SCMR, phenol content and leaf thickness exerted maximum negative indirect effect on pod yield.

Keywords: Groundnut, Morpho-biochemical characters, Path coefficient analysis

Groundnut (*Arachis hypogaea* L.) is an annual legume crop grown as primarily for oilseed, food and feed on a large scale throughout the world. In India, 80 percent of the groundnut produced is crushed primarily for high quality edible oil (44-51%) extraction. Studying the association between traits will help in developing a selection index to identify the superior plants or lines.

The experimental material comprised 18 genotypes including 3 checks *viz.*, JL-24, LGN-1 and LGN-123. The genotypes were sown at Oilseed Research Station, Latur during *kharif*, 2016 in Randomized Block Design (RBD). Analysis of variances calculated by replication means based on five randomly selected plants for yield and morpho-biochemical characters were used for analysis. Genotypic, phenotypic and environmental correlation coefficients computed by the procedure of Falconer (1989). Path coefficient analysis was carried out according to Dewey and Lu (1959).

Significant variation was observed for all the traits. The pod yield/plant showed positive and significant association with SCMR and negative and significant

association with leaf thickness. The correlation between thrips population and phenol content was negative and significant. The interrelationships were negative and significant for phenol content with leaf thickness and total sugar, whereas, positive and significant with trichome frequency and leaf water content. Total sugar shows positive and significant association with thrips incidence and jassid incidence, highest quantities were noticed in susceptible genotypes. Total sugar was negative and significant with leaf water content. Trichome frequency was negative and significant with thrips incidence and jassid incidence. The lower incidence of thrips occurred due to high leaf trichomes. Leaf thickness exhibited positive and non-significant association with thrips incidence and jassid incidence. The relationship between leaf thickness and thrips and jassid population were positive but non-significant indicating no role of leaf thickness with thrips and jassid population.

A perusal of path coefficient among the characters showed that leaf water content, SCMR, total sugar, thrips incidence, and phenol content exerted positive direct effect

on pod yield at genotypic level. The characters trichome frequency, leaf thickness and jassid incidence exerted negative direct effect on pod yield at genotypic level. The result of path analysis also indicated that the components viz., trichome frequency through total sugar and thrips incidence; leaf thickness through SCMR, leaf water content, phenol content and total sugar; jassid incidence through leaf water content, SCMR, phenol content and leaf thickness exerted maximum negative indirect effect on pod yield.

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Combining ability studies for yield and its component traits in safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Combining ability for ten characters was studied by crossing three lines and five testers in line x tester fashion. The estimates of SCA variance were not higher than GCA variance in most of the traits indicating preponderance of non-additive gene action. The line, GMU-2720 had significant positive GCA effects for seed yield/plant, number of branches, number of capitula/plant, number of seed/capitulum, and oil content whereas significant negative GCA effects for days to 50% flowering, days to maturity and plant height. The cross, GMU-2720 x GMU-3423 and JMU-1339 x PBN-96 were best for majority of the characters and thus identified as promising cross combinations for further improvement programme in safflower.

Keywords: Coefficient of variation, Combining ability, GCA, Safflower, SCA, Testers

Combining ability analysis is a powerful tool to discriminate good as well as poor combiners, choose appropriate parental material in breeding programmes and study the nature of gene effects involved in the inheritance of various characters. Proper choice of parents based on their combining ability effects is a prerequisite for the breeding programme.

Three lines (GMU-2720, PBNS-12, JMU-1339) and five testers (GMU-3423, PBN-96, NARI-6, GMU-3431, EC-757665) were crossed in line x tester fashion to generate 15 F₁ hybrids during *rabi* 2017. The Parental lines, hybrids and check (Sharda) were evaluated during *rabi* 2018 in randomized block design with two replications with inter and intra row spacing 45 and 20 cm, respectively. Standard procedures were followed for calculating different genetic estimates (Kempthorne, 1957; Singh and Choudhary, 1979; Rashid *et al.*, 2007).

The variances due to parents and crosses and also parent vs. crosses were highly significant for all the characters except days to 50% flowering and test weight for parents, test weight and oil content. The variance due to genotypes was highly significant for all character thus justifying the selection of parent for combining ability. The variances due to SCA were higher in the magnitude than that of respective GCA variances for all the characters (except plant height, number of branches and *J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

number of seeds/capitulum) signifying preponderance of non-additive type of gene interaction among the hybrids and could be exploited by heterosis breeding. None of the parents was a good general combiner for all the characters under study. Overall appraisal of general combining ability effects revealed that line, GMU-2720 was a consistent general combiner for majority of the characters including seed yield/plant followed by GMU-1339. The line, GMU-1339 and PBN-96 depicted good general combining ability for oil content and other five traits.

Only few crosses exhibited significant and desirable SCA (specific combining ability) effects for one or two characters. Majority of the crosses with significant SCA effects involved at least one good combiner parent indicating the significance of non-additive gene action. The best hybrids on the basis of significant and positive SCA effect for seed yield/plant were GMU-2720 x GMU-3423 and GMU-1339 x PBN-96. The cross, GMU-2720 x GMU-3423 was best specific combiner for majority of the characters under investigation. The high SCA effect for good x average (GMU-2720 x GMU-3423) parents might be due to epistatic or additive x dominance gene interaction. While, in the cross of average x poor (GMU-1339 x PBN-96) parents, magnitude of SCA was higher due to average combiner or complementary epistatic effect in the same direction. Thus, crosses showing high SCA

effect involving either one or both good general combiner parent could be successfully exploited for varietal improvement. The GCA effects of the line and tester and SCA effect of crosses (GMU-2720 x EC-757665 and GMU-1339 x EC-757665) indicated that the crosses between one or both good general combiners were not the best specific combinations for seed yield. Even with the same amount of heterotic effects, the SCA effect may be lower where mean performance of their parents is higher. Thus, the choice of best cross combination on the basis of per se performance could be more realistic and suitable for

exploitation of heterosis for yield improvement in safflower.

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Influence of different levels of waxy bloom intensity on gray mold disease severity in castor

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ABSTRACT

It is assumed that the presence of wax on castor predispose the crop to gray mold infection in contrary to other plant-pathogen systems, where wax acts as a protective barrier. However, there is no scientific evidence to implicate it in aiding disease development, field observations and screening of 26 genotypes with different wax levels under controlled conditions in glass house and poly house showed that genotypes with high wax intensities showed higher disease severity (~60-80%) compared to low or no wax genotypes (~1-15%) indicating the role of wax in susceptibility of castor to gray mold.

Keywords: Wax layer, Cuticle, Protection against pathogens, Qualitative differences

India is the world's largest producer of castor. The area under castor cultivation is continuously declining in Andhra Pradesh and Telangana mainly due to crop shift and yield loss due to gray mold caused by the fungus *Botryotinia ricini*. Gray mold infects spikes of castor plant resulting in yield losses up to 100%. The plant and raceme architecture, together with the weather conditions play a bigger role in the disease development. Cuticle layer is implicated in plant-pathogen interaction leading to either resistance or susceptibility reaction depending on the pathogen (Podila *et al.*, 1993; Goodwin *et al.*, 2007). It has been observed since many years that genotypes having no waxy bloom on capsules showed low levels of disease severity. The present investigation has been taken up to establish the role of waxy bloom in promoting the gray mold disease.

A set of 26 genotypes having different waxy intensities (no bloom to high bloom) were sown in the field and poly-house. When the crop was at 40-50 percent of capsule development stage the pathogen inoculum was sprayed on spikes. Simultaneously cut spikes were

screened in glass house. Disease severity was recorded continuously for 10 days and percentages were calculated. Double, triple and extra bloom varieties showed very high gray mold severity (50-80%). No bloom and single bloom lines showed less gray mold severity (1-20%). Among double and triple bloom lines, less disease severity (20-30%) was noticed when the wax intensity was low on the capsule and leaf surface (DCS-107, ICH-538). Non-spiny genotypes (JI-315, 48-1) also showed less disease severity (25%). Among single bloom types, there was high disease severity (50%) in genotypes with relatively high intensities of wax (RG-2717, RG-1645).

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Table 1 Average Disease severity from field, glasshouse, polyhouse screenings of no bloom, single bloom, triple and >triple bloom genotypes (Susceptible check DCH-519 recorded 90% disease severity)

Bloom type	Genotype	Disease severity (%)	Bloom type	Genotype	Disease severity (%)
No bloom	DPC-9	8.3	Triple bloom	ICH-538	33.3
	RG-1963	4.8		JI-315 (non-spiny)	25.0
	ICS-324	1.7		SKI-337	42.2
	ICS-325	1.7		JI-96	45.0
<Single bloom	RG-2944	31.2	>Triple bloom	JI-226 (high wax)	51.0
	RG-1274	12.2		DCS-118(high wax)	82.2
	RG-3126	15.6		TMV-5 (high wax)	50.6
	RG1645 (high wax)	52.8		RG-1289 (high wax)	75.0

Assessment of genetic variability, heritability and genetic advance for yield and yield contributing traits in Mesta (*Hibiscus* spp.)

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ABSTRACT

The present investigation was conducted to estimate the extent of genetic variability, heritability and genetic advance in Mesta (*Hibiscus* spp. L). A set of 110 genotypes were evaluated at Oilseeds Research Station, Latur during *kharif*, 2018. Substantial amount of genetic variability was observed for all the characters studied. The estimates of genotypic coefficient of variances (GCV) and phenotypic coefficient of variances (PCV) were high for some characters. High heritability estimates were observed for all the traits under the study. However, high genetic advance as per cent of mean was noted for all the characters except for days to maturity where it was moderate. Much variability was present in the material for all the characters which can be used in the future by simple selection.

Keywords: GCV, Genetic advance, Germplasm evaluation, Mesta, PCV, Variability

Mesta is a tall annual or perennial, herbaceous plant from Malvaceae family cultivated for its stem fibres, edible calyces, leaves and seed purpose. Mesta comprises of two major cultivated species *viz.*, kenaf (*Hibiscus cannabinus* L. 2n = 36) and Roselle (*Hibiscus sabdariffa* L. 2n = 72). Kenaf's relatively high seed oil content (21-26%) and its similarity to cotton seed oil suggest that the seed oil may be used as a source of edible oil (Ali *et al.*, 1995; Akhter *et al.*, 2015). Thus it is a potent source of vegetable oil as it produces enough of seed yield per hectare. Kenaf breeding for higher yield is main objective in any crop improvement programme. The present study was therefore undertaken to assess the genetic variability in germplasm of mesta.

The present investigation was undertaken at Oilseed Research Station, Latur during *kharif*, 2018. The experimental material comprised of 110 genotypes obtained from CRIJAF, Barrackpore with 10 checks. The experimental material was evaluated in Randomized Block Design (RBD) in two replications.

Analysis of variance indicated highly significant differences among the genotypes for all the characters studied. The PCV were slightly higher than GCV for all the characters studied. The character days to 50 per cent flowering showed moderate values of GCV and PCV. Days to maturity recorded lower estimates for GCV, PCV.

GCV and PCV values of plant height were found to be moderate. Moderate values of GCV, PCV and lower value of ECV were observed for the character basal stem diameter indicating moderate range of variability, less influence of environment. Number of capsules/plant recorded higher estimates of GCV, PCV and lower estimate of ECV indicating high variability. GCV and PCV values of number of seeds/capsule were found to be moderate indicating moderate range of variability. The trait oil content exhibited moderate GCV, PCV and low ECV estimates indicating moderate variability. The character seed yield/plant recorded higher estimates of GCV, PCV and moderate estimate of ECV indicating high variability.

Higher estimates of heritability (broad sense) were observed for all the traits studied. Days to 50 per cent flowering exhibited high heritability coupled with high genetic advance as per cent of mean indicating predominance of additive gene action and offers a better chance for improvement of this trait through simple selection and remaining characters in study show high heritability coupled with moderate genetic advance as per cent of mean revealing both additive and non-additive gene actions hence hybridization followed by selection could be the best option for creating more variability.

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Identification of important characters by principal component analysis in sesame germplasm

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ABSTRACT

The objective of the present research was to identify superior sesame genotypes and important characters in order to explain their differences for further use in cultivar development program. Based on principal component analysis the first three principal components accounted for 65.93% of total variations. Among the nine morphological traits seed yield/plant, branches/plant, capsules/plant and plant height were greater contributors to variability. Hence in designing a hybridization program due weightage can be given to these four characters.

Keywords: Germplasm, Sesame, Component analysis

Sesame seed is rich in oil (50–60%), protein (18–25%) and carbohydrates (13.5%). In spite of its nutritional value, it has not gained importance as compared to other oilseed crops due to low harvest index, lack of wider adaptability, susceptibility to diseases and pests, indeterminate growth habit and non-synchronous maturity (Yol and Uzun, 2012). Improvement for these traits is of major importance in enhancing seed yield of this crop. The prerequisite for genetic improvement of yield related traits is the presence of genetic variability. To know about the usable existing variability, estimation of genetic distance is crucial. Principal component analysis (PCA) can be used to uncover similarities between variables and classify the genotypes. Hence, in the present study PCA was used for identification of important traits to be used in future breeding program.

Experimental material for the present investigation comprised of 45 sesame genotypes screened for nine morphological characters during *kharif* season of the agricultural year 2017-18. All recommended agronomic practices were followed to raise a healthy crop. The data was subjected to principal component analysis (PCA) using statistical software SPAR1 (Statistical Package for Agricultural Research, developed by IASRI, 1991) and grouping of genotypes into different clusters was done according to Tocher's method (Rao, 1952) using the coordinate distance between the genotypes.

The trait like plant height (PH), capsules /plant (C/P) and seed number/capsule (SN/C) exhibited higher standard deviations (SD) than the other agronomic characters i.e. branches/plant (B/P), capsule length (CL), thousand seed weight (TSW) and seed yield/plant (SY/P) (Table 1). Therefore, PH, C/P and SN/C are useful indices for classifying sesame germplasm. The Eigen values of the

first three PCs were higher than unity and their variance accounted for 65.93% hence they were considered significant. The first PC that accounted for 31.34% of the variation was positively related to seed yield and its contributing traits like B/P, C/P and PH. It was negatively associated with dry matter (DM) and CL. The second component was related to TSW, SN/C, CW, DM, B/P, C/P and CL. The third PC was positively related to SN/C, CL and SY/P. The first, second and third PCs with a cumulative of 65.93% revealed the most variation among the populations, showing a high degree of correlation among the traits studied.

The character PH, B/P and C/P had positive correlation with seed yield whereas CL, CW, SN/C and TSW were negatively correlated with seed yield. It clearly showed that SY/P, PH, B/P and C/P loaded more on PC1 and accounted for more variation compared to other parameters. Thus, they contributed more towards variability.

The present study reports that the traits SY/P, B/P, C/P and PH were greater contributors of variability and due weightage should be given to them while formulating breeding schedule. As PC1 was constituted by most of the yield attributing traits, an intensive selection procedure can be designed to bring out fast improvement of seed yield by selecting the genotypes from PC1.

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Table 1 Descriptive statistic of evaluated yield traits in sesame genotypes

Trait	Mean	Min.	Max.	CV (%)	Standard Deviation
DM (Days to maturity)	86.14	84.00	88.33	1.25	1.20
B/P (Branches per plant)	2.26	1.33	3.20	10.15	0.49
C/P (Capsules per plant)	47.30	23.53	75.87	7.14	12.23
PH (Plant height, cm)	88.45	67.70	106.53	6.92	10.27
CL (Capsule length, cm)	2.57	1.98	3.06	2.38	0.28
CW (Capsule width, mm)	7.11	2.74	9.01	0.86	1.14
SN/C (Seeds per capsule)	55.62	42.07	72.27	1.83	7.62
TSW (Thousand seed weight, g)	1.45	0.85	1.93	1.41	0.25
SY/P (Seed yield per plant, g)	1.43	0.48	3.69	12.60	0.72

Character association and path coefficient studies on yield and its attributes in safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Thirty two genotypes were evaluated for the estimation of heritability, correlation, path analysis and genetic divergence for ten yield traits. High estimates of heritability were recorded for all the traits. High heritability coupled with high genetic advance was recorded for plant height, seed yield/plant, number of seeds/capitulum and number of effective capitulum/plant, 100-seed weight and harvest index. The seed weight contributed maximum towards genetic divergence. From the combined results of correlation coefficient and path analysis, it was observed that number of effective capitulum, number of seeds/capitulum, 100-seed weight are the major yield contributing characters to apply selection pressure for improving yield. The genotypes possessing combination of above characters should be used in a breeding programme for obtaining high yielding segregants.

Keywords: Capitulum, Genetic divergence, Heritability, Path analysis, Safflower

In India safflower is grown as a rainfed crop in *rabi* season on residual soil moisture both, as a sole crop as well as inter crop with other *rabi* crops like sorghum, Bengal gram, etc. The average productivity is very low (200-500 kg/ha) and hence it is necessary to boost up the productivity per unit area. This can be achieved by exploiting heterosis or by developing varieties through systematic breeding programme suitable for rainfed as well as irrigated conditions. The present investigation therefore was planned to evaluate the genetic variability, correlation and path analysis studies in germplasm accessions of safflower

The materials for this study comprised of 32 promising genotypes of safflower and two checks i.e. A-1 (NC), PBNS-12. The seeds were sown in a randomized block design with two replications under rainfed conditions during *rabi* season, 2016-17. There were five rows of three meters length of each entry in a replication and the spacing adopted was 45 cm x 20 cm. Observations were recorded on days to 50% flowering, days to maturity, number of effective capitulum/plant, number of seeds/capitulum, plant height (cm), test weight (g), hull content (%), harvest index, oil content (%) and seed yield/plant (g). Analysis of variance as per standard

statistical procedures and path analysis as suggested by Dewey and Lu (1959) were worked out. Generalized Mahalanobis distance (D^2) was used for grouping the genotypes and assessing the cause of genetic variability.

The analysis of variance revealed significant differences for all the characters studied. Higher GCV for number of seeds/capitulum, test weight and number of effective capitulum/plant indicated scope for improvement of these traits. Plant height (0.34), days to maturity (0.49), number of effective capitulum/plant (0.45), test weight (0.40) and harvest index (0.36) exhibited strong positive correlation with seed yield. Number of seeds/capitulum exhibited significant and positive correlation with oil content; test weight with oil content, test weight with seed yield/plant; days to maturity with seed yield/plant were positive and strongly associated with each other. Path analysis indicated days to maturity exerted the highest direct positive effect on seed yield/plant followed by harvest index and number of seeds/capitulum while direct negative influence was observed for oil content and plant height. The present investigation clearly revealed that the characters days to maturity, number of effective capitula/plant, number of seeds/capitula, hull content and harvest index showed higher direct positive effects and

indirect effects with other components traits. These findings are in conformity with Diwarkar *et al.* (2006). Direct selection for these characters would enhance the breeding efficiency for seed yield in safflower.

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Variations for physical and nutritional quality traits in advanced breeding lines of groundnut

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ABSTRACT

Eighty four advanced breeding lines of groundnut were evaluated for quality traits with four checks during summer, 2019. Three genotypes, PBS 29180, PBS 29067 and PBS 29148 recorded 80.1 g, 76.3 g, and 72.6 g hundred kernel weight, respectively. Protein content was high (33.8%) in PBS 29124 followed by PBS 29082 (32.7%) and PBS 29116 (32.3%). The oil content ranged from 45.0% (PBS 29105) to 53.1 (PBS 19031). Soluble sugar content was high (6.95%) in PBS 29116. Three genotypes viz., PBS 29079B, PBS 29148 and PBS 29180 had desired combination of traits required for confectionery purpose which can be used as donor parents in breeding program or can be released as varieties after further evaluation and validation.

Keywords: Groundnut, Quality traits, Oil, Protein, Soluble Sugar

Confectionery groundnut with premium edible grade has great demand all over the world. Large seed size (>60 g/100 kernel), high protein (>30 %), high soluble sugar (>6 %), low to moderate oil (42%-47%), uniform pod size and shape, pink or tan seed color, ease of blanching and high oleic/linoleic (O/L) ratio along with good shelling percentage are the important traits for confectionery or table purpose groundnuts (Dwivedi and Nigam, 1995; Kona *et al.*, 2019).

Eighty four advanced breeding lines (ABLs) along with four checks viz., BAU 13, GJGHPS1, Mallika and TKG 19A were evaluated during summer, 2019 for quality traits viz., hundred kernel weight, protein, oil and soluble sugar contents. Protein, oil and soluble sugars were estimated using NIR-Dickey John, Instalab 700 (Mahatma *et al.*, 2016).

All the traits showed significant variations among ABLs when compared to checks. Three genotypes viz., PBS 29180 (80.1 g/100 kernel), PBS 29067 (76.3 g/100 kernel) and PBS 29148 (72.7 g/100 kernel) were found superior over checks (57.2 g/100 kernel). Twenty-nine genotypes recorded >30% of protein of which PBS 29124 recorded the highest (33.82%) followed by PBS 29082 (32.78%) and PBS 29116 (32.27%). The oil content varied from 45.0% (PBS 29105) to 53.1% (PBS 19031). The soluble sugar content ranged from 3.82% (PBS 29189) to 6.95% (PBS 29116). Three ABLs, PBS 29079B, PBS 29148 and PBS 29180 recorded high kernel weight (>70

g), high protein (>30 %), high soluble sugar (>6 %) and low oil (45-47%) which can be used as donor parents in breeding program or can be exploited as confectionery varieties after further validation.

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Early rosette mutant plants of safflower (*Carthamus tinctorious* L.)

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ABSTRACT

Many high yielding safflower varieties with maturity duration of 140-145 days or more have rosette period ranging from 22-40 days. It was thought to convert high yielding varieties of safflower in to less rosette period genotypes, without reducing yield and oil content. For this if hybridization were applied it affects many other important traits. Therefore, in high yielding varieties/genotypes radiation were applied to create variation and genotypes with reduced rosette period. The mutants with less rosette period as compare to normal genotypes were selected in M_2 generation and tested for their stability in M_3 generation. In present study in A-1 and other genotypes, mutants were obtained having 15-20days less rosette than normal genotypes.

Keywords: Early maturity, Mutation, Rosette stage, Safflower, Short duration line

Rosette is a physiological state of safflower in which the leaves comes at ground level and forms a whorl at ground level without elongation of stem. The elongation in safflower starts from 40 to 45 days after sowing, such varieties matured in 145-150 days. The rosette period which usually lasts for 22-45 days actually has a positive correlation with maturity duration. Reducing the duration of rosette period could reduce the duration of the crop and thus help in better productivity on per day basis. In nature safflower genotypes are available which are having less or zero rosette period and such genotypes mature in 100 or 105 days at IGKVV, Raipur. In nature some genotypes are available that exhibit zero rosette periods, which means continuous elongation of stem after germination, and get matured in 100-105 days. But these early maturing genotypes with zero or less rosette period are poor in yield as well as low in oil content. Therefore, an attempt has been made to reduce the rosette period in high yielding varieties of safflower through radiation breeding, which will be good yielder for oil as well as for seed yield.

A high yielding variety of safflower A-1, promising genotypes/pipeline entries RSS 2012-13, RSS-3 and RSS-7 were selected for study since they were found promising for seed yield, oil yield and maturity durations. The LD_{50} was estimated as 500Gy Gamma rays. The experimental populations were treated with 300Gy gamma radiation which was considered as sub optimum so that the irradiated population would have enough radiation effect as well as provide a good plant stand.

In M_1 population from each of 800-850 plants, main capitulum and two more capitula were picked. M_2 were raised in progeny row, each capitulum seeds were sown in one row. Plants of each progeny rows were observed at different growth stages at proper intervals. Plants from each of the genotypes were selected for reduced rosette period, bud shapes, number of branches, plant heights and maturity durations. In M_3 generation, individual progeny rows of selected probable mutants were grown and observed for stable expression of the traits. Such plants

with stable traits were selected. These plants showed 15-20 days early maturity duration than their normal genotypes (Fig. 1). Similar studies have been reported by Kotcha *et al.* (2007) and Rampure *et al.* (2017) in safflower for improvement of different characters. In M_4 progeny from these mutant lines are under test for their yield and oil contents and these lines are expected to mature early as well.

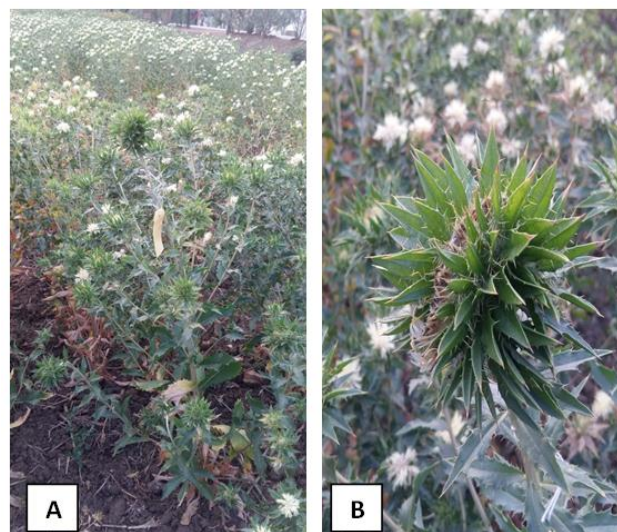


Fig. 1. (A) RSS 2012-7 showing early flowering due to reduced rosette period; (B) Mutation in capitulum shape

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Status of varietal improvement in sesame (*Sesamum indicum* L.) in ANGRAU, Andhra Pradesh

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ABSTRACT

Sesame is grown in area of 64000 hectares in Andhra Pradesh producing 16000 tons with a productivity of 257 kg/ha. It is cultivated both in *kharif* and *rabi* seasons mostly in West Godavari, Visakhapatnam, Srikakulam, Vizianagaram, Kadapa, Krishna, Guntur and Kurnool districts. The state average yields are low when compared to the national average yields. The major constraints in improving productivity include non-availability of location and season specific improved varieties with high yield and oil content, severe incidence of phyllody under late sown conditions, seed shattering and non-availability of early maturing varieties.

Keywords: Narrow genetic base, Pure line selections, Selection from local cultivars, Sesame

Varietal improvement in sesame was carried out in ANGRAU at Agricultural Research Station, Yellamanchilli from 1960 onwards at Regional Agricultural Research Station, Jagtial both under AICRP on Sesame and through state schemes with the objectives of development of high yielding varieties with high oil content, earliness (80 days), tolerance to biotic (leaf webber/capsule borer, gall fly, phyllody, *Cercospora* and *Alternaria* leafspot and *Macrophomina* root rot) and abiotic (moisture stress and water logging) stresses, improved plant architecture (short stature, non-seed shattering habit), uniformity in maturity and determinate growth habit in addition to developing white seeded varieties for export purpose. The breeding approaches followed in ANGRAU were pure line and pedigree methods. Selection within local types was carried out for a long time under low input conditions. Single plant selections from local types resulted in successful cultivars in Sesame. Five improved varieties from Yellamanchilli (Gouri, Madhavi, YLM 11, YLM 17 and YLM 66) and

four varieties from Jagtial (Chandana, Rajeswari, Swetha Til and Hima) were developed. Some of the promising genotypes at various stages of testing and superior to YLM 66 include YLM 142, YLM 146, YLM 151, YLM 152 and YLM153 (ANGRAU Research and Extension Highlights, 2017-18 and 2018-19). Non availability of genomic tools and deep insights on molecular background of the important agronomic traits and working with narrow genetic base are the causes for the slow progress in yield improvement of sesame. The suitability of released sesame varieties, specific features of promising sesame genotypes developed in ANGRAU and future thrust areas of genetic improvement in sesame are documented.

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Efficacy of omega-3-enriched medicated massage oil in Rheumatoid Arthritis

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ABSTRACT

Omega-3 enriched topical formulation for *Amavata* (Rheumatoid Arthritis) has been developed using linseed oil. This linseed oil based topical formulation was effective in controlling and management of arthritis based on clinical study. It was also observed that there was no adverse effect of supplementation of linseed oil for the period of three months, indicating safety of linseed oil.

Keywords: Rheumatoid Arthritis, Omega-3-enriched medicated massage oil

Rheumatoid Arthritis (*Amavata*) is mainly due to inflammation and deformity of joints affecting 1% of population. There are very limited drugs having good efficacy (Urman *et al.*, 2018). Recent studies have indicated the effect of omega-3-fatty acids on inflammatory process in rheumatoid arthritis. A meta-analysis conducted earlier on several clinical trials showed positive clinical benefits of omega-3 fatty acid in joint pain and tenderness (Calder, 2017). In view of this, present study was undertaken to understand the effect of linseed oil for the management of Rheumatoid Arthritis (RA) and thereby to find a better and alternative method of treatment for Rheumatoid Arthritis. *Chinchadi* oil which is commonly used for pain management by Ayurvedic clinicians was also used. It is hypothesized that a combination of *chinchadi* oil and linseed oil will likely have better efficacy in the treatment and management of *Amavata*. The objective of present study was to validate omega-3-massage oil in a clinical study.

Approval of human ethical committee to carry out a clinical study (Reference no: BVDUCOA/EC/1553/2015-16) was obtained from Institutional Human Ethics Committee. In an open clinical trial, 32 patients fulfilling the inclusion and exclusion criteria of Rheumatoid Arthritis of either sex were recruited. Patients were divided in two groups namely *sarvangaabhyanga* with control massage oil and *sarvangaabhyanga* with omega-3 enriched massage oil. *Abhyanga* was given for 30 minutes and patient was advised to take rest. Then, patient

underwent *ThapaSweda* followed by hot water bath. The *SarvangaAbhyanga* and *ThapaSweda* treatments were given every day for 14 days. Omega-3-fatty acid softgel capsule was given as a part of internal medicine in omega-3-fortified massage oil group for 3 months.

Significant improvement in functional parameters such as grip power (left and right hand, $p < 0.05$) and non-significant reduction in walking time was recorded. Other clinical parameters like joint pain, swelling, morning stiffness and tenderness were also altered positively. There was a significant reduction in C-reactive protein and RA-factor in treatment group as compared to control group ($p < 0.05$). Further, based on biochemical parameters and clinical signs and symptoms, it was observed that there was no adverse effect of topical and oral administration of omega-3 oil for a period of three months. Omega-3 enriched topical formulation for *Amavata* (Rheumatoid Arthritis) has been developed using linseed oil. Thus, linseed oil has proven effective in management of RA and this gives an alternative to the people suffering from RA.

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Marker assisted conversion of a high oleic maintainer line into a high oleic CMS line in sunflower (*Helianthus annuus* L.)

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ABSTRACT

In order to diversify the CMS lines for a sustainable production system of hybrid sunflower seeds with enhanced oleic acid content, the present study was attempted for the first time in India to transfer cytoplasmic male sterility into a newly developed high oleic maintainer line, COSFHO 7B using marker-assisted backcross breeding (MABB) approach. This MABC strategy successfully recovered the recurrent parent genome in BC₃F₁ generation and decreased heterozygosity of newly developed high oleic CMS plants. Field evaluation of few important agronomic traits of the high oleic CMS line in BC₄F₁ generation showed that it was comparable to the fertile maintainer counterpart, COSFHO 7B. The present study implies that marker assisted backcross breeding strategy could considerably decrease the time needed for complete recovery of recurrent parent genome

Keywords: Cytoplasmic male sterility, Hybrids, Oleic acid, MABB, Sunflower

Production of hybrid sunflower seeds with improved oil quality is a profitable industry across the globe. Breeding for nutritional traits is costly, laborious and time consuming by conventional biochemical methods. Hence,

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it is beyond the capacity of a breeder to undertake large scale quality breeding programme. Use of molecular markers linked to quality traits would have a great impact on improvement of quality traits using marker-assisted

backcrossing (MAB) strategy. An allele specific marker, HO Fsp_b located on linkage group 14 has provided an opportunity to imply marker assisted backcross breeding (MABB) to develop high oleic versions of sunflower cultivars popularly grown in India.

Molecular marker that was tightly linked with OD-HO allele (HO Fsp_b) and polymorphic markers unlinked to OD-HO allele were used to apply foreground and background selection, respectively, in backcrosses between a high oleic donor (maintainer line, COSFHO 7B) and low oleic CMS line, COSF 7A. During the marker assisted breeding programme, foreground selection was practiced from F₁ generation till BC₂F₁ generation whereas background selection was undertaken in BC₂F₁ generation. In each generation, only the completely male sterile progenies having the high oleic specific allele were subjected to phenotypic assessment of oleic acid content using GC (gas chromatography) and NIR (Near infrared spectroscopy) and advanced to the subsequent generations. Among seven BC₄F₃ family progenies of high oleic maintainer lines (COSFHO 7B) evaluated, three family progenies showed 100% homozygosity i.e., no segregation for high oleic acid content both genotypically using allele

specific marker as well as phenotypically through fatty acid estimation using Gas Chromatography. Out of the three positive BC₄F₃ progenies of COSFHO 7B, one best performing BC₄F₃ progeny of COSFHO 7B was subjected to marker assisted conversion into high oleic male sterile line. The converted male sterile lines of COSF 7A were subjected to two backcrosses with high oleic maintainer line, COSFHO 7B to obtain BC₂F₁ generation. Both foreground selection as well as background selection using identified polymorphic markers is being undertaken in BC₂F₁ generation to identify high oleic CMS line with maximum recurrent parent genome recovery in sunflower.

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GG 41: A high yielding Virginia runner groundnut (*Arachis hypogaea* L.) variety for Gujarat state

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ABSTRACT

A Virginia runner groundnut Variety GG 41 was developed from the cross GG 21 and TPG 41. This genotype was tested at multilocation from 2014 to 2018 during *kharif* season in Gujarat. It recorded a high mean pod yield of 2722 kg/ha as compared to the checks viz., GG 11 (2352 kg/ha) and GJG 17 (2344 kg/ha). Pod yield superiority of this variety over the checks, GG 11 and GJG 17 were 15.74% and 16.10%. Average kernel yield of GG 41 was 2010 kg/ha as against the checks GG 11 (1586 kg/ha) and GJG 17 (1596 kg/ha). Mean 100-kernel weight of GG 41 was 56.48 g; 100-pod weight was 144.98 g; shelling out-turn was 73.84% and the average oil content was 51.44%. Incidence of stem rot and collar rot of the variety was very low as compared to the check varieties. The damage due to leaf defoliators and thrips under field conditions was lower in GG 41 as compared to the check varieties. Based on the superior performance, this genotype has been released in 15th Combined Joint AGRESCO Committee of SAUs of Gujarat as GG 41 for general cultivation in the *kharif* rainfed spreading variety groundnut growing areas of the Gujarat State.

Keywords: Spreading type, Stem rot, Collar rot, Defoliators, Thrips

Gujarat is the leading groundnut growing state and contributes nearly about 33% to 35% of the area and production of total groundnut grown in the country. In *kharif* season, 60% area is covered under Virginia group while, 40% area is covered under Spanish bunch types. Area under groundnut in Gujarat during 2016-17 was 17.59 lakh ha having 31.57 lakh tones production and a productivity of 1795 kg/ha (Anonymous, 2019). In Virginia runner group, GJG 17 has been released in the year 2011 in the state for *kharif* cultivation. Continuous

research efforts were made to develop high yielding Virginia runner genotypes with high shelling in order to find-out an alternative for presently grown Virginia runner varieties like GG 11 and GJG 17 for *kharif* cultivation in the state.

The Virginia runner groundnut variety GG 41 was developed through hybridization of GG-21 x TPG 41 followed by pedigree method of selection at Main Oilseeds Research Station, Junagadh Agricultural University Junagadh. It was isolated from the segregating

populations and evaluated for its yield performance. The genotype was tested under multi location trials in Gujarat during *kharif* 2014 to 2018. It was screened for reaction to major pests (thrips, jassids and *Spodoptera*) as well as major diseases (rust, ELS, LLS, stem rot and collar rot) under field conditions. The yield data were analyzed for a randomized block design as suggested by Panse and Sukhatme (1985).

Of 17 evaluation trials, this entry has given 2722 kg/ha of pod yield as compared to 2352 and 2344 kg/ha of pod yield of check varieties GG 11 and GJG 17, respectively. Pod yield increase was to the tune of 15.74% and 16.10%, respectively. This genotype also exhibited higher kernel and oil yields than the check varieties. The entry GG 41 was comparable to the checks against tikka and rust diseases, while stem rot and collar rot incidence was low in GG 41 as compared to the check varieties. The pest infestation was lower in GG 41 as compared to the check varieties. Based on its consistent superior

performance over locations and years, GG 41 has been released for general cultivation in the *kharif* groundnut growing areas of Gujarat. By virtue of superior performance for high pod and kernel yields and oil with better quality characteristics, the newly developed variety GG 41 has been identified for release by 15th Combined Joint AGRESCO meeting of SAUs held on 29 April - 1 May 2019 at AAU, Anand (Anonymous, 2019) for general cultivation in the *kharif* rainfed spreading groundnut growing areas of the entire Gujarat State

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Variation in quality traits of different seed sizes of groundnut

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ABSTRACT

Groundnut is an energy rich oilseed and food crop. There is no information on quality traits of different seed sizes of a same groundnut variety. Therefore, in present investigation seven groundnut varieties i.e. Girnar 2, Girnar 3, GJG 9, GJG22, GG 20, KDG 128 and TG 37A were used to find out variations in quality traits of different seed sizes of groundnut. Small seed of groundnut possessed higher content of soluble sugars and protein while bold seeds had higher oil content. Oleic acid content was higher in bold seeds while linoleic acid was higher in small seeds.

Keywords: Groundnut, Linoleic acid, Oleic, Quality, Seed size, Soluble sugars

Groundnut is an energy rich oilseed and food crop. About 50% of its produce is used for direct consumption especially as value-added products like roasted and salted groundnuts, groundnut-candy, peanut-butter etc. After grading of groundnut kernels bold seeds are generally used for direct consumption in various forms of value added products. Medium and small sized kernels are either used for oil extraction or as a bird feed. There is no information of quality traits of different seed sizes of same groundnut varieties.

Seven groundnut varieties, Girnar 2, Girnar 3, GJG 9, GJG 22, GG 20, KDG 128 and TG 37A were used. Bold, medium and small kernels were graded by hand picking. Hundred seed weight of graded kernels were recorded. Oil, protein and total soluble sugars contents were analysed by NIR. Sugar and fatty acid profiles were estimated using Ion chromatograph (Bishi *et al.*, 2015) and Gas chromatograph (Misra and Mathur, 1998) respectively. Data were statistically analysed for significance.

Variation of oil content in small seed of these seven cultivars ranged from 4% (GJG 9) to 12% (Girnar 2). Bold seeded cultivars (Girnar 2, GJG 22 and GG 20) had higher variation for oil, protein and sugar contents between bold and small kernels than that of normal (Java) seeded cultivars (KDG 128, GJG 9 and TG 37A). Results of sugar profiling showed that inositol, sucrose and raffinose contents reduced with increase in seed size. Small seeds of all the genotypes possessed higher inositol, sucrose and raffinose content while lower trehalose content compared to medium and bold seeds of respective cultivars. Fatty acid profile also differed with seed size. Oleic acid content was significantly lower in small seeds of GG 20 and GJG 22 (52 and 54%) as compared to their medium (60% and 64%) and bold seeds (63% and 68%). These results showed that sugar and protein biosynthesis takes place early during seed maturation than oil biosynthesis. Similarly higher content of oleic acid in bold seeds showed that oleic acid accumulated later during seed maturation. Thus, to have higher proportion of oleic acid in oil, medium and bold seeds should be used for oil

extraction. Whereas, medium and small seeds of groundnut can be used for table purpose that requires low oil, high sugar and protein contents.

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Optimizing maturity index calculation of groundnut in selected varieties at Coimbatore condition

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ABSTRACT

The present study was taken up to evaluate the efficiency of the maturity index calculating methods *viz.*, shell out method, seed hull ratio maturity index, hull scrape method and maturity profile board (MPB) method in determining the maturity duration of ten groundnut varieties CO 7, ICGV 07222, VRI 6, VRI 8, GPBD 4, VRI 3, Chico, Gangapuri, ICGV 91114 and ICGV 93468 at Coimbatore. In Shell out and hull scrape method maturity indices ranged from 70-80% and in seed hull ratio maturity index it ranged from 2.9-3.6 which revealed the highest number of matured pods with maximum weight. In hull scrape method and MPB the colour of mesocarp exactly revealed maturity status of groundnut pods with a strong correlation with yield. Thus, maturity index in groundnut is more reliable when calculated by hull scrape method in combination with maturity profile board (MPB) to determine the days until digging.

Keywords: Groundnut, Hull scrape, Maturity profile board, Shell out method, Seed hull ratio

Groundnut pod development takes place in the soil making it difficult to correctly judge the maturity of the crop. Over the past few decades, several methods have been used to assess groundnut maturity. The present study considered shell out, seed hull ratio maturity index, hull scrape and maturity profile board (MPB) methods and their efficiency for predicting the correct date of harvest in groundnut.

Ten groundnut varieties with wide difference in days to maturity *viz.*, CO 7, ICGV 07222, VRI 6, VRI 8, GPBD 4, VRI 3, Chico, Gangapuri, ICGV 91114 and ICGV 93468 were taken up for the study in two seasons *rabi* 2018-19 and *kharif* 2019 at Department of Oilseeds, CPBG, TNAU. A range of five different days to maturity check was planned with five days interval for all the varieties under study. In each harvest of all the varieties, the maturity index by shell out method (Miller and Burns, 1971), seed hull ratio method (Pattee *et al.*, 1977), hull scrape method and Maturity Profile Board (Williams and Drexler, 1981) was calculated along with average yield. Coefficient of correlation was calculated among days after sowing, maturity indices and average pod yield and tested for its significance.

In all the varieties, the highest average yield in both the seasons clustered around the third and fourth harvests which were scheduled to be the mean maturity duration of the varieties. On the whole, the maturity duration of the

varieties was higher during *rabi* season in comparison to those in *kharif* season. Thus, from the study, the optimum maturity indices for predicting the date of harvest for groundnut are summarized in the Table.1. The hull scrape method of maturity index showed highest positive correlation of 55% with average pod yield while shell out method stood second with 48% correlation. Thus, the maturity indices calculations by hull scrape method and Maturity Profile Board method which are based on mesocarp colour were most reliable. A groundnut cultivator is suggested to examine the mesocarp colour and calculate the maturity index according to the Hull Scrape method. If the maturity index is under 70%, the samples may be placed on the MPB to determine a prediction for harvest date.

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Table 1 Corresponding days to maturity and maturity indices

Genotypes	Rabi				Kharif			
	Maturity Index				Maturity Index			
	DTM	SO (%)	SHMI	HS (%)	DTM	SO (%)	SHMI	HS (%)
CO 7	105-110	72-74.3	3.1-3.5	71.3-75.2	110	71.9	3.4	74.1
ICGV07222	120-125	71.6-75.3	3-3.2	72.6-73.4	120	74.6	2.9	72.3
VRI 6	125-130	70.3-72.6	3.1-3.3	71.6-74.8	120-125	71.2-74.3	3.3-3.4	73.4-75.7
VRI 8	110	70	2.9	72.1	110	76.3	3.8	74.6
GPBD 4	110-115	72.3-79.4	2.9-3.2	76.3-77.4	110	75.7	3.4	73.2
VRI 3	90-95	77.4-78.6	3.5-3.6	73.7-75.2	90-95	70.5-73.4	2.9-3.5	72.7-74.3
CHICO	85-90	71.4-74.7	2.9-3.3	76.2-76.8	80-85	71.2-74.6	3.3-3.6	73.6-74.9
GANGAPURI	90-95	74.8-79	3.3-3.5	73.4-74.6	85-90	72.3-76.2	3.2-3.7	73.2-75.2
ICGV91114	95	72.8	3.4	71.6	95	76.3	3.6	74.6
ICGV93468	95	76.8	3.6	73.8	90	74.5	3.2	72.8

DTM – Days to maturity, SO – Shell out, SHMI – Seed hull maturity index, HS – Hull scrape

Evaluation of soybean RIL population for charcoal rot resistance

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ABSTRACT

Charcoal rot disease caused by *Macrophomina phaseolina* (Tassi) Goid. is a major threat to soybean production. Identification of resistant sources and their deployment in resistance breeding programs is the best way to tackle this disease. Current study aimed to screen 125 Recombinant Inbred Lines (RILs) derived from the cross JS-97-52 × JS-90-41 for charcoal rot resistance using cut-stem inoculation technique. Out of 125, 21 lines were found to be resistant compared to the better parent JS-97-52. These lines would further be confirmed for their resistance under field condition for their utilization in charcoal rot resistance breeding program.

Keywords: RILs, Soybean, Charcoal rot, Resistance, Donor source

Soybean (*Glycine max* L.), the leading oilseed crop in India is facing many forms of biotic and abiotic stresses. Charcoal rot disease caused by *Macrophomina phaseolina* (Tassi) Goid. is a serious menace to the soybean production (Smith and Carvil 1997). Genetic resistance is the effective and economical way of managing this disease (Silva *et al.*, 2019). Therefore, present study aimed to screen recombinant inbred line (RIL) population through cut-stem inoculation technique (Twizeyimana *et al.*, 2012) to identify potential donors of charcoal rot resistance for their further utilization in breeding programs.

A F2:9 RIL population (J-97-52 × JS-90-41) of size 125 along with parents was screened for charcoal rot resistance using cut-stem inoculation technique. Trial was conducted in RBD design with three replications in a net house during *kharif* 2019. Average minimum temperature and maximum temperature during experiment were (24.6°C) and (34.3°C), respectively. At V2 growth stage, plants were cut 20 mm above the unifoliate leaf and inoculated with 8 days old culture of Jabalpur isolate using

10 µL pipette tips. Disease severity was measured in terms of linear necrosis length 15 days after inoculation (Fig. 1).

Average necrosis length in parents, JS-97-52 and JS-90-41, was 20.3 mm and 28.6 mm, respectively. Length of necrosis across population ranged from 7.78 mm (104-49) to 83.11 (104-11) with a mean of 36.13 mm. Heritability of the trait was 52.6%. Low heritability is attributed to its complex mode of inheritance confounded with high environmental sensitivity. Though parents did not differ significantly for the trait, several transgressive segregants were observed across the population indicating polygenic mode of inheritance. Lines, 104-49, 104-38, 104-67, 104-59, 104-30, 104-1, 104-105, 104-52, 104-53, 104-115, 104-52, 104-53, 104-115, 104-68, 104-31, 104-93, 104-29, 104-3, 104-54, 104-32 and 104-15 showed better resistance reaction than the better parent (JS-97-52). These lines would further be confirmed under field conditions for their resistance and will be used as parents in charcoal rot resistance breeding program.



Screening of RIL population for charcoal rot resistance

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Evaluation of groundnut germplasm for pod yield and its attributes in summer

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ABSTRACT

Forty eight germplasm collections were evaluated for pod yield and its attributes during summer 2018 and 2019. High heritability coupled with high GAM were observed for pod yield per plant, HPW, HKW and kernel length indicating that selection for these characters could be more effective due to additive gene action. Pod yield per plant correlated significantly and positively with SP, SMK, and kernel length to width ratio. Both DFI and DFF correlated significantly and negatively with pod yield per plant. SLA had low heritability and GAM. Genotypes NRCG 14507, NRCG CS 254, NRCG CS 313 and Girnar 1 showed early flowering initiation (35 DAS). The surrogate trait of water use efficiency (SLA) was lowest (150<) in genotypes viz., NRCG 17284, SG 99, Gangapuri, ICGS 9114 and VRI 3. Genotypes viz., JGN3, NRCG CS 62, TMV9, ICGS 76, NRCG 8763 showed higher shelling percentage (>70%). Genotypes NRCG 10620 and TG 39 exhibited higher yields over two summer seasons.

Keywords: Genetic advance as percent of mean, Groundnut, Heritability, Pod yield, Summer

The area under irrigated summer groundnut accounts for about 16% of the total area and contributes 28% of the production. There is a greater scope to expand groundnut area under summer season, wherever irrigation facilities are available. Low temperature at germination and high temperature at flowering are major constraints in summer groundnut cultivation. Hence identification of efficient flowering and high yielding genotypes with high water use efficiency is an important breeding strategy to develop groundnut varieties suitable for summer season. Present investigation was an attempt to evaluate the 48 germplasm for pod yield and its attributes in summer season.

A total of 48 germplasm collections consisting of 17 NRCG accessions and 31 released varieties were planted in augmented design with five checks in four blocks at the experimental plots of ICAR-Directorate of Groundnut Research (ICAR-DGR), Junagadh during summer season for two years (2018 and 2019). Standard agronomic practices were followed to raise healthy crop and data collected on days to first initiation (DFI) of flowering, days to 50 per cent flowering (DFF), SLA and SCMR at

60 days, shelling per cent, hundred kernel weight and pod yield/plant. The mean values of the data recorded were subjected to statistical analysis using SPSS (version 16.0) software for descriptive statistical analysis, analysis of variance (ANOVA) and correlation among traits.

The analysis of variance revealed significant differences for all the traits. Large variation was observed for DFI (34 to 49 days); SMK (25 to 83%); SP (26 to 72%) and pod yield (1 to 13 g per plant). The PCV and GCV estimates were low for SLA, SCMR and DFI and DFF, whereas pod yield and HKW had higher estimates. SLA had low heritability and genetic advance as per cent of mean (GAM), whereas SCMR had moderate heritability and low GAM, suggesting the presence of non-additive gene action and simple selection may not be effective. SMK showed moderate estimates of heritability and GAM. High heritability coupled with high GAM were observed for pod yield per plant, HPW, HKW and kernel length indicating that selection for these characters could be more effective due to additive gene action. Pod yield per plant correlated significant positively with SP, SMK,

and kernel length to width ratio. Both DFI and DFF are correlated significant negatively with pod yield per plant (Zongo *et al.*, 2017).

Identification of trait specific germplasm and successful introgression of trait is the key activity for summer groundnut crop improvement. Genotypes NRCG 14507, NRCG CS 254, NRCG CS 313 and Girnar 1 showed early flowering initiation (35 DAS). SLA was lowest (<150) in genotypes *viz.*, NRCG 17284, SG 99, Gangapuri, ICGS 9114, VRI3 and ICGS 76. Genotypes

viz., JGN3, NRCG CS 62, TMV9, ICGS 76, NRCG 8763 showed higher shelling per centage (>70%).

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Evaluation, characterization and confirmation of hybrids derived from diverse CMS sources in sunflower (*Helianthus annuus* L.)

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ABSTRACT

The research was conducted at University of Agricultural Sciences, Dharwad, during 2016-2018 to evaluate hybrids derived from diverse CMS sources (CMS PET 1, CMS PEF and CMS-I). Among the hybrids evaluated, FMS852A× RHA6D1 recorded 98% fertility restoration with on par performance of seed yield per plant (63.17 g/plant), oil content (38.48 %) and linoleic acid (65.69 %) with the check KBSH53. The parental lines and hybrids were characterized according to PPV&FRA guidelines. The hybrids were confirmed by ORS312, ORS484, ORS460, ORS3640, ORS934, HA4011, ORS1065, ORS349, ORS309 and ORS316 SSR markers.

Keywords: *Helianthus petiolaris*, *Helianthus annuus* sp. *lenticularis*, *heterosis*, CMS

Commercial exploitation of heterosis for seed yield and oil content in sunflower during the last two decades has narrowed down the genetic variability of CMS (Petiolaris base) and restorer lines resulting in yield plateau of hybrids, besides making them vulnerable to pest and diseases. Hence, diversification is needed and the hybrids resulting from new diverse CMS sources pose problem of fertility restoration which needs to be examined and evaluated.

The experimental material comprised of eight CMS lines derived from three diverse CMS sources i.e. CMS PET 1 (*Helianthus petiolaris*) - CMS335A, CMS711A, CMS851A, CMS234A, CMS607A; CMS PEF (*Helianthus petiolaris* sp. *fallax*) - FMS852A, FMS407A and CMS-I (*Helianthus annuus* sp. *lenticularis*) - IMS850A; eight restorer lines - NS8, NS15, NS19, RHA95C1, RHA6D1, RHAIV77, R-59, DSR-35; and eleven hybrids *viz.*, FMS407A × RHA6D1, FMS407A × RHA95C1, FMS407A × NS19, FMS407A × NS8, FMS852A × RHA6D1, IMS850A × NS8, CMS711A × DSR35, CMS851A × NS15, CMS607A × R59 including checks *viz.*, DSFH 3 and KBSH 53. These were characterized according to PPV&FRA descriptors. For molecular hybridity confirmation, DNA was isolated according to Solodenko and Sivolap (2005) procedure by CTAB method. Oil content was estimated using NMR and fatty acid composition by gas chromatography.

Among the 11 hybrids evaluated, FMS852A× RHA6D1 recorded 98% fertility restoration with on a par performance of seed yield/plant (63.17 g/plant), oil content (38.48%), linoleic acid (65.69%) and less number of days (66 days) to 50 % flowering compared to check KBSH53 (100%, 62.15 g/plant, 39.03%, 25.02% and 68 days, respectively). Morphological characterization showed that all the genotypes exhibited cordate leaf shape, rounded bract shape and convex type of head. Pollen colour was yellow in all the genotypes but white in NS8. The hybrids from fallax CMS source were confirmed by SSR markers ORS312, ORS484, ORS460, ORS3640 and ORS934 while hybrids from lenticularis CMS source were identified by ORS312. The petiolaris source hybrids were confirmed by HA4011, ORS1065, ORS349, ORS309 and ORS316 SSR markers.

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Identification of new molecular markers for low glucosinolates in Indian mustard (*Brassica juncea* L. Czern & Coss.)

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ABSTRACT

The study was carried out to identify molecular markers linked to low glucosinolates in *Brassica juncea* using recombinant inbred lines developed from cross between Pusa Mustard 21 × EC597325. Parental polymorphism studies with 594 SSR markers, revealed 62 informative markers. The bulk segregant analysis (BSA) revealed four microsatellite markers differentiating both the parental lines and the high and low glucosinolates bulks, hence putatively linked to the genomic regions controlling low glucosinolates.

Keywords: Glucosinolates, Molecular markers, Mustard, SSR markers

Quality in oilseed Brassicas is defined by the improved fatty acid profile of the oil and low total glucosinolates in the seed meal cake. Presence of high concentration of total glucosinolates causes nutritional disorders and toxicity in animals and birds (Griffiths *et al.*, 1998). Major constraint for development of low glucosinolate varieties is the complex nature of inheritance of total glucosinolates. Hence, an effort was made to develop molecular markers linked to low glucosinolate trait.

The present study was conducted to identify molecular markers linked to glucosinolate trait using 608 RILs population developed from cross Pusa Mustard 21 × EC597325 which was in F8 generation. Genomic DNA isolation was done using modified cetyl-trimethyl-ammonium bromide (CTAB) method (Doyle and Doyle, 1990). A set of 594 microsatellite markers available in public domain (www.brassica.info) was used. Polymorphism survey was carried out between 'Pusa Mustard 21' and 'EC597325'. The polymorphic markers identified in parental polymorphism survey were used in BSA as described by Michelmore *et al.* (1991).

Total glucosinolates were estimated using tetra chloropalladate as per the modified method suggested by Kumar *et al.* (2004). Parent 1 (Pusa Mustard 21) had 88.89 μ moles of glucosinolates per gram of seed while parent 2 (EC597325) exhibited 22.91 μ moles per gram of seed. Range for its content in RIL population varied from 12 to 92 μ moles per gram of seed. The selected SSR markers

(that were polymorphic between parents) were employed to screen for parental polymorphism. Out of 594 SSR markers, 413 (69.5%) were amplified and 62 (10.4%) informative markers were found in this study.

The BSA revealed four microsatellite markers differentiating both the parental lines and the high and low glucosinolates bulks, hence were considered putatively linked to the genomic regions controlling total glucosinolates. Interestingly we could identify markers from A and B genome. Our results support both schools of thought that genes governing total glucosinolates are present in both A and B genomes.

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SSR primers derived from various *Brassica* spp. and *Arabidopsis* used for identification of polymorphic markers between Pusa Mustard 21 and EC597325

Primer source	Number of primers tested	Number of primers amplified	Number of polymorphic markers
<i>B. rapa</i>	119	72 (60.5%)	21 (17.6%)
<i>B. nigra</i>	158	109 (69.0%)	19 (12.0%)
<i>B. napus</i>	164	135 (82.3%)	12 (7.3%)
<i>B. oleracea</i>	48	19 (39.6%)	2 (4.2%)
<i>Arabidopsis thaliana</i>	56	38 (67.9%)	8 (14.3%)
Others	49	40(81.6%)	0
Total	594	413 (69.5%)	62(10.4%)

Screening of sunflower genotypes for confectionery characters

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ABSTRACT

Screening of 58 sunflower accessions was done for yield and confectionery parameters for identification of superior confectionery genotypes. The experiment was laid as per augmented design during spring 2019 and data recorded was subjected to statistical analysis for partition of variance components as well as computation of correlation coefficients. Significant differences among entries were observed for all the parameters studied. The superior entries identified were EC-734792, EC-734800, EC-734825 and EC-734844. Among traits specific for confectionery quality significant positive correlation was observed only for 100 seed weight and seed yield per plant. Other confectionery traits such as seed length, seed width, kernel weight and hull content formed a different set.

Keywords: Accession screening, Confectionery, Sunflower

In recent years, there has been an increase in demand and acceptance of sunflower for table purpose. Its production is mainly in middle and east Anatolia region of Turkey. Other major markets can be found in china, Russia, Ukraine, Argentina, Spain, France etc. The market price of confectionery sunflower is approximately 6-8% higher than that of oil sunflower.

In this study, 57 genotypes acquired from UAS, Bengaluru were evaluated along with one check for yield and its component traits as well as traits specific to confectionery quality (days to 50% flowering, plant height (cm), head diameter (cm), seed yield/plant (g), volume weight (g/100ml), harvest index (%), 100 seed weight (g), hull content (%), head weight (g), kernel weight (g), seed length (cm), seed width (cm). These inbreds were sown in augmented design during spring 2019 at research farm of PAU, Ludhiana. Each sunflower genotype was raised in plot area of 480 m². Data obtained were statistically analyzed for analysis of variance using model $Y_{ij} = \mu + G_i + R_j + e_{ij}$ and Pearson's correlation was computed among traits.

As per ANOVA significant difference were found among entries for seed yield/plant (g), volume weight

(g/100ml), 100 seed weight (g), hull content (%), head weight (g), kernel-weight (g), seed-length (cm) and seed-width (cm). The genotypes that were found superior for seed yield/plant were EC-734792 (37.9 g), EC-734808 (37.6 g), EC-734790 (32.8 g) and EC-734805-I (30.4 g). EC-734825 (1.79 cm) and EC-734810 (1.65 cm) were superior for seed-length while, EC-734800 (0.62 cm), EC-734825 (0.58 cm) and EC-734823 (0.56 cm) for seed-width. The genotypes that were found superior for kernel weight were EC-734844 (0.67 g), EC-734864 (0.62g) and EC-734820 (0.58 g), while the 100 seed weight was maximum for EC-734800 (10.14 g), EC-734844 (10.13 g) and EC-734863-II (10.07 g). The genotypes with less hull content were EC-734807 (3.41%), EC-734867 (5.84%) and EC-734803 (6.48%). Significant positive correlation existed between seed yield/plant and days to 50% flowering, plant height, head diameter, 100 seed weight. Among other confectionery specific traits positive and significant correlation existed between hull content and 100 seed weight with kernel weight for seed width with seed length and kernel weight (Table 1).

Table 1 Correlation coefficient among yield and other confectionery parameters

	Days to 50% flowering	Plant height (cm)	Head diameter (cm)	Seed yield/plant (g)	Volume weight (g/100ml)	Harvest index (%)	100 seed weight (g)	Hull content	Head weight	Kernal weight	Seed length	Seed width
Days to 50% flowering	1.00											
Plant height (cm)	0.28*	1.00										
Head diameter (cm)	0.38*	0.68*	1.00									
Seed yield per plant (g)	0.45*	0.65*	0.63*	1.00								
Volume weight (g/100ml)	-0.15	-0.03	-0.31*	-0.16	1.00							
Harvest index (%)	-0.13	-0.07	0.12	0.21	0	1.00						
100 seed weight (g)	0.17	0.31*	0.37*	0.30*	-0.31*	-0.06	1.00					
Hull content (%)	0.08	-0.17	-0.24	-0.02	-0.31*	-0.17	0.19	1.00				
Head weight (g)	-0.04	-0.01	0.02	0.14	-0.40*	-0.06	0.57*	0.77*	1.00			
Kernel weight (g)	0.04	0.1	0.13	0.03	0.03	-0.11	0.34*	0.26*	0.34*	1.00		
Seed length (cm)	0.17	-0.06	0.06	0.15	-0.28*	0.06	0.16	0.09	0.14	0.07	1.00	
Seed width (cm)	0.38*	-0.29*	-0.11	-0.07	-0.19	-0.29*	0.11	0.38*	0.24	0.30*	0.37*	1.00

Combining ability and gene action analysis in sunflower (*Helianthus annuus* L.)

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ABSTRACT

The present investigation was undertaken to study the combining ability and gene action in sunflower. Five CMS lines and nine restorers were included as parental material. CMS 10A was a good general combiner for days to 50% flowering, days to maturity, head diameter, 100 seed weight, seed yield/plant, volume weight and seed filling. Similarly, CMS 519A and CMS 62A were good general combiners for seed yield and component traits. Among the testers, TSG-04 was a good general combiner for days to 50% flowering, days to maturity, plant height and 100 seed weight. Out of 45 hybrids, five hybrids viz., CMS 62A x SCG-04, CMS 234-1017A x TSG-327, CMS 234-1017A x TSG-111 and CMS SUN-35-519A x TSG-289 exhibited significant desirable sca effect for seed yield and component traits.

Keywords: Combiner, Characteristics, Chromosome, Hybrids, Sunflower, Traits

Improving the seed yield is an important objective in sunflower breeding especially in the present situation of less than 8 q/ha national average for the crop. Hybrid technology has given a big boost to sunflower productivity and continued efforts to identify newer hybrids with better yield potential has been the primary pursuit of sunflower breeders.

In this line, identifying right parents for producing hybrids is an important activity. Present investigation was carried out to identify better parental lines from among 5 CMS and 7 restorer lines in sunflower.

The experimental material for the study included five CMS lines as female parents and nine restorers as male parents those were crossed and produced 45 new hybrids in *kharif* 2018. Parental lines, hybrids and checks were evaluated in *rabi* 2018-2019 in RBD at Oilseed Research Station, Latur. Combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kempthorne (1957).

The mean sum of squares for parents and crosses showed significant differences for all the characters, indicating presence of the sufficient variability in the genetic material.

Perusal of *gca* effects of 14 parents for 9 characters reveals that the CMS 10A was found to be good general combiner for days to 50% flowering, days to maturity, head diameter, 100 seed weight, seed yield/plant, volume weight, seed filling and oil content. Among the male, TSG-04 was found good general combiner for days to 50% flowering, days to maturity, plant height and 100 seed weight. TSG-281 exhibited significant *gca* effect for seed yield/plant and oil content.

The present results thus suggest that these parents possessed high concentration of favorable genes for the respective traits and may be utilized in crossing programme to develop hererotic hybrids containing majority of desirable characteristics.

For plant height the hybrids viz., CMS 10A x SCG-04 (-18.200), CMS 234-1017A x TSG-269 (-17.511) and CMS SUN-35-519A x TSG-111 (-15.244) exhibited the highest significant negative sca effect. The hybrids CMS 519A x TSG-289 (1.902), CMS 62A x TSG-269 (1.676) and CMS 519A x TSG-327 (1.622) recorded high positively significant sca effects for head diameter which helps in increasing number of seeds/head ultimately increase yield. For seed yield/plant eight hybrids viz., CMS 62A x SCG-04 (8.143), CMS SUN-35-519A x TSG-04 (7.781), CMS SUN-35-519A x TSG-289 (6.931), CMS SUN-35-519A x TSG-269 (5.531), CMS 519A x TSG-257 (4.888), CMS 234-1017 x TSG-327 (4.527), CMS 10A x TSG-281 (4.431) and CMS 234-1017A x SCG-04 (4.177) exhibited significant positive sca effect. Volume weight (g/100ml) hybrids viz., CMS 62A x TSG-281 (7.419), CMS SUN-35-519A x TSG-257 (6.198), CMS 234-1017A x SCG-04 (5.872) and CMS SUN-35-519A X TSG-274 (5.808) were exhibited significant highest positive sca effect among the hybrids. 16 hybrids exhibited significant sca effect in oil content.

In the present study presence of additive type of gene action for characters viz., seed yield/plant, volume weight and seed filling (%) was confirmed by the ratio of (δ^2gca/δ^2sca) was more than unity for characters indicating additive gene action. Similarly the ratio of (δ^2gca/δ^2sca) was less than 1 for days to 50% flowering (0.3756), days to maturity (-0.0492), plant height (0.6649), head diameter (0.5786), 100-seed weight (g) (0.0383) and oil content (%) (0.1832) which indicated that there is presence of non-additive gene action. In such situation development of hybrids and synthetics can be effectively done.

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Studies on variability analysis in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

The present investigation in groundnut was undertaken to study the extent of genetic variability for yield contributing characters in eighteen groundnut genotypes including three checks. These were evaluated at Oilseed Research Station, Latur during *kharif* 2016. The observations were recorded on selected five plants for seventeen characters. The estimates of genotypic and phenotypic coefficient of variation indicated that maximum GCV and PCV were observed for number of pods/plant, kernel yield/plant, pod yield/plant, harvest index, total sugar, thrips incidence, trichome frequency, SMCR. The estimates of variability were appreciably high for harvest index, number of pods/plant, kernel yield/plant and pod yield/plant, total sugar, and trichome frequency.

Keywords: GCV, Groundnut, PCV, Yield and yield traits

Groundnut yields are low in India and being an important oilseed crop of the country, if the productivity is increased in this crop, the production of edible vegetable oil would go up substantially. This is more so because, major portion of the groundnut produced in India is crushed primarily for high quality edible oil extraction. Improving the productivity would depend on the right combination of yield contributing traits and therefore, breeding programmes would get better outputs if there is a clear understanding of the yield contributing traits as well as their contribution levels. Present investigation was taken up to study the extent of genetic variability for yield contributing characters in eighteen groundnut genotypes.

The investigation was undertaken at Oilseed Research Station, Latur during *kharif*, 2016. The experimental material comprised eighteen genotypes including three checks *viz.*, JL-24, LGN-1 and LGN-123. The replication means based on five randomly selected plants for yield, yield contributing and morpho-biochemical characters were used for analysis. The phenotypic and genotypic components of variances based on analysis of variance were estimated.

The amount of variability present for improvement of economic characters and its effective management in a population determines the success of any breeding programme. The estimates of genetic parameter (Table 1) revealed that there were closer correspondences between Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) for all the traits except kernel yield/plant. PCV were higher than GCV for all characters studied indicating the role of environmental variances in the total variance. The trait, number of pods/plant showed high PCV and GCV estimates. Hence this character can be relied upon during selection process and simple selection can be practiced for further improvement. The phenotypic coefficient of variation and genotypic coefficient of variation estimates were relatively high for number of pods/plant, kernel yield/plant, pod yield/plant, and harvest index in decreasing order of their magnitude. The phenotypic and genotypic coefficient of variation estimates was moderate for test weight. However, the low phenotypic and genotypic coefficient of variation values obtained for shelling per cent, days to maturity, oil content, days to 50% flowering indicating the limited scope for selection for these traits.

Table 1 Parameters of genetic variability for yield and yield contributing characters

Parameters	Range	Mean	GV (δ^2_g)	PV (δ^2_p)	GCV (%)	PCV (%)	Broad sense heritability (%)
Days to 50% flowering	26-31.5	28.90	2.09	3.62	5.00	6.58	57.6
Days to maturity	114.5-124.5	119.9	8.70	10.60	2.46	2.71	82.1
No of pod/plant	12.35-27.5	19.28	24.22	26.15	25.53	26.52	92.6
Shelling (%)	61.1-67.8	63.27	2.17	5.06	2.33	3.55	42.9
Test weight (g)	25.1-52.5	32.70	39.17	43.25	19.12	20.10	90.6
Harvest index (%)	31.1-63.6	39.80	76.89	79.36	22.01	22.36	96.9
Oil content (%)	47.6-51.7	49.50	1.69	1.76	2.63	2.68	96.2
Kernel yield/plant (g)	7.10-15.5	11.40	7.11	8.18	23.39	25.09	86.9
Pod yield (g)	11.4-24.9	17.90	16.74	19.37	22.73	24.45	86.4

GV- Genotypic variance, PV- Phenotypic variance, GCV- Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation, GAM- Genetic advance as % mean

Use of CRISPR-CAS9 system in groundnut (*Arachis hypogaea*) transformation targeting *ahFAD2* gene

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ABSTRACT

Down regulation of *ahFAD2* results in reduced conversion of oleic to linoleic acid thus enhancing O/L ratio in groundnut. Novel gene editing technique, CRISPR-CAS9 was used to edit *ahFAD2* gene in groundnut to enhance O/L ratio. Guide RNA (gRNA) was identified and designed targeting 1200 bp within the 1710 bp long *ahFAD2* gene. Later, gRNA was successfully cloned into p53 construct having, CAS9. Entire construct was transferred into *Agrobacterium* and validated using PCR primers. Explants co-cultured with *Agrobacterium*, produced multiple shoots. Transformed shoots were selected on hygromycin selective media.

Keywords: *ahFAD2*, CRISPR-CAS9, Groundnut, Gene editing, Oleic/linoleic acid ratio, Transformation

Shelf-life and oil quality of groundnut is affected by fatty acid composition, mainly the ratio of oleic and linoleic acids. O/L ratio in groundnut, is an oil stability indicator (Bolton and Sanders, 2002). High oleic acid can also reduce the risk of cardiovascular disease, prevent cancer, and increase insulin sensitivity (Colomer and Menendez, 2006). Negative relation exists between oleic and linoleic acid contents in groundnuts. Two homologous genes *ahFAD2A* and *ahFAD2B*, regulate the $\Delta 12$ fatty acid desaturase (FAD) activity in conversion of oleic acid (C18:1; $\Delta 9$) to linoleic acid (C18:2; $\Delta 9$, $\Delta 12$). A single base pair substitution (G:C/A:T) mutation at 448 bp in *ahFAD2A* and 1-bp insertion (A:T) mutation at 442 bp in *ahFAD2B* reduces enzymatic activity (Chu *et al.*, 2009). CRISPR-CAS9, a novel gene editing approach was used in this study to edit *ahFAD2* in groundnut.

Gene sequence of *ahFAD2* having 1710 bp was retrieved from Peanut Base (<http://Peanutbase.org/>). Target site within *ahFAD2* was selected by using gene specific primer. Amplified products were sequenced and used as template to design gRNAs. The gRNA showing no off-target mutation was ligated into p53 construct having CAS9, specific to dicots. The construct was transferred into *Agrobacterium* strain LBA4404 and confirmed through colony PCR for the presence of CAS9 and gRNA. Efforts are being made to transfer construct into plant cells derived from de-embryonated cotyledons and leaves of groundnut cv. GG-20.

Gene specific primers designed gave an amplicon of 1200 bp. Sequence of amplicon showed 100% similarity

with the *ahFAD2* full sequence. With the help of bioinformatic tools, gRNA (5`TGTGGTCTATGATCT GTTAATGG3`) with no-off target was identified. This gRNA was ligated with construct p53 and successfully cloned. PCR validation of gene construct in *Agrobacterium* with nine primers showed expected amplicon size. Multiple shoots growth was observed from the explants after co-culturing with *Agrobacterium*. Well elongated individual shoots were observed in shoot elongation media. Transformed shoots established on hygromycin selection media due to presence of hygromycin resistant gene in the construct, but non-transformed shoots did not survive. Research is still in progress to confirm and validate successful gene editing in *ahFAD2*. Knowledge and skills generated from this study will be beneficial for breeders to address genetic improvement for quality, biotic and abiotic stresses.

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Search for heterotic cross combinations in Indian mustard [*Brassica juncea* (L.) Czern & Coss]

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ABSTRACT

Fifteen indigenous lines of Indian mustard along with three testers namely RH 749, Giriraj and NRCHB 101 were crossed to generate 45 F₁s. These hybrids along with their parents were raised in RBD design with 3 replications. The data on the yield and yield traits were taken and analysis of variance, estimation of combining ability effects, heterobeltiosis and economic heterosis followed. Four lines showed positive significant gca effects for number of siliqua/plant while tester Giriraj exhibited positive significant gca effect. IC 571655, IC 571625 and IC558816 displayed highly significant positive gca effect for seed yield/hectare. Giriraj × IC-589670, Giriraj×IC-571655 and NRCHB-101×IC-558816 displayed positive significant standard heterosis coupled with high *per se* performance for seed yield/hectare.

Keywords: GCA, Heterosis, Indian mustard, Line x tester, SCA

India holds premier position in the world in terms of area under oilseeds but the yield of the most of oilseeds is less than the world average. Moreover, on the other hand the edible oil demand of our country is increasing very rapidly with increasing population. Heterosis breeding could be a possible substitute for obtaining quantum leaps in mustard production and productivity. The line × tester analysis helps in the recognition of good general combiners and specific cross combinations as well as the selection of breeding method for genetic improvement of several quantitative characters. The knowledge on combining ability of different genotypes for seed yield and its component traits is useful in designing successful breeding scheme. Selection of diverse parents with good general combining ability is very important in heterosis breeding.

Present study involved 15 Indigenous collection lines (IC-558816, IC-571655, IC-571625, IC-393232, IC-342777, IC-597879, IC-571635, IC-589670, IC-447111, IC-989662, IC-538737, IC-538719, IC-989681, IC-989686, IC-581669) which were crossed with three testers *viz.*, Giriraj, NRCHB-101 and RH-749 during 2017-18 to develop 45 crosses. These 45 F₁s along with 18 parents and 2 checks (Kranti and DMH-1) were evaluated in randomized block design with 3 replications during *rabi* 2018-19 in Agricultural Research Farm, Institute of Agricultural Sciences, B.H.U. Varanasi. The data on the 14 yield traits were taken which were subjected to following statistical analysis: analysis of variance, Estimation of combining ability effects, estimation of heterosis, heterobeltiosis and economic heterosis.

The mean sum of squares due to crosses was significant for all the traits except for days to maturity, plant height and number of siliqua on main raceme. Only 4 lines showed positive significant gca effects for number of siliqua/plant while tester Giriraj exhibited positive

significant gca effect. IC-571655, IC-571625 and IC-558816 displayed highly significant positive gca effect for seed yield/hectare and among the testers NRCHB-101 and Giriraj showed significant gca effects. These results are in accordance with the results of Gami *et al.* (2013) and Singh *et al.* (2013). Giriraj × IC-538737, Giriraj × IC-571655, NRCHB 101 × IC-571625 and Giriraj × IC-589670 (368.86) crosses showed highly significant positive sca effects for seed yield/hectare. These findings are in accordance with the findings reported by Yadava *et al.* (2012) and Singh *et al.* (2013). Top three crosses *viz.*, Giriraj × IC-589670, Giriraj × IC-571655 and NRCHB-101 × IC-558816 displayed positive significant standard heterosis (over DMH-1) coupled with high *per se* performance for seed yield/hectare. Lines possessing significant gca effects may be used in breeding programme. The hybrids that showed highly significant yield can be retested and superior crosses can be converted into CGMS system to develop A, B and R lines.

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Top five crosses on the basis of *per se* performance, sca effect and standard heterosis for seed yield/ha over national check DMH-1

Crosses	<i>Per se</i> performance	sca effect	Standard heterosis (%)
Giriraj x IC-589670	3432.25	368.86 *	39.30
Giriraj x IC-571655	3402.38	373.72 *	38.08
NRCHB-101 x IC-558816	3207.69	180.29	30.18
NRCHB-101 x IC-571625	3139.95	374.94 *	27.43
NRCHB-101 x IC-581669	3211.47	205.95	14.10

Heterosis studies for yield and its contributing characters in sesame (*Sesamum indicum* L.)

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ABSTRACT

Heterosis for eleven characters was studied evaluation of parent and 28 F₁ derived from crossing the 8 genotypes in half-diallel fashion. The analysis of variance revealed that significant differences existed among parents and hybrids for all characters. This validated that considerable amount of variability among experimental material. Five crosses viz., G-1 x IC-204025, LOCAL x AKT-101, LOCAL x AKT-306, LOCAL x YLM-17, AKT-306 x YLM-17 and G-1 x AKT-306 manifested significant and positive heterosis over better parent and both standard checks JLT-408 and Phule Til-1, respectively, for seed yield/plant. These crosses have been identified for exploitation of heterosis and also for utilization in future breeding programmes to obtain desirable transgressive segregants for the development of superior genotypes.

Keywords: Half-diallel, Heterosis, Sesame

Exploitation of heterosis in sesame (*Sesamum indicum* L.) is considered as a means of maximizing the yield. For exploitation of hybrid vigour, high degree of heterosis for seed yield and its components is a prerequisite. The present study was undertaken to estimate the level of heterosis in sesame.

Eight genotypes, (LOCAL, G1, AKT-306, AKT-101, IC-205283, IC-203871, IC-204025, YLM-17) were crossed in half-diallel fashion to generate 28 F₁ hybrids during summer 2018. The Parental lines, hybrids and check (Phule Til-1, JLT-408.) were evaluated in *kharif* 2018 in randomized block design with three replications with inter and intra row spacing 45 and 20 cm, respectively. Observations were recorded in each replication for 11 quantitative characters.

The variance due to genotypes was highly significant for all character thus indicating the considerable amount of genetic variability present in genotypes for all characters under study. Among the 11 characters, plant height, no. of branches/plant, no. of capsule/plant, 1000 seed weight showed significantly high correlation with seed yield. For number of branches/plant AKT-306 x IC-203871 (39.39%) exhibited the highest significant positive heterosis over better parent and Local x AKT-306 (40.28% and 36.12%) showed the highest significant positive heterosis over both the checks. For the character, Number of capsules/plant, LOCAL x AKT-101 (40.38%) showed

highest significant positive heterobeltosis and G-1 x IC-204025 (40.24 and 33.50%) exhibited the highest significant positive heterosis over both the checks JLT-408 and Phule Til-1. For oil content, AKT-306 x IC-205283 (7.02%) exhibited the highest significant positive heterosis over better parent and LOCAL x IC-204025 exhibited 10.34% and 14.19% heterosis over the checks, respectively. These results are in agreement with Saravanan *et al.* (2002) and Thiyagu *et al.* (2007). From the present investigation, it could be concluded that five crosses G-1 x IC-204025, AKT-306 x YLM-17, LOCAL x AKT-306, LOCAL x AKT-101 and G-1 x AKT-306 were most promising for seed yield and other desirable traits and hence they could be evaluated further to exploit the heterosis. Also, these crosses could be utilized in future breeding programmes through biparental mating or recurrent selection breeding approaches to obtain desirable segregants for development of superior genotypes for seed yield and its component traits.

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Heterosis for yield and yield contributing traits in sunflower (*Helianthus annuus* L.)

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ABSTRACT

The present experiment involved four CMS lines and six testers which were crossed in line x tester fashion to estimate the heterosis for seed yield and yield contributing traits in sunflower. Resulting 24 F₁ hybrids were evaluated in two replications in RBD along with two commercial checks LSFH-171 and LSFH-35. Range of standard heterosis in 24 F₁ hybrids over check LSFH-171 was from -6.42 to 31.74 and over the other check LSFH-35 it was from -13.56 to 13.56 for oil content. Extent of heterosis for seed yield in hybrids ranged from -20.51 to 37.18 over LSFH-171 and from -6.06 to 62.12 over LSFH-35. Hybrid PET 89-1 x EC-601951 exhibited significant negative heterosis for early flowering and days to maturity over both checks. Based on *per se* performance, hybrids CMS 234A x EC-601957, CMS-234A x EC-601951, CMS-243A x EC-601957, PET-89-1A x EC-601951 and CMS-234A x EC-623008 were superior for oil content and most of the yield contributing traits indicating them to be promising new combinations for hybrid development.

Keywords: Heterosis, Line x Tester, Sunflower, Yield traits

The main objective of heterosis breeding is to improve the oil content and seed yield. Hybrids are preferred over varietal populations because of their high productivity in terms of seed and oil yield. Hybrids are more productive, uniform and also respond to higher level of fertilizer application and irrigation. In view of these advantages, the coverage of area is more under hybrids and it is around 95 per cent.

The experiment was conducted at the experimental field of Oilseed Research Station, Latur during 2017-18 by adopting line x tester design consisted of four lines (CMS-17 A, CMS-234A, CMS-243A and CMS-PET-89-1A) and six testers (EC-623008, EC-601951, EC-601957, EC-279309, 99RT and RHA-1-1). The resultant 24 F₁ hybrids along with their 10 parents and two checks *viz.*, LSFH-35 and LSFH-171 were evaluated in RBD with two replications. Observations were recorded on randomly selected plants for ten characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed filling (%), seed yield/plant (g), 100 seed weight, volume weight (g/100 ml), hull content (%) and oil content (%).

Two cross combinations *viz.*, PET-89-1A x EC-601957R (-9.20%, -8.67%), CMS-243A x 99 RT (- 6.90%, -6.36 %) showed highly significant and negative standard heterosis over both checks for days to maturity. For plant

height, crosses CMS-17A x 99RT (-36.52%, -41.67%) and CMS-17A x EC-601951R (-26.47%, -32.44 %) exhibited highest negative heterosis over both the standard checks. For the percentage of filled seed, significant positive heterosis was recorded in crosses CMS-17A x EC-623008R (3.57%, 12.31%), CMS-234A x EC-601957R (2.49%, 11.14%) over the checks. Only one cross CMS 234A x 99 RT (-10.52%, -19.72 %) exhibited significant negative heterosis for hull content. For the oil yield the crosses CMS-234A x EC-601951R (31.74%, 21.69%), CMS-234A x EC-601957R (32.11%, 22.03%) and 234 x EC-623008R (22.94%, 13.56%) recorded highest significant positive heterosis over both checks. Seed yield/plant is the ultimate objective in crop breeding and hence high heterosis for seed yield is always looked for. Two crosses, CMS-17A x EC-601951R (37.18%, 62.12%), and PET-89-1A x RH-1-1 (15.38%, 36.36%) exhibited significant positive heterosis over both the standard checks. It was concluded that, different hybrids were promising for oil content and most of the yield contributing traits and five crosses *viz.*, CMS-234A x EC-601957, CMS-234A x EC-601951, CMS-243A x EC-601957, PET-89-1 A x EC-601951 and CMS-234A x EC-623008 were promising. These hybrid combinations could be further tested for their field performance.

Heterosis for yield and component traits in safflower (*Carthamus tinctorius* L.)

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ABSTRACT

The present study in safflower revealed that for all the characters investigated in 15 crosses, heterosis was noticed in both positive and negative directions indicating that genes with negative as well as positive effects were involved in trait manifestations. Among 15 crosses, the cross GMU-2720 x GMU-3423 for number of branches/plant, number capitulum/plant showed highest significant and positive heterobeltiosis and standard heterosis in desirable direction. PBNS-12 x GMU-3431 for number of seed/capitulum; GMU-2720 x GMU-3423 for seed yield/plant and GMU-1339 x GMU-3423 for oil content showed highest significant and positive standard heterosis in desirable direction. Thus, five crosses GMU-2720 x GMU-3423, GMU-1339 x PBN-96, GMU-1339 x EC-757665, GMU-1339 x EC-757665 and PBNS-12 x EC-757665, showed maximum standard heterosis in desired direction for majority of the characters.

Keywords: Heterosis, Heterobeltiosis, Safflower, Standard heterosis

Safflower is a self-pollinated crop but insects particularly bees are necessary for optimum pollination and maximization of yield. Cross pollination mainly through bees to the extent of 10-28% depending on genotype and insect activity has been reported in safflower (Weiss, 2000). Heterosis breeding could be a potential alternative for achieving quantum jumps in production and productivity. The comprehensive review of heterosis in safflower indicate that there is a significant amount of heterosis over commercial cultivars indicating the possibility of exploiting heterosis at commercial level in safflower (Sarode *et al.*, 2008).

The present study consisted of the crosses made by utilizing three lines (GMU-2720, PBNS-12 and JMU-1339) and five testers (GMU-3423, PBN-96, NARI-6, GMU-3431 and EC-757665) were crossed in line x tester fashion to generate 15 F₁ hybrids during *rabi* 2017. The parents, hybrids and checks (Sharda) were evaluated in *rabi* 2018 in randomized block design with two replications with inter and intra row spacing 45 and 20 cm, respectively. Observations were recorded in each replication for 10 quantitative characters.

The analysis of variance revealed the presence of considerable amount of genetic differences among the treatment, parents and crosses for majority of the characters. The cross GMU-2720 x GMU-3423 showed highest significant and positive heterosis over better parent and standard check for number of branches/plant, number

capitulum/plant in desirable direction. Highest significant and positive standard heterosis for number seeds/capitulum was exhibited in cross PBNS-12 x GMU-3431 followed by GMU-2720 x GMU-3423 and GMU-2720 x EC-757665. Highest significant positive standard heterosis for seed yield/plant was reported in cross GMU-2720 x GMU-3423 followed by GMU-1339 x PBN-96, GMU-2720 x EC-757665, GMU-1339 x GMU-3431. Highest significant and positive standard heterosis for oil content was recorded in the cross 1339 x GMU-3423 followed by GMU-1339 x GMU-3431 and GMU-2720 x PBN-96. The crosses which showed significant and positive standard heterosis (Table 1) for safflower seed yield also manifested significant standard heterosis in desired direction for majority of yield attributing characters. It is suggested that, for getting higher yield from F₁ hybrids, parents which compensate each other for main yield components and number of capitulum/plant should be involved.

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Table 1 Best heterotic crosses and their performance for seed yield and related traits in safflower

Crosses	Seed yield/ plant (g)	Better parent heterosis (%)	Standard heterosis (%)	Significant standard heterosis for other traits in desirable direction	Standard heterosis for other traits in desirable direction
GMU 2720 x GMU 3423	65.0	73.3 **	32.6**	DF, DM, NB, NC, NS, SYP, HC, OC	TW
GMU 1339 x PBN 96	63.6	70.7**	29.8**	NB, NC, NS, SYP, HC, OC	DM, TW
GMU 2720 x EC 757665	63.4	69.2**	29.4**	50% DF, DM, PH, NB, NC, NS, SYP, HC, OC	-
GMU 1339 x EC 757665	63.4	70.2**	29.3**	PH, NB, NC, NS, SYP, HC, OC	DM, TW
PBNS 12 x EC 757665	62.2	90.2**	26.9**	DM, NB, NC, NS, SYP, OC	50% DF, PH, HC

*Significant at 5% level, ** Significant at 1% level.

Where, DF=Days to 50 % flowering; PH=Plant height(cm); NC=No. of capitulum/plant; TW=100-seed weight (g); OC=Oil content (%)
DM=Days to maturity; NB=No of Branches; NS=No. of seeds/capitulum; SYP=Seed yield/ plant (g); HC=Hull content (%)

AMS-1001 (PDKV yellow gold): A new high yielding, charcoal rot and yellow mosaic virus disease resistant soybean variety

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ABSTRACT

Soybean variety AMS-1001 is a high yielding mutant of JS-93-05. In multi-location trials, AMS-1001 recorded yield increase over state check MAUS-71 by 24.17% and national check JS-335 by 20.58%. In state multilocation trials AMS-1001 recorded 36.01%, 30.58% and 33.82% increase yield over JS-335, JS-97-52 and MAUS-71, respectively. AMS-1001 has also given 23.90% higher seed yield over check variety JS-335, in adaptive trials on

farmer's field. This culture has shown highly resistant reaction to charcoal-rot and YMV diseases. AMS-1001 differentiated from other soybean varieties using molecular markers and primer Glysatt-180 was found specific to the sample AMS-1001 and can be used for its identification. Considering its yield superiority and resistance to diseases the SVRC has released AMS-1001 for Maharashtra state. The national identity of this variety is IC-626343.

Keywords: AMS-1001, Charcoal rot, Soybean, Yellow mosaic virus

Soybean (*Glycine max* L.) is world most important seed legume, which contributes to 25% of the global edible oil, about two-thirds of the world's protein concentrate for livestock feeding. Soybean meal is a valuable ingredient in formulated feeds for poultry and fish (Agrawal *et al.*, 2013). It is therefore no surprise that global soybean demand is increasing rapidly. Improved varieties, in any crops, are essential for achieving higher productivity. Lack in diversification of varieties is a major constraint of low productivity. About more than 115 soybean varieties have been released in India but most of the varieties have narrow genetic base and hence restricted to grow on small area. Soybean culture AMS-1001 has ability to produce sustainable optimum yield with resistance to root rot/charcoal rot and yellow mosaic virus disease which have become the emerging problems in Vidarbha region.

Irradiation of seed material of soybean variety JS-9305 was done with three treatments *viz.*, 150 Gy, 250 Gy and 300 Gy at Bhabha Atomic Research Centre, Trombay, Mumbai in the year 2006 and during *kharif* 2006 the treated seed material was sown at Research Farm of Regional Research Center (Dr. PDKV), Amravati to raise the M1 population. Subsequently, from 2007 to 2010, eight generations (two generations in a year) were completed (up to M8) and a stable line was developed which was named as AMS-1001. The soybean culture AMS-1001 was tested in preliminary and advanced yield trials along with the check varieties from 2012 to 2017. Based on superiority in University multilocation varietal trials (MVT) it was promoted for testing over different locations of Maharashtra. The adoptive trials (on-farm trial) were conducted on farmer's field during *kharif* 2017. The culture AMS-1001 was also screened for major diseases and insect-pests. The resistance of this culture to root rot/ charcoal rot was tested in natural as well as sick plot condition.

The culture AMS-1001 is the mutant of soybean variety JS 93-05. AMS-1001 has determinate growth habit and matures in 95 to 100 days. In station trial conducted during *kharif* 2011, the culture AMS-1001 gave 2563 kg/ha seed yield, which was 10.90% higher than national check JS-93-05. Based on average seed yield over six years, the culture AMS-1001 (2173 kg/ha) recorded 24.17% and 20.58% increase in seed yield over state check MAUS-71 (1750 kg/ha) and over national check JS-335 (1802 kg/ha), respectively. In state multilocation trial, culture AMS-1001 registered higher seed yield potential of

1989 kg/ha and showed an increase in seed yield over national checks JS-335 (1469 kg/ha) by 36.01% and another national check JS 97-52 (1453kg/ha) by 30.58%. The soybean culture AMS-1001 was also screened for root rot/ charcoal rot and Yellow mosaic virus disease over seven years from 2011 to 2017. AMS-1001 showed highly resistant reaction to both the diseases under natural field condition, whereas, it showed absolute resistance to root rot/ charcoal rot in sick plot. The key morphological characters to distinguish this culture from other varieties during seed production are medium maturity, determinant growth habit, purple flower, glabrous pods/stem with pointed ovate dark green leaves. Also, AMS-1001 gave a unique band when its DNA was subjected to fingerprinting with glysatt-180 primer establishing its distinct nature from source material as well as national checks (Fig. 1). Considering the superiority over the check varieties in different trials the culture AMS-1001 was released as AMS-1001 (PDKV Yellow Gold) by the 50th State Varietal Release Committee (SVRC) meeting during 2018. It is recommended for *kharif* planting in Vidarbha region of Maharashtra. The national identity of the variety is IC-626343.



Fig. 1. DNA Finger printing of soybean variety AMS-1001 (PDKV Yellow Gold) (Lane 1, 2 and 3 are samples AMS-1001, JS-93-05 and JS-335, respectively. Lane 4 and 5 are control samples. M is the 100 base pair (M/S BR Biochem Life Sciences) molecular weight size standard)

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Development of random mating population for genetic enhancement of yield traits in sunflower (*Helianthus annuus* L.)

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ABSTRACT

As in any crop, in sunflower, to develop improved breeding lines having superior yield, oil content and resistant to biotic and abiotic stresses, it is essential to have genetically diverse parental lines. In this study, we used six trait specific inbred lines and allowed random mating in isolation. Through population improvement a total of 150 new restorer lines have been developed. Significant variation was observed for different traits among the lines studied. The progenies RGP-11-P1-S2 (39.89%), RGP-58-P4-S2 (39.31%), RGP-58-P4-S1-1 (39.31%) were promising for oil content. RGP-58-P4-S2 (32.1 g/plant), RGP-85-P1-S1 (31.3 g/plant), RGP-85-P1 (30.1 g/plant) for high seed yield. Based on survival under stress condition, the progenies RGP-21-P5, RGP-21-P6, RGP-32-P1 and RGP-61-P2 were identified as best genotypes under moisture stress conditions. RGP-21-P4-S1-3 and RGP-50-P2-S1 were completely free from powdery mildew.

Keywords: Gene pool, Powdery mildew resistance, Random mating, Restorer line, Sunflower

Improvement in sunflower emphasizes the urgency of generating a heterotic hybrid that is achieved by heterotic vigour available in the genetically diverse parental lines which indicates certain level of heterozygosity and suggests use of population improvement as a long term breeding strategy for exploitation of hidden variability, thus making it available for selection. Moreover, sunflower researchers have been successful in the development of hybrid parents through exploitation of available genetic variability by direct selection and by the use of conventional methods. These methods produce hybrids with a relatively narrow genetic base, accumulate linkage blocks due to rapid fixation of genes and limit recombination. On the other hand, population improvement procedures offer more opportunities for recombination to break linkages between desired and undesired traits and provide long term breeding strategy to derive diverse and broad genetic based superior varieties/hybrid parents. But, systematic population improvement programmes for genetic enhancement of yield components are scanty in sunflower. Therefore, a population improvement programme for restorer gene pool has been initiated for genetic enhancement of oil content, resistance to biotic and abiotic stresses and seed yield as a whole.

Initial material for present investigation consisted of advanced breeding lines *viz.*, CSFI-5075, RHA-6D-1, RHA-95C-1, RHA-1-1, GPR-58 and P-62R that were selected on the basis of their superiority for seed yield, oil content, physiological parameters and good combining ability from germplasm maintained at ICAR-IIOR, Rajendranagar, Hyderabad and from AICRP centres. Random mating was initiated during 2013-14. In *kharif* 2014 and *rabi* 2015 random mating cycle 2 and 3 were completed and material was advanced through open pollination in isolation. In random mating 3, from restorer

gene pool, individual plants were selected based on flowering initiation, plant height, head diameter, seed setting under bagged condition, seed colour, seed shape, 100-seed weight and oil content and yield potential of the plant. All selected progenies were advanced from S1 to S6 through selfing and characterized and evaluated for yield and yield contributing traits and oil content through NMR. Newly developed material was also screened for root traits in poly bags as well as for drought tolerance and powdery mildew resistance under field condition.

A total of 150 new restorer lines were developed through population improvement. Uniform progenies were characterized for agronomically important traits. Range for different traits included-61-80 for days to 50% flowering, 74.8 to 140.6 cm for plant height, 15.8 to 30.0 cm for head diameter, 92-110 for days to maturity, 2.4 to 32.1 g/plant for seed yield under selfing bag, and 28.5 to 39.9% for oil content. The progenies RGP-11-P1-S2 (39.89%), RGP-58-P4-S2 (39.31%), RGP-58-P4-S1-1 (39.31%) were promising for oil content compared to best check RHA-6D-1 (39.00%), while RGP-21-P1 (80 days), RGP-21-P1-S2 (79 days), RGP-21-P3-S1 (78 days), RGP-21-P1-S2 (79 days), RGP-21-P3-S1 (78 days) for late maturity, RGP-58-P4-S2 (32.1 g/plant), RGP-85-P1-S1 (31.3 g/plant), RGP-85-P1 (30.1 g/plant) for high seed yield were promising (Anonymous, 2017).

Root traits were studied in 36 newly developed R lines along with check, by growing the plants in poly bags. Significant variation was observed for different root traits and five lines (RGP-21-P8, RGP-33-P5, RGP-46-P3, RGP-50-P2 and RGP-60-P2) were promising (Anonymous, 2019). Twenty four newly developed progenies that were selected based on desired root traits and wilting symptoms were sown in field for their evaluation for drought stress tolerance. Under stress, the most affected trait was dry matter production and the least

affected was the leaf number. Based on survival under stress condition, the progenies RGP-21-P5, RGP-21-P6, RGP-32-P1 and RGP-61-P2 were identified as best. Furthermore, a total of 10 lines reported to be resistant to powdery mildew were screened along with susceptible and resistant checks during *rabi* 2018-19 (Anonymous 2019). Only two newly developed restorer inbred lines RGP-21-P4-S1-3 and RGP-50-P2-S1 were completely free of the disease even up to maturity. Thus, population improvement programme led to development of promising

genotypes in sunflower and these could be utilized in future breeding programmes.

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Evaluation of advanced breeding lines of sesame (*Sesamum indicum* L.) for seed yield and oil content

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ABSTRACT

The present investigation was carried out to evaluate the advanced breeding lines in sesame for seed yield and oil content. The experiment was conducted during *kharif* 2018, with eight entries (seven advanced breeding lines and one check Sarada) in randomized block design, with plot size of 3.0 x 4.5 m and spacing of 30 x 15 cm. Data was recorded on the parameters *viz.*, days to maturity, seed yield (kg/ha), oil percent and oil yield kg/ha. Among all the entries tested, YLM-146 and YLM-142 recorded significant and highest seed yield 1017 kg/ha and 963 kg/ha, respectively compared to the check Sarada (YLM-66).

Keywords: Oil percent, Sesame, Seed yield

Sesame is an important oilseed crop with high nutrition and medicinal value. It is a part and parcel of our daily life since times immemorial. It is mostly grown in tropical and subtropical countries. In India average yield of sesame is 413 kg/ha, while in Andhra Pradesh the average productivity is 280 kg/ha. There is a great demand for sesame seed and oil in present situation. The main objective of this experiment was to evaluate the advanced breeding lines of sesame (brown seed) for seed yield and oil content.

The experiment was conducted during *kharif* 2018 at Agricultural Research Station, Yellamanchili, Visakhapatnam Dt. Seven advanced breeding lines of sesame (brown seed) were tested against the check YLM-66 during *kharif* 2018 in randomized block design with three replications, plot size of 3.0 x 4.5 m and spacing of 30 x 15 cm. Data was recorded for the parameters *viz.*, days to maturity, seed yield (kg/ha), oil percent and oil yield kg/ha. Oil analysis was carried out using non-destructive Oxford 4000 Nuclear Magnetic Resonance analyzer (NMR).

Among the seven entries, YLM-142 and YLM-146 recorded significant highest seed yield of 963 kg/ha and 1017 kg/ha compared to check YLM-66 (687 kg/ha) (Table 1). The results are in accordance with Bindu *et al.* (2014) and Lokesh *et al.* (2013). The entries YLM-142 and YLM-146 were with similar maturity duration as YLM-66 with 88 days. YLM-142 and YLM 146 recorded

oil percentage 50.36% and 50.42%, respectively while the check YLM-66 showed 50.70% of oil. In terms of oil yield kg/ha, YLM-142 and YLM-146 recorded 513 kg/ha and 485 kg/ha, respectively while the check YLM-66 recorded 348 kg/ha.

Mean performance of the advanced breeding lines for seed yield (kg/ha) and oil percent

Entry name	Seed yield (kg/ha)	Days to maturity	Oil content %	Oil yield (kg/ha)
YLM-136	739	88	47.63	352
YLM-139	766	88	47.71	365
YLM-141	660	89	46.96	310
YLM-142	963	88	50.36	485
YLM-143	739	89	50.52	373
YLM-146	1017	88	50.42	513
YLM-147	660	90	49.84	329
YLM-66 (Sarada) check	687	88	50.70	348
CD (0.05)	162.4	NS		
CV %	11.69	1.2		

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Identification of promising sunflower (*Helianthus annuus* L.) inbred lines for oil and quality parameters

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ABSTRACT

Improvement of oil content and oil quality are the major goals in sunflower research. In the present study, a set of 60 sunflower inbred lines were evaluated for oil content and fatty acid profile. Oil content in the inbreds, ranged from 28.13 (GPR-58) to 41.03% (RHA-6D-1 and AKSFI-42-1). Nine inbred lines showed more than 38 percent oil content and one line showed high linoleic acid content of 70.2% (RHA-272). Two other inbred lines *viz.*, AKSFI-52-2 (10.47%) and CSFI-5033 (10.27%) recorded high stearic acid content.

Keywords: Advanced lines, Fatty acid profile, Oil content, Sunflower

Quality of vegetable oils is mostly associated with their fatty acid profile. The objective of the present study was to determine the oil content and fatty acid profile of the 60 sunflower inbred lines.

The oil content (%) was measured by Nuclear Magnetic Resonance (NMR) spectroscopy using 30 g samples as described by Yadav and Murthy (2006). Oil was extracted in hexane using a Soxhlet apparatus and methyl esters were obtained by two step catalytic process. Fatty acid composition was determined using an Agilent 7860A gas chromatograph (GC) equipped with a flame ionization detector (FID) and an auto sampler as described in Anjani and Yadav (2017).

A total of 60 inbred lines were analysed for oil content and fatty acid profile. Oil content in the inbred lines ranged between 28.13 (GPR-58) and 41.03 (RHA6D-1 and AKSFI-42-1) with an average of 33.72 %. Nine inbred lines *viz.*, AKSFI-42-1 (41.03%), RHA-6 D1 (41.03%), RHA-288 (40.34%), CSFI-5133 (39.90%), AKSFI-52-2 (39.51%), R-630 (39.43%), GKVK-1

(39.40%), GPR-102 (38.87%) and HOHAL-23 (38.22%) showed more than 38.0% oil content. Maximum oleic and linoleic acid contents were recorded in RHA-272 (70.2%) and HOHAL-23 (48.30%), respectively. Stearic acid, ranged from 2.67% (CSFI-5075) to AKSFI-52-2 (10.47%) with an average of 5.53%. High stearic acid increases the stability of oil and has great importance in chocolate industry. High oil content inbred lines can be utilized in the variety/hybrid development as well as for population improvement program in sunflower.

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YTP-1 (YRCS-1205): A promising castor variety for Tamil Nadu

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ABSTRACT

Castor variety YTP-1 suitable for intercropping, mixed cropping and bund crop systems. The variety can be maintained as annual/perennial. The variety is tested across years in station trials, MLT, ART, OFT and AICRP trials. The average annual seed yield is 1484 kg/ha. As perennial the seed yield is 3 kg/plant/annum.

Keywords: Castor, Perennial Variety, YTP-1

Castor (*Ricinus communis* L.) is an important industrial oilseed crop augurs to rainfed, and areas with limited irrigation. The crop is suitable for resource poor small and marginal farmers. In Tamil Nadu castor is cultivated in two different ecosystems. Hybrids are cultivated mainly as pure crop both under rainfed and irrigated systems. Varieties are cultivated as intercrop, mixed crop with pulses and groundnut. Castor varieties are also cultivated as shade crop for turmeric and as bund crop with cotton and vegetables. In this context, castor variety YTP-1 is released for cultivation both as annual and perennial in the intercropping/mixed cropping system and as bund crop.

The variety is evaluated at Tapioca and Castor Research Station, Yethapur, Tamil Nadu Agricultural University, Tamil Nadu. The variety is derivative of the cross Salem local x TMV-6. The variety was tested under the culture number YRCS-1205, in 219 trials viz., 3 station trials, 13 MLT, 103 ART and 89 OFT and in 20 locations

in AICRP – Coordinated trials along with check variety (Co-1). Weighted mean and percent increase over check variety is worked out as per the standard procedures. The entry YRCS-1205 is tested for wilt reaction in National screening nursery at ICAR-IIOR, Hyderabad and SDAU, SK Nagar, Gujarat.

The variety recorded average seed yield of 1484 kg per ha which is 35 per cent higher than check variety Co1. Overall performance of the variety is summarized in Table 1. The new variety is red stemmed, triple bloom and spiny. The variety can be maintained as perennial with average yield of 3 kg/plant/annum. The variety is resistant to lodging with non-shattering capsules. This variety is specifically known for high basal branching with more than 95 percent of female flowers. The variety is fertilizer responsive and suitable for intercropping also. First harvest could be done on 120th days of sowing. YRCS 1205, released as YTP-1, is bold seeded with 100 seed weight of 45 gram and is resistant to wilt.

Table 1 Overall performance of castor variety YTP-1 (Tested as YRCS-1205)

Trial name	No. of trials	YRCS 1205	CO 1
Station	3	1848	1225
MLT	13	1010	620
ART	103	1585	1335
AICRP	20	2093	-
OFT	80	1266	860
W. Mean		1484	1096
% increase over check CO-1	219	35.0	-

Differentially expressed genes in transcriptomes of monoecious and pistillate lines of castor (*Ricinus communis* L.)

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ABSTRACT

Transcriptome sequencing of 12 tissues from different sex morphs was carried out to identify differentially expressed genes governing sex expression in castor. Comparative analysis of different transcriptomes resulted in identification of transcription factors (1054), DE unigenes (540), miRNA targets, which will pave way for understanding the role of key genes involved in sex mechanism in castor.

Keywords: Castor, Differential expression, Monoecious, Pistillate, Sex morphs, Transcriptome

Castor hybrid seed production is based on a two-line system involving the pistillate and male lines. Pistillate parents possess both the systems of sex reversals and environmental sensitive gene for the expression of staminate flowers that has been exploited in hybrid seed

production. Pistillate lines are maintained through a refined method by exploiting the sex reversion mechanism under high temperatures with interspersed staminate flowers (ISF) as pollen source which often results in high cost of rouging and low genetic purity in

certified hybrid seed production plots. An attempt has been made to study the vegetative to floral differentiation stage in pistillate, monoecious, male and hermaphrodite types to have an understanding of the sex mechanism.

The pistillate line M-574 which produced completely female, interspersed staminate flower types (ISF) and its derivative with completely male flowers with a single hermaphrodite flower at the top and the monoecious cultivar DCS-107 were selected. Twelve transcriptomes were generated from various tissues (leaf, inflorescences, flower buds) and sex types (pistillate, monoecious, male); de novo assembly was done using rnaSPAdes assembler v3.10.1 and the data was mined for differentially expressed transcripts by RSEM (RNA-Seq by Expectation-Maximization) software. Annotation of differential expressed genes and analysis of transcription factors was done against NCBI non-redundant database (<ftp://ftp.ncbi.nlm.nih.gov/blast/db/>) and plant specific transcription database (PlantTFDB; <http://planttfdb.cbi.pku.edu.cn/index.php?sp=Osi>) using Blastx algorithm having threshold expected value $1e-3 / <1e-5$, respectively was done using Standalone local ncbi-blast-2.6.0+. Semi-quantitative PCR of 14 DEGs involved in response to hormone stimulus, transcription factors, signal transduction, sex differentiation, pollination, reproduction and histone demethylation/methylation in the monoecious and female apical buds reported by Tan *et al.* (2016) was carried out.

De novo assembly of the 12 transcriptomes was done and the number of contigs was 71418. The total DEGs between the pistillate and male line of the

isogenic line M574 were 1453 while those in male and female buds of the monoecious line DCS-107 were 810 (Table 1). In all comparisons, higher DEGs were detected in transcriptomes involving the pistillate line. Interestingly in agreement with this observation, comparison of male and female buds with hermaphrodite flowers resulted in higher DEGs in male buds (1592) as compared to those of female (218). The study also provided valuable leads with regard to the transcription factors that are differentially expressed (1054) and the DE unigenes (540). Further, the miRNA targets, SSRs and SNPs were mined which serve as a valuable genomic resources. Semi-quantitative analysis of 14 genes reported to govern sex expression in castor indicated that only the expression of Auxin response factor, Xaa-pro amino peptidase and conserved hypothetical protein was in agreement with those reported earlier. The present focus is on functional validation of DEGs and transcription factors identified in this study through quantitative PCR in different sex types and under different conditions being exploited for manipulation of sex expression in castor.

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Table 1 Castor transcriptome and differentially expressed genes in different tissues

Sample	FDR	logFC	Up-Regulated	Down-Regulated	Total
Leaf sample vs female flower pistillate plant (1 vs 2)	0.05	2	1130	1068	2198
Leaf sample vs male buds from male line 574 (1 vs 11)	0.001	10	928	126	1054
Hermaphrodite flowers vs male buds from male line 574 (9 vs 11)	0.05	2	1227	365	1592
Female buds from a completely female line M574 vs hermaphrodite flowers (8 vs 9)	0.05	2	41	177	218
Female buds from a completely female line M574 vs male buds from a completely male line M574 (8 vs 11)	0.05	2	910	543	1453
Male buds from monoecious line DCS-107 vs female buds from monoecious line DCS-107 (10 vs 12)	0.05	2	401	409	810
Female zone from monoecious plant vs male zone from monoecious plant (3 vs 4)	0.05 0.01	2 5	0	0	No DEGs

FDR: False discovery rate

Identifying drought tolerant germplasm through multiplexing polygenic traits in soybean (*Glycine max* L. Merrill)

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ABSTRACT

Soybean being an important seed legume, majority of its cultivated area reported the highest frequency of drought occurring during seed fill growth stage. Identifying novel germplasm for drought tolerance, following multi-tier selection scheme, is an activity in plant genetic resources (PGR) fetching importance in developing climate smart drought tolerant soybean varieties. Multiplexing polygenic drought tolerance related traits into a multi-trait index is an efficient system which identified 3 (TGX-709-50E, J-732 and EC-107407) drought tolerant soybean germplasm. Molecular analysis of these germplasm is in progress for identifying putative drought tolerant genes.

Keywords: Drought, Germplasm, Soybean

During successful soybean production in India, there were 12 major drought scenarios. In majority of soybean growing regions, the highest frequency of drought occurs during seed filling (R5 plus 8-10 days) (Bhatia *et al.*, 2014). Soybean varieties having root systems extended around one meter limit their access to water during drought. Carbon through carbon dioxide from air is stored in the roots and leaves. Doubling root biomass to a nominal two meters make crops more drought resistant and would lock away more carbon in soil down to 2 meters in the crop lands which could reduce the annual rise in global CO₂ levels in the atmosphere, helping fight global warming. Under the present climate scenario, developing drought tolerant soybean varieties is a way forward in realizing desirable genetic combinations through plant genetic resources (PGR) activities identifying novel germplasm for drought tolerance.

Drought tolerance related traits i.e. delayed leaf senescence, stem reserve mobilization (SRM), and physiological, root system architecture (RSA), phenological, morphological and seed traits were analyzed in the respective tiers of a three-tier selection scheme in field trails (Sinclair, 2011). A total of 993 accessions were screened for delayed leaf senescence trait at the seed fill stage in a summer field trial-2016. Promising accessions were evaluated for SRM trait in a field trial framed in sets of sprayed chemical desiccant (KI 0.2%) versus unsprayed control during kharif-2016. Identified accessions were evaluated during kharif 2017 and 2018 in rainout-shelter *vis-à-vis* irrigated field. A total of 22 polygenic traits were multiplexed in a multi-trait index derived through principal component analysis for correlation matrix to identify drought

tolerant germplasm. Transcriptome sequencing of drought susceptible and tolerant lines was done through nanopore sequencing technology.

Delayed leaf senescence induces extreme drought tolerance. Screening for this trait identified eighty-six accessions with high score (4-5), of which 8 accessions belonged to early, 59 accessions to medium and 19 accessions to late flowering category. SRM trait evaluated among these 86 accessions revealed high SMR values in six accessions i.e. PI-159923 (96.6%), TGX-709-50E (90.6%), EC-291448(84.3%), EC-107407 (83.6%), MACS-345 (80.8%) and J-732 (77.4%) as compared to tolerant check JS-97-52 (75.3%). Multiplexing polygenic physiological, RSA, phenological, morphological and seed traits through principal component analysis revealed above average index values (> 0) in three accessions *viz.*, TGX-709-50E (2.4), J-732 (1.1) and EC-107407 (0.2) (Table 1). Molecular analysis through transcriptome sequencing of these putative drought tolerant germplasm is in progress for identifying putative drought tolerant genes. Nine differentially expressed genes in drought tolerance lines were identified and are being characterized.

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Accessions	Multi trait index	Drought resistance index	Rooting depth (>100cm)	Root dry weight (g)	RLD* cm/cm ³	Surf Area cm ²	Root Volume cm ³	Days to maturity	Plant height (cm)	100-seed weight (g)
TGX-709-50E	2.4	1.8	137	8.0	0.63	4057	51.8	98	55.3	11.0
J-732	1.1	1.2	152	10.2	0.65	4803	68.6	98	50.9	8.1
EC-107407	0.2	1.5	136	3.0	0.29	2082	31.8	97	54.7	9.5
JS-97-52 (T)	2.1	1.9	156	10.6	0.57	4944	84.6	108	61.5	8.6
NRC-37 (S)	-1.0	0.9	151	7.3	0.40	2751	37.8	103	49.7	10.4
Mean		1.1	138	5.6	0.42	2946	41.1	103	53.9	10.7
CV%		37.1	16	50.2	43	45	49.7	4	14.2	18.7

*RLD: Root length density

Comparative genomics studies of Rpp1 gene associated with soybean (*Glycine max* L.) rust resistance

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ABSTRACT

Whole genome sequence of rust resistant and susceptible lines were used for comparative genomics studies. Three putative NBS-LRR genes were identified at Rpp1 locus associated with soybean rust.

Keywords: Comparative genomics, Rpp1, Rust resistance, Soybean

Soybean (*Glycine max* L.), one of the most important oilseed crops worldwide is severely affected by rust caused by *Phakopsora pachyrhizi* Syd. & P. Syd. Development of resistant cultivars is considered as the most effective approach for the soybean rust control.

The whole genome sequence of soybean genotype JS-335 was obtained from National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Comparative analysis was performed using SoySNP50K data.

To identify the genomic region associated with rust resistance, we compared the SNPs from SoySNP50K data of various rust resistant and susceptible soybean accessions. The SNPs located at Rpp1 locus from accession PI-200492 were selected for comparative studies with SNPs from rust susceptible accessions. Haplotype analysis of SoySNP50K data near Rpp1 locus was conducted using 24 SNPs spread over 12 Mb genomic region from position 48753972-61504294. Interestingly, Rpp1 locus was found between genomic region 60346170 to 61392614 bp in PI-200492 using haplotype analysis (Table 1). To identify rust resistance genes at Rpp1 locus, we short listed nine NBS-LRR genes (Glyma18G46875, Glyma18G51533, Glyma18G51546, Glyma18G51715, Glyma18G51741, Glyma18G51765, Glyma18G51930, Glyma18g51950 and Glyma18G51960) on chromosome 18 between genomic region 56545509 to 6069629 bp. Three NBS-LRR genes viz., Glyma18G51715, Glyma18G51741 and Glyma18G51765 were located within the Rpp1 genomic region previously mapped precisely on Gm18 from 60463046

to 60612672 bp (Hyten *et al.*, 2007). These three genes were shortlisted as potential candidate rust resistance genes. Comparative and evolutionary analysis was further performed to identify the genetic variation in these NBS-LRR genes from Williams 82 and JS-335. Interestingly there were larger numbers of SNPs and InDels in the NBS-LRR genes at Rpp1 locus in JS 335. Multiple sequence alignment of three NBS-LRR proteins showed high protein sequence similarity. Whole genome sequence of rust resistant accession EC-241780 was further used to locate putative Rpp1 gene.

This study was initiated with a broad objective of identifying Rpp1 gene associated with rust resistance. Three NBS-LRR genes were identified as putative Rpp1 genes. The SNPs and InDels identified within the NBS-LRR genes in this study will be valuable resource for the marker development more particularly to screen genotypes for rust resistance. Our study provides insights of genome-wide sequence variation more particularly at Rpp1 loci which will help to develop rust resistant soybean cultivars through efficient exploration of the genomic resource.

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Haplotype analysis using SNPs from soybean rust resistant and susceptible accessions

POS	SNP ID	Williams82	PI548438	PI548456	PI471904	PI240664	PI200492	Gene ID
		(S)	(S)	(S)	(S)	(S)	(R)	
54884573	ss715631604	T	C	C	C	C	C	GLYMA18G45131
54890186	ss715631605	A	C	C	C	C	C	GLYMA18G45140
54953350	ss715631613	A	G	G	G	G	G	GLYMA18G45200
55672211	ss715631686	T	C	C	C	C	C	GLYMA18G45970
55821870	ss715631701	T	G	G	G	G	G	GLYMA18G46050
60101621	ss715632246	A	C	C	C	C	C	GLYMA18G51140
60346170	ss715632284	C	C	C	C	C	T	GLYMA18G51470
60427879	ss715632297	A	A	A	A	A	G	GLYMA18G51570
60441713	ss715632299	G	G	G	G	G	A	GLYMA18G51581
60598485	ss715632315	A	A	G	G	A	G	GLYMA18G51840
60846509	ss715632356	T	T	T	T	T	C	GLYMA18G52130
61090464	ss715632388	A	A	A	A	A	G	GLYMA18G52500
61308122	ss715632411	T	T	T	T	C	C	GLYMA18G52860
61357788	ss715632418	T	T	T	T	T	G	GLYMA18G52920
61392614	ss715632423	G	G	G	G	G	A	GLYMA18G52980
61504294	ss715632432	G	T	T	T	T	T	GLYMA18G53170
61778293	ss715632470	A	A	A	A	A	A	GLYMA18G53460

Evaluation and characterization of sunflower (*Helianthus annuus* L.) germplasm lines

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ABSTRACT

Evaluation and characterization of sunflower germplasm lines is important due to increasing needs of varietal improvement and it is essential for the gene bank management to avoid duplications. In the present investigation, 67 germplasm lines including B, R lines and inbreds were evaluated and characterized by using six yield and yield contributing traits. Frequency distribution under each group was calculated. Five parameters *viz.*, days to 50% flowering (early-50.56 % and medium-49.44%), days to maturity (early-46.07% and medium-53.93%), head diameter (small-59.55% and medium-40.45%), 100-seed weight (low-11.24% and medium-88.76%) and single plant yield (low-1.12% and medium-98.88%) were dimorphic. Whereas, plant height showed five states of expression namely very short (19.10%), short (55.06%), medium (19.10%), tall (4.49%) and very tall (2.25%). Two genotypes namely, CMS-104B and HA-291B were found promising for head diameter and HA-2023B for seed yield/plant. Further, based on the objective the genotypes from the different groups will be used in breeding programme.

Keywords: Evaluation, Germplasm, Sunflower

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops in India contributing major portion of edible oil requirements. Germplasm resources constitute the building blocks of crop improvement programme. These provide basic raw material and reservoir of genes for breeding high yielding cultivars with tolerance to biotic and abiotic stress. Evaluation and characterization of germplasm is the first and basic step to start any breeding programme (Kulkarni *et al.*, 2015). Hence, the present study was carried out to characterize and evaluate the sunflower germplasm for yield and yield contributing traits.

The field experiment was conducted during *kharif* 2018 at Agricultural Research Station, Tornala, Siddipet,

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Telangana. A total of 67 germplasm lines including 22 B lines, 34 R lines and 11 inbred lines received from different AICRP centers of India were evaluated and grouped for yield and its contributing traits. Each genotype was sown in 2 rows of 3.0 m length by adopting a spacing of 60 cm x 30 cm in Augmented Block Design (Federer 1956). Data pertaining to four parameters *viz.*, plant height, head diameter, 100-seed weight and single plant yield were recorded on single plant basis on five randomly selected plants in each genotype at appropriate growth stages, whereas, days to 50% flowering and days to maturity were recorded on plot basis and grouping was done by using the DUS test guidelines (Anonymous, 2009).

In the present study, 67 sunflower germplasm lines were evaluated and characterized by using six traits. The genotypes under study showed wide range of variability for all the traits studied. Frequency distribution for all the characters was also computed. Based on days to 50% flowering genotypes under study were grouped as early (45 no.) and medium (44 no.) duration and among them HA-2023B (53 days) was early and R-7 was late (66 days). On the basis of days to maturity, all the entries fall under early (41 no.) and medium (48 no.) duration groups with a range of 82 (RGP-42-PL-1 and CMS-70B) days to 94 (GMU-370) days. Plant height was in the range of 60 cm (TSG-22 and P-138R) to 175 cm (CMS-108B) and based on this entries were grouped into 5 groups viz., very short (17 no.), short (49 no.), medium (17 no.), tall (4 no.) and very tall (2 no.). Head diameter was in the range of 9 cm (TSG-22 and R-7) to 18 cm (CMS-104B and HA-291B) and most of the genotypes possessed small (52 no.) head diameter followed medium (36 no.) head diameter. 100-seed weight was in range of 4.2 (CPI-3 and 856 R) to 5.9 (HA-248B) with

two categories viz., medium (79 no.) and low (10 no.). Except one entry (CPI-3) all the entries were having medium single plant yield and among them HA-2023B had highest single plant yield (33.6 g). Better performing lines for different quantitative characters could be used to constitute gene pool. Promising sunflower population and lines can be generated by using gene pools as base population.

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Assessment of heritability and genetic advance in soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

Selection is effective only when the observed variability in the population is heritable in nature. Heritability estimates give a measure of transmission of characters from one generation to the other, as consistency in the performance of the selection depends on the heritable portion of the variability. Thirty advanced lines of soybean were evaluated in a randomized block design with three replications to estimate heritability and genetic advance for 11 agromorphological characters under rainfed conditions during *kharif* 2018. High heritability accompanied with high genetic advance expressed as percent of mean was recorded in seed yield/plant, harvest index, biological yield/plant, 100 seed weight, days to 50% flowering, days to maturity, plant height and oil content, which indicates the preponderance of additive gene effects and therefore these characters possess high selective value. Thus, selection for these characters can be done for their improvement.

Keywords: Genetic advance, Heritability, Soybean

Soybean [*Glycine max* (L.) Merrill] is considered as a miracle crop because of its dual qualities viz., high protein (40%) and oil content (20%) in seed. These two parameters in one crop have thus, gained considerable importance in the agricultural economy of the World. The crop has potential to provide nutritional security and eradicate rampant protein malnutrition in the country. The bigger challenge for soybean scientists is to develop new technologies for meeting the manifold increase in demand for edible oil, animal feed and direct consumption as a food in the face of changing climate scenario.

The study was conducted in Randomized Block Design (RBD) with three replications at Central Agricultural University Research Farm, Andro, Imphal East during *kharif* 2018. Each entry was accommodated in a single row of 3.0 m length with a spacing of 45 × 10 cm. The recommended packages of practices were adopted for optimum crop growth and development with proper plant protection under rainfed condition. The observations were recorded on the basis of ten randomly selected plants of each genotype of each replication for eleven quantitative characters viz., days to 50% flowering, days to maturity, plant height (cm), number of branches/plant, number of pods/plant, number of

seeds/pod, 100 seed weight (g), biological yield/plant (g), seed yield/plant (g), harvest index (%) and oil content (%). Observations on days to 50% flowering and days to maturity were recorded on plot basis. Heritability and genetic advance estimates were classified according to Johnson *et al.* (1955).

In the present studies, high heritability in broad sense was observed for biological yield/plant and seed yield/plant followed by harvest index, days to maturity, oil content, days to 50% flowering, 100 seed weight and plant height. High heritability estimates shows that the characters were least influenced by the environmental effects. It also suggests that the phenotypes are the true representative of their genotypes for these traits and selection based on phenotypic values could be more reliable. It reminds that it is good index of transmission of characters from parent to their offspring helps in selection of elite genotypes (Adsul and Monpara, 2014). High heritability with high genetic advance, indicates the presence of predominant additive gene action for a given character and is desirable as this indicates the scope for rapid gains in selection. High heritability accompanied with high genetic advance expressed as percent of mean was recorded in seed yield per plant, harvest index, biological yield/plant, 100 seed weight, days to 50%

flowering, days to maturity, plant height and oil content, which indicates the preponderance of additive gene effects and therefore, these characters possess high selective value. Thus, selection for these characters can be done for their improvement (Mahbub *et al.*, 2015). The characters like number of branches/plant and number of seeds/pod exhibited moderate heritability coupled with low genetic advance suggesting the presence of non-additive gene action and highly influenced by environmental effects. Thus, in this case selection may not be effective.

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Assessment of genetic purity of two sunflower (*Helianthus annuus* L.) hybrids using sequence characterized amplified region (SCAR) markers

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ABSTRACT

Random amplified polymorphic DNA (RAPD) technique is easier to identify true hybrids. However, it has inherent disadvantage of less reproducibility and that can be overcome by conversion of RAPD markers into sequence characterized amplified region (SCAR) markers. In the present investigation, RAPD analysis was carried out with the two hybrids, KBSH 41 and KBSH 42 along with their parents, polymorphic markers were identified and those markers were converted into SCAR markers. These markers would be of immense potential during routine genetic purity assessment of the two sunflower hybrids.

Keywords: Genetic purity, Hybrid PCR, RAPD, SCAR, Sunflower

Sunflower (*Helianthus annuus* L.) hybrids are widely used all over the world with significant positive impact on seed and oil yields. The success of hybrids in the farmer's field depends upon availability of seeds with high genetic purity. Conventionally, genetic purity is assessed through grow out test (GOT) which is based on the morphological characters, requiring one full season and expenditure in storage and hence increased hybrid seed cost. DNA-based methods offer better alternative to GOT. However, the main requirement is the development of an appropriate marker which can clearly distinguish the male and female

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parents of the hybrid. Though RAPD marker system is universally adopted for hybrid purity assessment, the conversion to SCAR (Paran and Michelmore, 1993), significantly improves the reproducibility and reliability. The present investigation was carried out to develop SCAR markers for two sunflower hybrids.

Two sunflower hybrids and their parents, KBSH 41 (CMS 234A × RHA-95C-1) and KBSH 42 (CMS 851A × RHA 95C-1) were used. Genomic DNA isolation from leaf samples was done following Doyle and Doyle (1987) with modifications. PCRs with RAPD markers were

performed, robust male specific bands were chosen, the gel pieces corresponding to them were cut out, DNA was eluted and cloned. The positive clones were sequenced, SCAR primers were designed and used for amplification.

Though RAPD markers have been earlier used for assessing the purity of sunflower hybrids (Wankhede, 2004), it is ideal to convert them into SCARs to improve their reproducibility. In this study, polymorphic RAPD markers (OPJ14 and OPG11) were identified for two sunflower hybrids. Based on the sequences of the male specific bands, SCAR markers were designed and used. PCR conditions were standardized to eliminate non-specific bands and specific intense bands of expected size were obtained.

After testing with bulk DNA, the markers were validated with the hybrid individuals (Fig. 1). As could be seen from the figure, OPJ14 RAPD marker based SCAR marker gave a dominant marker system with both the hybrids while OPJ11 marker based SCAR, gave a dominant marker with KBSH41 but a co-dominant marker with KBSH 42 hybrid. Male specific amplicons of expected sizes were obtained with hybrid individuals (900 bp with OPJ14 for KBSH41, 500 bp with KBSH42 and 1000 bp with OPG11 for both hybrids). Absence of the

expected bands in some plants indicated that these were not true hybrids. The frequency of such contaminants indicates the degree of purity of the corresponding hybrid seed lot. Thus, this study demonstrates that RAPD markers, if converted into stable SCAR markers, could be utilized successfully in hybrid purity assessment. Additionally, SCAR markers could even be used for differentiating multiple hybrids when they give amplicons of different sizes especially when there is contamination/deliberate mixture of one hybrid seed lot with some other hybrids.

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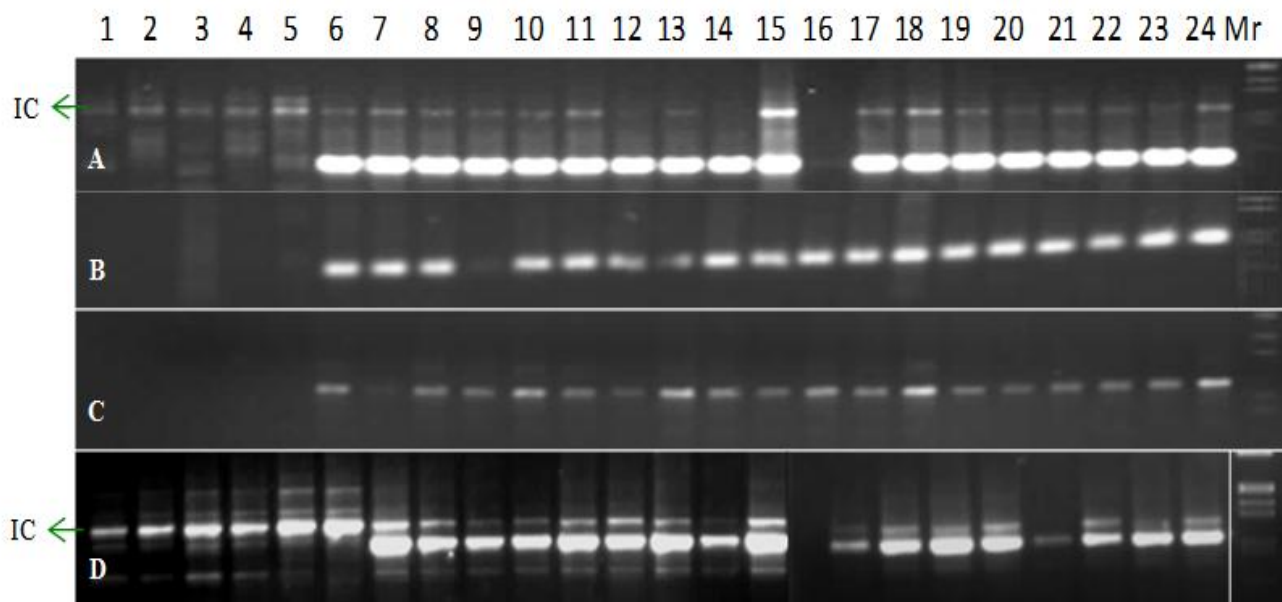


Fig. 1. Amplification profile with SCAR markers

- | | |
|---|---|
| A. KBSH41 with OPJ14 (900bp) | D. KBSH41 with OPG11 primer (1000bp) |
| B. KBSH42 with OPJ14 primer (500bp) | Lane 1-5 female individuals, Lane 6 female bulk |
| C. KBSH41 with OPG11 primer (1000bp) | Lane 7-23 hybrid individuals, Lane 23 hybrid bulk |
| Lane 1-4 female individuals, Lane 5 female bulk | Lane 24 male individual Mr - DNA Marker |
| Lane 6-18 hybrid individuals, Lane 19 hybrid bulk | IC - Internal control (Actin) |
| Lane 20-23 male individuals, Lane 24 male bulk | |
| Mr - DNA Marker, IC - Internal Control (Actin) | |

Correlation studies for quantitative traits in sesame (*Sesamum indicum* L.)

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ABSTRACT

The genetic variability could be determined with the help of genetic parameters such as genetic coefficient of variation, heritability estimates and genetic advance. The present investigation was therefore planned to evaluate different germplasm lines of sesame with objectives to study the genetic variability and correlation. The observed variability in the chosen 20 genotypes of sesame could be partitioned into heritable (genetic) and non-heritable (non-genetic) components.

Keywords: Heritability, GCV, PCV, Qualitative traits, Sesame

Sesame is one of the world's oldest cultivated oilseed crop. Selection is the basis of crop improvement; hence it is necessary to make improvement in production of this crop by evaluation of different germplasm lines. The efficiency of selection depends on identification of genetic variability by the phenotypic expression of characters.

The experimental material consist of twenty genotypes with two checks *viz.*, JLT-408, JLT- 407 and obtained from Oilseed Research Centre, Latur. Genotypes were sown at BSP Research Farm, Department of Agricultural Botany, VNMKV, Parbhani (Maharashtra). The experimental material was evaluated in Randomized Block Design (RBD) with 3 replications under rainfed condition. The observations were recorded days to 50% flowering, number of primary branches/plant, plant height, number of capsules/plant, days to maturity, 1000-seed weight (g), number of chaffy seed/plant, seed yield/plant (g), seed yield/hectare (kg) and oil content (%). Observations were recorded on five plants selected at random from each genotype in each replication and were averaged. The analysis of variance was carried out by the standard procedure suggested by Panse and Sukhatme (1967). The interrelationship was worked out according to Johnson *et al.* (1955).

In the present study, efforts were made to analyse the components of variability in the promising genotypes for future breeding work. Phenotypic variance values were more than the genotypic variance in all the characters. High genotypic and phenotypic variances were observed for the characters seed yield/hectare

followed by number of chaffy seed/plant, plant height and number of capsules/plant. The present findings are in close agreement with those of Jadhav and Mohrir (2012) and Revathi *et al.* (2012). The GCV for all the characters were lower than the PCV. This relationship indicated that there was small effect of environment on these characters and phenotypic selection for such characters may be effective. Furthermore, high estimates of GCA and PCV were observed for number of capsules/plant and seed yield/hectare while low GCV and PCV were observed for 1000 seed weight, days to maturity and oil content. Higher broad sense heritability values were also associated with the character *viz.*, seed yield/ha (90.0%), oil content (78.0%) and seed yield/plant (77.4%). In the present study, seed yield/hectare, number of capsules/plant and plant height showed strong positive correlation with seed yield.

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Genetic variability parameters for yield and yield contributing characters in sesame germplasm lines

Characters	Range	General mean	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (bs)	Genetic advance	Genetic advance as % of mean
Days to 50 % flowering (days)	41.00 – 52.00	44.66	6.82	11.96	9.10	7.74	57.10	4.06	12.55
No. of Primary branches /plant	2.30 – 4.66	2.92	0.22	0.35	16.30	20.40	63.90	0.78	26.84
Plant height (cm)	57.90 – 88.60	69.28	93.45	134.22	13.95	16.72	69.60	16.61	23.98
No. of capsules /plant	17.83 – 60.26	33.36	91.71	129.45	28.70	34.10	70.90	16.60	49.77
Days to maturity (days)	84.00 – 109.33	94.81	55.71	93.85	7.87	10.21	59.40	11.84	12.49
1000 seed weight (g)	1.98– 2.44	2.16	0.010	0.02	4.65	7.34	40.10	0.13	6.06
No. of Chaffy seeds / capsule	6.60 – 122.27	39.27	618.95	652.52	63.34	65.03	94.90	49.91	127.08
Oil content (%)	33.57 – 52.71	44.67	24.56	31.48	11.09	12.56	78.00	9.01	20.19
Seed yield per Hectare (kg)	263.70 – 645.43	436.85	12849.41	14269.71	25.94	27.34	90.00	221.58	50.72
Seed yield per plant (g)	1.78 – 4.35	3.01	0.59	0.76	25.50	28.98	77.40	1.39	46.23

GCV = Genotypic coefficient of variation; bs = Broad sense; PCV = Phenotypic coefficient of variation

Morphological evaluation and comparative study of pollen viability of different promising genotypes of sesame (*Sesamum indicum* L.)

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ABSTRACT

The present investigation was carried out to evaluate 21 genotypes of sesame on the basis of 8 morphological characters to assess the pollen viability of the selected promising genotypes as well the ideal time for maximum pollen viability. Pollen viability was assessed at three different times, viz., 7.45 a.m., 11.00 a.m. and 12.45 p.m. Based on morphological characters all the genotypes were grouped into 3 major clusters. Depending upon genetic distance seven promising genotypes were selected from different clusters for future crossing program. The average pollen viability of these seven promising parents was 85.57% at 7.45 a.m. followed by 72.55% at 11.00 a.m. and 63.84% at 12.45 p.m. Maximum pollen viability was observed in the morning hours i.e. at 7.45 a.m. Interestingly, out of the selected genotypes, the wild species, *Sesamum mulayanam* showed significantly more pollen viability percentage (96.61%) at 7.45 a.m. as compared to the genotypes belonging to the cultivated species, indicating its potential as a good pollinator.

Keywords: Acetocarmine, Pollen viability, Pollen vigour, Sesamum, Wild species

Though genetic diversity is the prerequisite for any breeding programme, pollen quality is also important for both the growers and breeders. The quality of pollen is assessed on the basis of viability and vigor of the pollen grain. Pollen vigor refers to the speed of germination of pollen grains and the rate of pollen tube growth (Ottaviano and Mulcahy, 1989). One of the important factors for fertilization success is pollen viability; therefore, pollen performance may have a significant role in pollination for adequate seed yield (Sütyemez, 2011). Information on pollen biology of sesame is very limited and therefore, the aim of the present study was to assess the genetic diversity based on morphological characters and to assess pollen viability of the selected promising genotypes as well to identify the ideal time for getting maximum pollen viability in sesame.

Seeds of 21 genotypes collected from different eco-geographical locations were planted in RBD during summer 2015 at Agricultural Experimental Farm, University of Calcutta, Baruipur, West Bengal. Observations were recorded on 8 morphological traits namely plant height (cm), days to 50% flowering, days to maturity, number of primary branches/plant, number of capsules/plant, capsule length (cm), 1000 seed weight (g) and seed yield/plant (g). Cluster analysis of genotypes with respect to eight morphological characters was done by UPGMA method. Pollen viability was estimated using acetocarmine staining technique at three different times, viz., 7.45 a.m., 11.00 a.m. and 12.45 p.m.

Twenty one genotypes were grouped into 3 major clusters based on morphological traits. The origin of genotypes did not play a significant role in the

constitution of clusters (Iqbal *et al.*, 2018) and accessions were mainly grouped due to their morphological differences. In hybridization programme, parents belonging to different clusters are likely to produce more desirable segregants. Seven genotypes namely, SI-56, RJS-148-1-80, ACC-310448, CUS-57, CUMS-17, CUS-36, *S. mulayanam* were selected as promising parents from different clusters on the basis of their genetic distance. All the genotypes showed high pollen viability percentages in the morning time (7.45 a.m.) followed by 11.00 a.m. and 12.45 p.m. The average pollen viability was 85.57%, 72.55% and 63.84%, respectively. However, six genotypes of sesame showed 83.73% pollen viability, whereas wild *S. mulayanam* showed significantly more pollen viability percentages recording 96.61%. Therefore, it could be concluded that the wild species, *S. mulayanam* could act as a good pollinator and could be included in the crossing programmes.

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Variations for oil content and fatty acid composition in wild *Arachis* species

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ABSTRACT

Oil content and fatty acid composition of 41 wild species representing four sections of the genus *Arachis* were estimated. The major fatty acids observed in different wild *Arachis* species were palmitic, stearic, oleic, and linoleic acids. Oil content varied between 49% (*A. stenosperma*) to 58% (*A. batizocoi*). Oleic acid content was higher than linoleic acid. Oleic acid content ranged from 29.2% (*A. appressipila*) to 56.5% (*A. stenophylla*). Linoleic acid was in the range of 22.9% (*A. stenophylla*) to 46.7% (*A. monticola*). Ratio of oleic to linoleic acid ranged from 0.66 to 2.48. No significant relationship between oil content and fatty acid composition could be found.

Keywords: *Arachis*, Groundnut wild species, Fatty acid profile, Oil content

The genus *Arachis* contains about 81 species divided into nine sections. Unique and useful traits exist in these wild groundnut species, which can be used as a secondary pool for improvement of cultivated groundnut. Resistances to root-knot nematode, leaf spot and rust have been introgressed from wild species to cultivated groundnut in the past. The ICAR-Directorate of Groundnut Research, Junagadh, Gujarat maintains 106 wild *Arachis* accessions in the field gene bank of which 41 are seed-forming type. These wild species have not been characterized for oil and fatty acid composition. Hence, a study was carried out to estimate oil contents and fatty acid composition in these seed forming species. Mature seeds of 41 wild *Arachis* species of four sections (28 species of *Arachis*; 7 species of section Procumbentes; 5 of Erectoides and 1 from Heteranthae) were used in this study. Oil content was measured using a Soxhlet apparatus. Fatty acid composition was estimated using gas chromatography system equipped with flame ionization detector.

The oil content varied between 49% (*A. stenosperma*, NRCG 14866) to 58% (*A. batizocoi*,

NRCG 12018) with a mean of 53.6%, which is higher than what has been reported for Indian cultivars. Fatty acid composition in seeds revealed that oleic acid content was very low (29.2%) in two accessions of *A. appressipila* (NRCG 11785, NRCG 11786) and high (56.5%) in *A. stenophylla* (NRCG 11811). Linoleic acid was low (22.9%) in *A. stenophylla* (NRCG 11811) and high (46.7%) in *A. monticola* (NRCG 11799) indicating the absence of functional mutations on ahFAD2 genes in these species. Ratio of Oleic to Linoleic acid ranged from 0.66 to 2.48, the lowest value being recorded by two accessions of *A. appressipila* (NRCG 11785, NRCG 11786). Other long chain fatty acids, arachidic (C20:0), eicosenoic, (C20:1), behenic (C22:0), and lignoceric (C24:0) acids also occurred in minor proportions. While traces of palmitolic (C16:1), and linolenic (C18:3) were also observed in the species studied. In general it has been observed that the wild *Arachis* species were generally rich in oleic acid content while the species *A. stenophylla* recorded high linoleic acid which can be used as diverse source for improving oleic and linoleic acid contents.

Genetic variability, heritability and genetic advance in F₃ and F₄ generations of the cross GKVK-4 × NRCG-12473 in groundnut

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ABSTRACT

To study the quantum of variability for pod yield and water-use efficiency (WUE) related traits, F₃ and F₄ populations derived from the cross GKVK-4 × NRCG-12473 was evaluated. The variance indicated highly significant differences for all the ten characters studied. To conclude the present experimental results by considering variability and selection parameters simultaneously, specific leaf area @ 60 DAS and pod yield per plant exhibited high narrow sense heritability with high genetic advance as per cent of mean (GAM) implies that these characters have to be given more focus to improve the yield in groundnut breeding programme.

Keywords: Groundnut, Heritability, Selections, Water use efficiency

Groundnut (*Arachis hypogaea* L.) is cultivated worldwide as an important oilseed crop and one of the major grain legumes in tropical and sub-tropical regions. However, its productivity is strongly affected in drought-prone areas by water scarcity. To improve the important yield attributing characters along with high WUE, effective selection should be practiced. Hence, the information on heritability alone may not help; the genetic advance has an added edge over heritability as a guiding factor to breeders in the selection programme.

The field experiments of the present investigation were conducted at University of Agricultural Sciences, Bengaluru. To know the genetic variability among the genotypes for yield, physiological and morphometric traits were estimated in both F₃ and F₄ generations. Narrow sense heritability and GAM was estimated for all the ten characters viz., days to first flowering, plant height (cm), number of branches/plant, SCMR, SLA, number of pods/plant, SMK percentage, shelling percentage, kernel yield/plant and pod yield/plant as suggested by Kearsy and Pooni (1996) and Johnson *et al.* (1955), respectively.

The variance indicated highly significant differences for all the ten characters evaluated. Specific leaf area @ 60 DAS and pod yield/plant displayed high narrow sense heritability in both F₃ and F₄ generations. In consonance with our results, Puangbut *et al.* (2011) recorded high

heritability and high GAM for SLA and Thirumala Rao *et al.* (2014) registered high heritability and high GAM for pod yield in groundnut. The preponderance of additive gene action for the expression of these characters provides the evidence that larger proportion of phenotypic variance has been shared by genotypic variance, and reliable selection could be practised to improve these traits based on phenotypic expression.

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Genetic parameter and character association studies in Indian mustard (*Brassica juncea* L. Czern & Coss)

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ABSTRACT

Character association studies were carried out with 28 genotypes of Indian mustard. Analysis of variance estimates of all the ten characters studied were highly significant. Coefficient of variation for GCV and PCV were found high for the traits no. of secondary branches/plant, days to 50% flowering, 1000-seed weight and seed yield/plant. The character days to 50% flowering showed higher heritability with high genetic advance. Correlation study revealed that seed yield/plant had significant and positive association with plant height (0.48G and 0.32P), main raceme length (0.60G and 0.39P), number of siliquae/plant (0.58G and 0.39P), number of primary branches/plant (0.89G and 0.36P), number of secondary branches/plant (0.45G and 0.32P), number of primary branches/plant and oil content (0.52 G and 0.37P) at genotypic and phenotypic levels.

Keywords: GCV, Genetic advance, Heritability, Indian mustard, PCV, Variability

Brassica are rich source of vitamins, minerals and contains many medicinal properties. Oil is used in Northern India for cooking and frying purposes. It has industrial importance in soap making and in mixtures with mineral oils for lubrication and grease for various machines. It has 38 to 42% oil and 24% protein (Thakral, 1995). Character association studies with a set of genotypes will help in breeding programmes as that

provide an idea regarding the traits that could be considered for selections.

Seven morphologically diverse genotypes/varieties viz., Maya, Basanti, PM-28, PM-29, PM-30, Rohini and Kanti, and 21 direct crosses i.e., the F₁ populations constituted the material for evaluation. All the 28 genotypes were grown in RCBd with 3 replications at C.S. Azad University of Agriculture and Technology,

Kanpur (UP) during *rabi* 2017-18. The parents and F₁s were grown in single row of five-meter length spaced 45 cm apart. The distance of 20 cm between the plants in a row was maintained by thinning. All the recommended agronomic practices were adopted for raising good crop. The mean data of each plot was used for statistical analysis. Traits were computed on basis of mean data after computing for each character was subjected to standard method of analysis of variance, PCV and GCV, heritability, genetic advance as percent of mean were estimated by the formula suggested by Burton (1952) and Johanson *et al.* (1955). The genotypic correlation coefficients were estimated according to the formula given by Al-Jibouri *et al.* (1958).

The analysis of variance carried out for ten characters showed significant differences amongst the genotypes except for no. of primary branches/plant. Maximum GCV and PCV was recorded for no. of secondary branches/plant (6.79 and 8.16) followed by days to 50% flowering (6.01 and 6.66), seed yield/plant (5.93 and 6.67 g) and 1000 seed weight (5.81 and 6.84g). These traits suggested the possibility of yield improvement through selection. High heritability was shown by characters, days to maturity (83.81%), oil content (82.89%) and days to 50% flowering (81.62%), seed yield/plant (79.02%), 1000 seed weight (72.23%), number of secondary branches/plant (69.15%) and plant height (68.59%). High values of GCV coupled with very

heritability were observed for days to 50% flowering, suggesting that additive gene action might play a major role in the expression of these characters and selection would be rewarding in further improvement of these characters. From this study, it could be concluded that seed yield had significant and positive association with plant height, main raceme length, no. of siliquae/plant, no. of primary branches/plant, no. of secondary branches/plant, number of primary branches/plant and oil content at genotypic and phenotypic levels. Therefore, more emphasis should be given to these components while making selection for higher seed yield in mustard.

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Genetic analysis for seed yield and its contributing traits in Indian mustard [(*Brassica juncea* (L.) Czern & Coss)]

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ABSTRACT

Highly significant differences were recorded, majority of the characters except number of primary branches/plant, among the 28 genotypes of Indian mustard tested. Parent's vs F₁'s for all the characters revealed significant differences. The estimates of all genetic components were found highly significant for days to 50% flowering, days to maturity, plant height, main raceme length, number of siliquae/plant, number of primary branches/plant, number of secondary branches/plant, oil content, 1000-seed weight and seed yield/plant. The estimates of mean degree of dominance were more than unity for number of secondary branches/plant, 1000-seed weight, oil content and seed yield/plant. The proportion of genes with positive and negative effects was near or equal to theoretical value for all characters except seed yield/plant.

Keywords: *Brassica*, Gene action, Genetic components

Rapeseed-mustard is a group of crops comprising rapeseed, *B. campestris*, Indian mustard (*B. juncea* L.), black mustard (*B. nigra* L.) and taramira (*E. sativa* L.). Indian mustard fits well in cropping system of rainfed areas and accounts for >75% of the total area under rapeseed-mustard cultivation in India. Other cultivars like brown sarson and yellow sarson are under cultivation over a limited area in the Eastern part of the country including North-Eastern States. Genetic analysis
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among the genotypes would help in selecting the parents for breeding programmes.

The material for the present investigation consisted seven varieties/ genotypes (Maya, Basanti, PM-28, PM-29, PM-30, Rohini and Kanti) of Indian mustard. Using seven diverse genotypes, a diallel set (excluding reciprocals) was made to obtain 21 crosses during *rabi* 2018-19. All the 28 treatments, (7 parents and 21 F₁s) were grown in randomized complete block design with 3

replications at Oilseed Research Farm, Kalyanpur, CSAUA&T, Kanpur during *rabi* 2018-19. The parents and F₁s were grown in single row of 5.0 m length spaced 45 cm apart. The distance of 20 cm between the plants in a row was maintained by thinning. All the recommended agronomic practices were followed for raising the good crop. The following observations were recorded on 5 randomly taken plants in parents and F₁s in each replication namely, days to 50% flowering, days to maturity, plant height (cm), main raceme length, number of siliquae/plant, number of primary branches/plant, number of secondary branches/plant, oil content (%), 1000-seed weight (g) and seed yield/plant (g). Diallel numerical approach was suggested by Griffings (1956).

Analysis of variance further indicated highly significant differences among the parents except no. of primary branches/plant and 1000-seed weight. Highly significant differences were also found among F₁s for all the characters except no. of primary branches/plant, parent vs. F₁s revealed highly significant differences for all the characters. The regression coefficient did not deviate significantly from unity for all the characters, indicating the involvement of additive gene action. The estimates of all genetic components *viz.*, \hat{D} , \hat{H}^1 , \hat{H}^2 , \hat{F} , \hat{h}^2 and \hat{E} along with their standard errors were calculated. The estimates of \hat{h}^2 were positive and highly significant for all the characters except days to maturity.

The estimates of mean degree of dominance $(\hat{H}^1/\hat{D})^{0.5}$ were more than unity for number of siliquae/plant, no. of primary branches/plant, number of secondary branches/plant, 1000-seed weight and seed yield/plant indicating over dominance in these traits. The proportion of genes with positive and negative effects $(\hat{H}^2/4\hat{H}^1)$ were near or equal to theoretical value (0.25) for majority of characters indicating that positive and negative genes were symmetrically distributed among the parents for these attributes. The ratio \hat{h}^2/\hat{H}^2 which measures the group of genes showing over dominance were more than unity for all the characters. The coefficient of correlation between parental order of dominance and parental measurements were found negative for all characters except days to 50% flowering and days to maturity. These findings were similar to that of Chaurasiya *et al.* (2018).

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Studies on capsule shattering character in sesame (*Sesamum indicum* L.)

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ABSTRACT

Thirty five Indian sesame genotypes were evaluated for their genetic diversity for seed yield and yield attributing characters as well as capsule shattering characters. The analysis of variance revealed highly significant differences among the genotypes for all twenty characters. High magnitude of PCV and GCV was recorded for capsule split and opening before drying. Further, potential seed weight has the highest contribution to total divergence followed by capsule split before drying, retained seed weight, unattached seed weight and seed weight/capsule indicating their importance in the choice of parents for developing semi shattering genotypes.

Keywords: Genotypes, Sesame, Shattering, Yield

Most of the sesame varieties have indeterminate growth habit with continuous flowering. The plant continues to flower when the earliest set capsules at the lower portion of the plant are mature. Due to this non-synchronous maturity of the capsules, seed shattering in the field occurs. This can be avoided by developing semi shattering sesame genotypes. The present study was carried out to understand the variability for capsule shattering trait in sesame.

Experiment was carried out to study the comparative performance of 35 sesame genotypes of diverse genetic origin for 20 yield and its components with specific reference to capsule shattering characters. Observations were recorded on ten quantitative traits, *viz.*, days to maturity, plant height (cm), branch number/plant, capsule number/plant, capsule length (cm), capsule width (cm), seed number/capsule, seed weight/capsule, 1000-seed weight (g) and seed

yield/plant (g). Also observations were recorded on ten capsule shattering related traits, viz., capsule split before drying of capsules, capsule split after drying of capsules, capsule open before drying of capsules, capsule open after drying of capsules, unattached seed weight, retained seed weight, potential seed weight, unattached seed number, retained seed number and potential seed number.

Analysis of variance indicated highly significant differences among the genotypes with respect to all the 20 characters indicating wide variability. Three genotypes (Hima, Krishna and Thilak) were grouped as super shattering, nine semi shattering (CO-1, CUMS-17, JLT-408, Prachi, Rama, Rajeswari, RT-346, GT-10 and Savitri) and the rest genotypes as non-shattering types. High magnitude of PCV and GCV recorded for capsule split and opening before drying, unattached seed weight, retained seed weight, seed weight per capsule, potential seed weight, unattached seed number and retained seed number indicated relatively higher contribution of these characters towards genetic variability. Heritability in broad sense was high (>80%) for all characters. Genetic gain under selection was high (>90%) for retained seed weight and retained seed number. For characters like days to maturity, branches/plant, plant height, capsule

length, capsule width and thousand seed weight, it was low (<50 per cent). High heritability coupled with high genetic advance was recorded in capsule split before drying, retained seed weight, unattached seed number and retained seed number. Seed yield showed a highly significant and positive correlation with number of branches/plant, capsule number/plant, unattached seed number, retained seed number and thousand seed weight. Regarding contribution of characters to genetic divergence, potential seed weight has the highest contribution to total divergence followed by capsule split before drying, retained seed weight, unattached seed weight and seed weight/capsule.

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Genetic parameters, correlation and path analysis for seed yield and morphological characters in niger [*Guizotia abyssinica* (L.f.) Cass.]

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ABSTRACT

Twelve niger genotypes were tested in a randomized block design with three replications in *kharif* 2016-17 at AICRP on Safflower, Parbhani. The highest magnitude of GCV was obtained for number of capitula/plant (17.5) followed by plant height (14.9), number of productive branches (13.2) and seed yield (12.8) and low values of GCV estimated for plant stand (2.2), days to maturity (4.3), days to 50% flowering (4.6) and 1000 seed weight indicating the presence of lower genetic variability for these traits. Plant stand had significant positive correlation with number of productive branches/plant, number of capitula/plant, seed yield/plot, 1000-seed weight and seed yield (kg/ha) due to high positive direct and indirect effect.

Keywords: Correlation, Genetic parameters, Path, Niger

Niger is an important oil seed crop, the seed which is pale yellow with nutty taste and pleasant odour. Niger seeds contain about 40% edible oil with fatty acid composition of 70-80% linoleic acid, 7-8 % palmitic and steric acids, and 5-8% oleic acid. The high heritability coupled with high genetic advance could be beneficial before crossing species with self incompatibility mechanism, variability exists for morphological characters. However, these characters are not discrete and hence complicate the niger improvement programmes. The study of amount of such genetic variability including the important economic traits in niger can be achieved through mass selection. Path

analysis of yield components brings out the relative importance of their direct and indirect influence and helps in understanding their association with seed yield. Thus the present study was aimed at gathering information on existing genetic variability, nature and magnitude of association among seven attributes in twelve niger genotypes.

Twelve niger genotypes were grown in a randomized block design with three replications during *kharif* 2016-17 at Parbhani. Each genotype was sown in 10 rows of 4.0m length with the spacing of 30 cm within rows and 10 cm between plants. Observation were taken on 10 randomly selected plants in each entry for

recording data on plot basis for plant stand, days to 50% flowering, number of branches/plant, number capitula/plant, plant height (cm), days to maturity, 1000-seed weight (g) and seed yield/plot (g). The phenotypic and genotypic coefficient of variability were computed according to the method suggested by Burton (1952). The phenotypic and genotypic correlations were calculated as per the method described by Al jibouri *et al.* (1958). Path coefficient analysis was carried out with genotypic correlations following the standard methods (Panse and Sukathme, 1985).

Analysis of variance revealed highly significant differences for all the characters. The highest magnitude of GCV was obtained for number of capitula/plant (17.53) followed by plant height (14.93), number of branches/plant (13.18) and seed yield/plot (12.8). In general, genotypic correlation was higher in magnitude than their respective phenotypic correlation, indicating that selection for the correlated characters could give a better yield response than would be expected the basis of phenotypic correlations. Plant stand had significant positive correlation with number of branches/plant, number of capitula/plant, seed yield/net plot, 1000-seed weight seed yield (kg/ha) due to high positive direct and

indirect effect. Days to 50% flowering had significant positive correlated with days to maturity and plant height. Seed yield/plot positively correlated with plant stand, number of productive branches/plant, number of capitula per plant, plant height, days to maturity and 1000-seed weight. Therefore, these traits should be given priority during selection in yield improvement programme. Path analysis revealed that the significantly positive associations of number of productive branches/plant, number of capitula/plant and days to maturity for seed yield were due to high positive direct and indirect effect.

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India's first high oleic safflower variety for commercial cultivation

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ABSTRACT

Indian safflower varieties possess low oleic acid content (16-20%). Therefore, high oleic (>70%) safflower oil is imported from abroad to meet the domestic needs. ICAR-Indian Institute of Oilseeds Research developed India's first high oleic safflower variety, ISF-1, which has been notified recently for all India cultivation. ISF-1 contains 76% oleic acid and 31% oil. It gives four-fold higher oleic acid yield (4.41 q/ha) than the leading variety, PBNS-12 (1.0 q/ha). Its performance with respect to oleic acid content and seed and oil yield in AICRP (Safflower) trials and in farmers' fields across the country is presented in this paper.

Keywords: High oleic acid, Pedigree breeding, Safflower, Variety

Oleic acid is a monounsaturated fatty acid. Demand for high oleic acid safflower (*Carthamus tinctorius* L.) oil is increasing in oleochemical industry for use in production of several industrial products (Salimon *et al.*, 2012). High oleic safflower oil is preferred by food industry because of its high oxidative stability and suitability to deep and repeated frying and extended shelf life. Despite India is one of the top safflower growing countries it has been importing high oleic safflower oil (>70% oleic acid) because of low oleic acid content in Indian safflower varieties (16-20%). In order to reduce import burden of high oleic safflower oil, concerted research efforts were made at ICAR-Indian Institute of Oilseeds Research, Hyderabad with funding assistance from Marico Pvt. Ltd., Mumbai for developing high oleic safflower varieties suitable to Indian conditions.

A high oleic safflower variety ISF-1 was developed from the cross (A1 x 9-5-7)7-50-5-1 through pedigree breeding. During its developmental stages, the low oleic acid conferring gene OLOL was substituted with olol to increase oleic acid content. In the trials, ISF-1 had recorded 73-80.8% oleic acid content across the country. It gave 3.6 and 4.9 q/ha oleic acid yield while the leading variety, PBNS-12 gave 0.86 and 1.09 q/ha under rainfed and irrigated conditions, respectively when tested under AICRP (Safflower). ISF-1 had recorded 12.36 q/ha seed yield and 4.54 q/ha oil yield under rainfed, and 18.64 q/ha seed yield and 6.14 q/ha oil yield under Irrigation. When tested in farmers' fields across the country, ISF-1 was on par with the leading variety, PBNS-12 for seed and oil yield performance while recording four-fold higher oleic acid yield with an average oleic acid content of 78% as against 20% oleic acid in PBNS-12 (Fig. 1).

The global oleochemicals market was projected to reach USD 28.6 billion by 2025 (<https://www.grandviewresearch.com>). India has imported 65,359 MT of high oleic safflower oil during 2014-2016 (www.eximplus.com) causing severe oil import burden on the country. Since ISF-1 has been notified for all India cultivation, concerted efforts are now needed to popularize ISF-1 for

enhancing its cultivation so as to minimize oil import burden.

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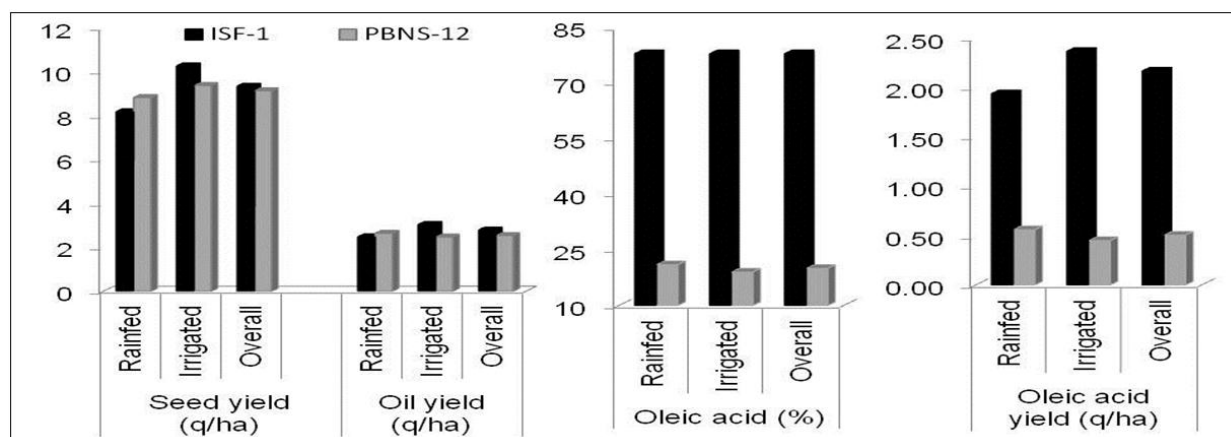


Fig. 1 Performance of ISF-1 and PBNS-12 in farmers' fields

Genetic variability in castor (*Ricinus communis* L.)

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ABSTRACT

A set of 60 castor genotypes was evaluated for assessment of genetic variability, heritability and genetic advance percent mean with respect to nine characters. The GCV and PCV were the highest for number of capsules on primary raceme followed by seed yield per plant, number of branches per plant and plant height. High genetic variability coupled with high heritability and high genetic advance was recorded for all the traits except days to flowering, days to maturity, number of nodes/plant, and oil content (%) indicating that direct selection for these traits could be effective.

Keywords: Castor, GCV, Genetic variability, PCV

Castor (*Ricinus communis* L.) is a monotypic species belonging to the Euphorbiaceae family and favors cross-pollination up to the extent of 50% due to its monoecious nature. For a successful breeding programme, the diversity among parents is of utmost importance. In breeding programme, progenies derived from diverse crosses selected based on genetic divergence analysis, are expected to show a broad spectrum of genetic variability, providing a greater scope for isolating transgressive segregants in advance generation and high heterosis.

In this background, 60 castor genotypes were evaluated in RBD with three replications at Castor-*J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar during *kharif* 2017 under irrigated conditions. The observations were recorded on 5 randomly selected plants from each replication. Observations were recorded on nine quantitative characters. Genotypic and phenotypic coefficient of variances was estimated based on the formula given by Burton (1952) and heritability and genetic advance were calculated according to Allard (1960).

Significant differences were noted among the genotype for all the characters indicating presence of high amount of variability (Table 1). High GCV and PCV were recorded for the characters number of

capsules on primary raceme followed by seed yield per plant, number of branches per plant, plant height and total raceme length. Thus, these characters offer better scope for selection as there was less influence of environment. High heritability was recorded in all the traits. The heritability value indicated the presence of additive gene action and further improvement in these traits could be effective through direct selection. High genetic advance was recorded for number of capsules on primary raceme, seed yield per plant, effective raceme length, number of branches per plant, plant height up to primary raceme and total raceme length indicating that

these characters are governed by additive genes and simple phenotypic selection will be rewarding for improvement of these characters.

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Table 1. Mean, range, variability parameters, heritability and genetic advance for eleven characters in castor

Parameter	Mean	Range	GCV %	PCV%	Heritability	GA (% mean)
Days to Flowering	73.15	58.3 - 88.0	10.45	10.78	0.98	21.76
Days to Maturity	136.60	115.60-155.65	6.00	6.26	0.92	11.86
Plant height	88.11	40.25-135.97	22.75	24.46	0.93	46.86
Number of branches per plant	9.0	4.5 – 13.5	25.32	26.57	0.94	51.45
Number of Capsules per plant	78.10	27.8-130.5	42.50	44.75	0.95	87.58
Total raceme Length	44.50	16.40-70.80	20.90	22.00	0.94	42.60
Oil content	42.00	30.00-52.42	6.70	7.00	0.90	12.98
Number of Nodes per plant	10.50	10.50-20.50	9.50	12.30	0.73	18.50
Seed yield per plant	230.55	70.80-400.54	39.50	41.42	0.93	79.35

Biofortification of linseed as functional food for profitability and nutritional security

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ABSTRACT

Fish oil is the traditional source of dietary omega-3 fatty acids, while flaxseed oil can be used as a vegetarian source of dietary omega-3 fatty acids. The flaxseed hull is a concentrated source of lignan, which might possess impressive cancer preventive properties, especially against breast and colon cancer. In functional foods arena, flaxseed has resurged as a potential ingredient with a vast array of medical benefits. Flaxseed supplemented food products are gaining popularity because of its high content of polyunsaturated fatty acids, protein, soluble fiber and phytochemicals. This paper describes about the development of biofortified linseed genotypes with enhanced alpha - linolenic acid (ALA), and lignan, predominantly the secoisolariciresinol diglucoside (SDG).

Keywords: Biofortification, Linseed, Profitability, Nutritional security

A set of 240 mutants generated and stabilized (M₆ generation) at AICRP on MULLaRP through induced mutagenesis were grown in an augmented design along with four checks and evaluated for growth, yield and quality parameters during *rabi* (2017-18). In the subsequent *rabi* 2018-19, based on their superior performance for yield and enhanced nutraceuticals, ten lines were selected and advanced to M₇ generation and evaluated for yield and quality parameters in an augmented design along with four checks. Molecular characterization of the promising genotypes was done using SSR analysis.

The results indicated that linseed genotypes *viz.*, DLV 6, DLV 8, DLV 9, DLV 10, DLV 19, DLV 20, DLV 21, DLV 25 and DLV 26 can be used as a functional food as they play an important role in lowering cholesterol levels, stunt the growth of tumours and stabilize the blood sugar levels (Hall et al., 2006). Nevertheless advanced breeding lines such as DLV 25 with higher oleic acid (49.2%) can be used for cooking oil after suitable modification of ALA content (Table 1). Farmers traditionally grow local varieties resulting in poor crop productivity. These improved biofortified linseed varieties developed at UAS, Dharwad can be grown for achieving optimum yields, which also fetch

the cultivators a premium price and also provide socio-economic security of marginal farmers and also nutritional security to the consumers. Marker trait association studies revealed that the SSR marker Lu 60 was associated with ALA content (Fig. 1).

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Table 1 Performance of superior advanced breeding lines with their enhance nutraceuticals

Genotype	SDG content in DFF (mg/g dry matter)	ALA content (%)
DLV 10	24.2	47.12
DLV 8	22.5	30.4
DLV 6	21.2	48.8
DLV 9	20.3	55.72
DLV 19	20.5	53.2
DLV21	16.7	60.23
DLV 20	16.8	60.25
DLV 26	21.7	47.97
DLV25	18.2	16.8 (With 49.2% Oleic acid)
Indira Alsi (NC)	17.2	54.6
NL-115 (SC)	12.7	53.71

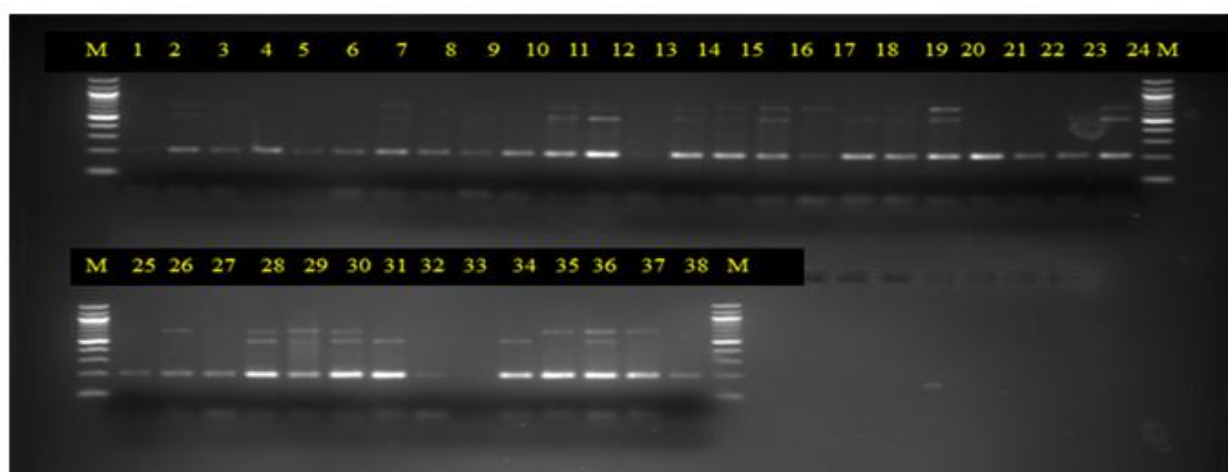


Fig. 1 Genotypes showing amplification with the primer Lu 60 associated with ALA (M=100 bp marker)

Assessment of genetic diversity in sunflower germplasm lines

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ABSTRACT

The present study was undertaken to estimate the extent of genetic diversity among germplasm lines and to identify genetically diverse lines of sunflower for their further exploitation. Thirty- three genotypes were grouped into eight clusters by using Tocher's method. On the basis of average inter cluster distance, cluster mean and mean performance of genotypes, 16 superior crosses have been suggested which are expected to yield desirable genetic gain in breeding programme.

Keywords: Genetic diversity, Germplasm lines, Sunflower

Sunflower (*Helianthus annuus* L.) is one of the most important edible oilseed crops of the world and it accounts for nearly 14% of the global production of vegetable oilseed crops. Sunflower contains 38 to 42% edible oil with high level of linoleic acid (55-60%) and low oleic acid (25-30%). Genetic diversity is of major interest to the plant breeders. The D^2 statistics enables one to discriminate between different lines according to the genetic diversity (Mahalanobis, 1936). Therefore, the present study was undertaken with the objectives of estimating genetic diversity among germplasm lines and to identify genetically diverse lines of sunflower for their further exploitation in breeding programme.

The material for the present study consisted of 33 genotypes including three checks *viz.*, AKSFI-54-1-1, TAS-82 and SS0808. Each genotype was sown with spacing of 60 cm between rows and 30 cm between plants in Randomized Block Design. The data obtained was subjected to D^2 analysis. Average intra and inter cluster statistical distances for eight clusters was calculated by Tocher's method.

The genotypes were grouped into 8 clusters (Table 1). The intra cluster D^2 values ranged from 0.00 to 17.15. Cluster V recorded the highest intra cluster distance (17.15). The average inter cluster distance was maximum between cluster VI and VIII (47.71) while it was lowest between cluster I and IV (11.38). According to Bhatt (1970), the mean statistical distance may be considered arbitrarily as a guide line and crosses between parents belonging to different clusters having same or higher inter cluster distance than the mean

statistical distance may be attempted. By considering the mean statistical distance as a guide line to select the divergent genotypes, 16 cluster combinations and 271 cross combinations were identified. However, the number of these cross combinations was further reduced on the basis of average inter cluster distance, cluster mean and mean performance of genotypes. Out of these cross combinations, 16 superior cross combinations (CMS-148B x DRSI-42, GMU-325 x AKSF-I-15-2, TAS-82 x CMS-148B, SS0808 x AKSF-I-15-2, GMU-325 x AKSF-10-2-2B, AKSF-I-15-2 x CMS-148B, CMS-148B x AKSF-10-2-2B, AKSF-15-1 x AKSF-I-15-2, GMU-325 x DRSI-42, HOHAL-34 x GMU-19, AKSF-1-15-2 x AKSF-10-2-2B, TAS -82 x AKSF-10-2-2B, HOHAL-32 x DRSI-42, AKSF-15-1 x AKSF-10-2-2B, AKSF-I-15-2 x DRSI-42, GMU-325 x HOHAL-34) have been finally suggested for hybridization programme on the basis of average inter cluster distance, cluster mean and mean performance of genotypes which are likely to give best desirable segregants.

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Table 1 Distribution of genotypes in different clusters by Tocher's method

Cluster	No. of genotypes	Name of genotypes
1	8	GP4-745, PSCLM -1B1, DRSF-108, GMU-325, GMU-296, GMU-477, GMU-106, GMU-447
2	8	CMS-302B, CMS 850B, HOHAL-34, GMU-804, GMU-1031, AKSF-6-3B, AKSFI-M-15-3, GMU-1046
3	8	LTRR-341, DRSF-113, GMU-313, AKSF-7-2B, TAS-82, SS0808, GMU-19, RHA138-2R
4	1	AKSF-15-1
5	5	TICO-10, AKSF-I-15-2, AKSFI-54-1-1, TS-3, GMU- 873
6	1	CMS-148B
7	1	AKSF-10-2-2B
8	1	DRSI-42

Effect of EMS on seed germination in white seeded sesame varieties (*Sesamum indicum* L.)

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ABSTRACT

In the present investigation, two white seeded sesame varieties VRI 3 and SVPR 1 were treated with seven different concentrations of EMS. Germination percentage and germination index were tested using two different germination methods. Seed germination decreased with increased concentration of Ethyl Methane Sulphonate (EMS)

in both the varieties. For fixing the lethal dose for the chemical mutagen Pro tray method of germination test was found reliable than germination paper method.

Keywords: Ethyl Methane Sulphonate (EMS), Germination methods, Lethal dose, Sesame

Sesame is popularly known as ‘queen of oilseeds’ because of the nutritional quality of seeds and other beneficial plant compounds. However, the productivity of sesame is relatively low compared to other oilseed crops. Mutation breeding offers the scope of increasing sesame yield by modifying flowering behaviour, duration, shattering nature and resistance to stresses. Ethyl Methane Sulphonate (EMS) is a powerful chemical mutagen which creates point mutations in plants; but higher concentration can lead to lethality of seeds. So, testing the effect of mutagen on seed germination is a prerequisite for mutation breeding. The aim of this study is to test the effect of EMS on seed germination of white seeded sesame varieties using two different germination methods.

Two white seeded sesame varieties viz., VRI 3 and SVPR 1 were treated with EMS. One gram of pre-soaked (Distilled water) seeds were treated at seven different concentrations viz., 0.2%, 0.4%, 0.6%, 0.8%, 1.0 %, 1.2% and 1.4%. To study the effect of different concentrations of EMS on seed germination, about 200 seeds of each dose along with control were sown in roll towel and pro tray with four and two replications, respectively. First and final count of germination was taken on third and sixth day after sowing, respectively. Germination percentage and germination index were calculated using following formula:

$$\text{Germination percentage} = \frac{\text{No. of seeds germinated}}{\text{Total No. of seeds sown}} \times 100$$

$$\text{Germination index (GI)} = \frac{\text{No. of germinated seeds}}{\text{Days of first count}} \times 100 + \frac{\text{No. of germinated seeds}}{\text{Days of final count}} \times 100$$

Germination percentage and germination rate were markedly affected by EMS. Seed germination decreased with increased concentration of EMS in both the varieties in both the methods. Germination was completely arrested above 1% and 0.8% EMS concentration in SVPR 1 and VRI 3, respectively by roll towel method. In pro tray method, germination was completely arrested in doses higher than 0.6% concentration in both the varieties. The ability of seed germination in pot mixture was lower compared to roll towel method after mutagen treatment. In case of the variety SVPR 1 minimum germination percent of 13.4 and 25 was observed in 1.0% and 0.6% EMS concentration in roll towel and pro tray methods, respectively. Similarly, for VRI 3 minimum germination percentage of 27.48 and 37.50 was registered in 0.8% and 0.6% concentration in roll towel and pro tray methods, respectively. Similar results were reported by Kumari *et al.* (2016) and Anbarasan *et al.* (2014). Germination index of control was higher than treated seeds in both the varieties. GI also drastically reduced at increased concentration of EMS in both the germination methods.

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Genetic variability for key physiological traits in groundnut under managed drought condition

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ABSTRACT

Drought is a major production constraint in rainfed groundnut. In the present study, genetic variability for relative water content (RWC) of leaf, membrane stability index (MSI), SPAD chlorophyll meter readings (SCMR)

and percent wilted plants was assessed in 40 advanced breeding lines of groundnut under managed drought condition. Significant differences were noticed for key physiological traits. The RWC of leaf, MSI and percentage of wilted plants under drought showed high GCV, PCV, heritability coupled with high genetic advance over mean. The SCMR showed lower GCV and PCV but exhibited high heritability with moderate genetic advance over mean indicating the possibility to improve this trait by proper selection methods.

Keywords: Drought, Groundnut, Physiological traits, MSI, RWC, SCMR

Drought is the major factor limiting the yield potential of rainfed groundnut crop in India. Crop physiologists have identified a number of physiological traits that would help the breeder in development and identification of moisture stress tolerant genotypes with high yield potential. The estimates of genetic variability, heritability and genetic advance have an immense value in making decisions about the selection methods to be employed to bring about improvement in the desirable traits and result in identifying the superior genotypes. (John *et al.*, 2012).

The present study consisted of 40 advanced breeding lines along with two checks which were subjected to assessment of key physiological traits under managed drought condition in a randomized complete block design with three replications at ZAHRS, Hiriyur. The moisture stress was imposed by withholding irrigation for 20 days at pod development stage (90 days after sowing). The physiological traits like relative water content (RWC), membrane stability index (MSI), SPAD chlorophyll readings (SCMR) and per cent wilted plants were recorded for each genotype in each replication as per standard procedures and/or standard formulae.

Significant differences were observed among the genotypes for all the physiological parameters ($p < 0.01$). The higher GCV, PCV, heritability and genetic advance over mean for RWC, MSI and percentage of

wilted plants (Table 1) reflects that, these traits can be used to select drought tolerant genotypes under stress environments. It also indicates the presence of additive gene action for this trait. Further, the SCMR showed lower GCV and PCV but high heritability with moderate genetic advance over mean indicating the possibility to improve this trait by proper selection methods. Similar findings were reported by Nigam *et al.* (2008) wherein it was suggested that, groundnut genotypes having ability to maintain higher SCMR and low SLA (Specific Leaf Area) under drought stress condition should be more drought tolerant.

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Table 1 Analysis of variance and estimates of genetic parameters in groundnut genotypes under managed drought situation

Characters	Mean	Range	PCV(%)	GCV(%)	h^2 (%)	GAM (%)
Relative water content (%)	56.14	20.49-86.02	36.17	36.17	99.90	74.48
Membrane stability index (%)	30.93	7.69-55.19	35.26	35.20	99.70	72.40
SPAD chlorophyll readings	43.16	35.77-53.99	10.02	8.13	65.80	13.58
Per cent wilted plants	29.89	12.54-56.31	40.19	38.30	90.80	75.21

Note: RWC-Relative water content, MSI-Membrane stability index, SCMR-Spad chlorophyll meter readings, PWP- percent wilted plants; ** indicates that significant @ 1%

Sunflower germplasm catalogue: Necessity and benefit to sunflower researchers

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ABSTRACT

The sunflower germplasm catalogue includes information on 3216 sunflower accessions maintained at ICAR-IIOR and NBPGR, New Delhi. The information is on 33 morphological DUS descriptors and 8 agronomic characters. The catalogue presents comprehensive and sound scientific content aiming to increase awareness about the material and their diversity.

Keywords: Agronomic characters, DUS descriptors, Germplasm catalogue, Sunflower

Sunflower crop is introduced to India in the early 70's and within four decades of its introduction it has emerged as one of the most important oilseed crops in Indian oilseed scenario. It is an important oilseed crop after soybean, groundnut and rapeseed mustard in India. The first attempt to augment and conserve sunflower genetic resources was made during 1969 with the introduction of four varieties of Russian origin, viz., 'VNIIMK 8931' (EC 68413), 'Peredovick' (EC68414), 'Armavirskij-3497' (EC 68415), and 'Armaverts' (EC 69874). The work on collection, evaluation and maintenance of sunflower germplasm was carried out at Germplasm Management Unit (GMU) located at the Project Coordinating Unit (PC Unit, Sunflower), Bangalore from 1983 till 2001. During 2001 PC unit, sunflower was transferred to Indian Institute of Oilseeds Research (IIOR), Hyderabad. At IIOR, sunflower collection composed of accessions of the domesticated species *Helianthus annuus* and its wild relative taxa. Sunflower germplasm is augmented, regenerated, characterized and distributed to conduct basic and applied research in country through All India Coordinated Research Project (AICRP) on sunflower in India. The new germplasm augmented at IIOR during the last five years include material from the United States Department of Agriculture (USDA) and Institute of Field and Vegetable Crops (IFVCNS), Novi Sad, Serbia. These newly procured germplasm accessions are

being utilized in the breeding programmes for specific traits i.e. plant height, high oil, CMS, R lines, high oleic and high test weight (Dudhe *et al*, 2019).

As there was no comprehensively compiled information on the availability of the sunflower genetic resources, efforts were made to make available the characterization and evaluation information on sunflower accessions maintained at IIOR and NBPGR along with their standard descriptors in a catalogue form. The information on 3216 sunflower accessions has been presented in the catalogue in a simple manner so that it is attractive and understandable enough to the oilseeds researchers, while retaining its technical rigor to be appreciated by sunflower researchers, thereby appealing to a much wider spectrum of readers. Each sunflower accession is described with morphological standardized descriptors and values for agronomic characters. At the end of the catalogue photographs of morphological characters have been given for better understanding.

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Genetic studies on yield and oil quality in sunflower (*Helianthus annuus* L.)

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ABSTRACT

Sunflower oil with high oleic acid content has nutritional benefit similar to olive oil. Forty five sunflower genotypes with varying oleic acid content were evaluated for the estimation of proportion of heritability, genetic advance, PCV and GCV for ten quantitative traits during *kharif* 2018. PCV was higher compared to GCV for all the traits. High PCV and High GCV were observed for seed yield per plant, hundred seed weight, oil yield and linoleic acid content. Seven characters viz., plant height, head diameter, hundred seed weight, seed yield/plant, oil yield, oleic acid content and linoleic acid content recorded high heritability followed by high genetic advance indicating the presence of additive gene action and are efficient for selection.

Keywords: Genetic advance, GCV, Heritability, High oleic, PCV, Sunflower

Based on the fatty acid composition, sunflower genotypes can be divided into traditional sunflower genotypes with oleic acid content of 14-39% of the oil, mid oleic acid sunflower genotypes with 42-72% oleic acid content and high oleic sunflower genotypes containing 75-91% oleic acid (Alimentarius, 2005). One of the important prerequisites of plant breeding is to know the nature and magnitude of genetic variability *J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

present in a population in order to improve the yield of potential genotypes. Phenotypic and genotypic variance, heritability and genetic advance are mostly used to assess the variability present in a population.

During *kharif* 2018, 45 sunflower genotypes developed through marker-assisted backcross breeding was raised in RBD with two replications in Department of Oilseeds, TNAU, Coimbatore. For observation of ten

biometric traits three plants from each genotype were randomly chosen and tagged. Oil content, oleic acid content and linoleic acid content of the seeds were estimated at Department of Plantation, Spices, Medicinal and Aromatic Plants, TNAU, Coimbatore by using NIR spectroscopy. The mean value from each character was used for statistical analysis.

The genotypic effect was significant for all the characters indicating that there is sufficient variability in the experimental material for various yield and yield contributing traits. Variability studies indicated that phenotypic variance was higher compared to genotypic variance. Seed yield/plant (g), hundred seed weight (g), oil yield (g) and linoleic acid content (%) exhibited high PCV and high GCV (Fig 1). High heritability coupled with high genetic advance was recorded for plant height,

head diameter, hundred seed weight, seed yield/plant, oil yield, oleic acid content and linoleic acid content indicating that these traits are controlled by additive gene action and are efficient for selection. Similar findings were reported by Rani *et al.* (2017).

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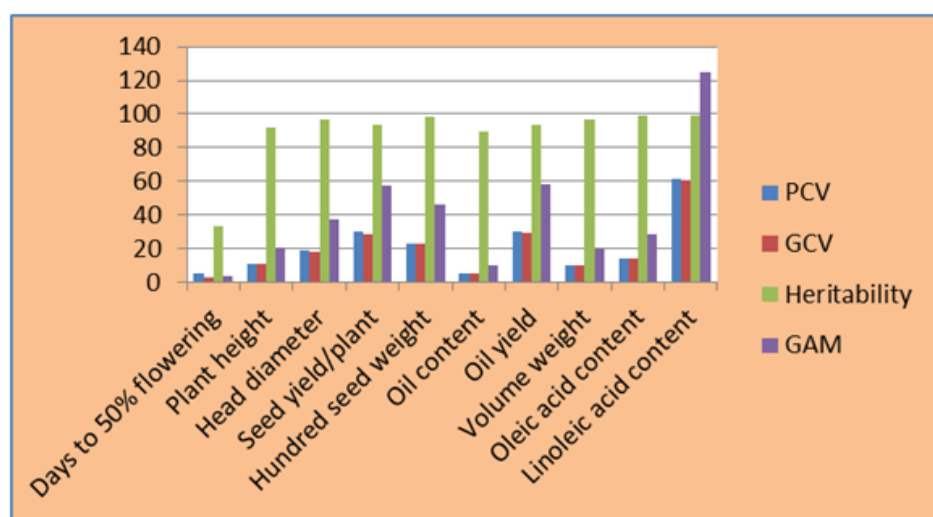


Fig. 1. Comparison of PCV, GCV, heritability and genetic advance as per cent of mean for 10 traits

Identification of mutants for qualitative and quantitative traits through induced mutagenesis in sesame (*Sesamum indicum* L.)

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ABSTRACT

Sesame is the leading oil seed crop. Creation of new genetic variability is prerequisite for any crop improvement programme. The white seeded sesame variety VRI 3 was subjected to induced mutation using gamma ray and combination treatments (300 Gy + 10 mM EMS, 350 Gy + 10 mM EMS and 400 Gy + 10 mM EMS). From M₂ generation, mutants were identified for multiple capsules per axis, closed capsules, tri leaf, determinate nature, early maturity, clustered flowering, profuse branching, high number of capsules, variation in capsule length and plant height etc. These mutants have to be forwarded to next generation to identify their true genetic behavior for further utilization in the future breeding programmes.

Keywords: Mutants, Sesame, Variability

Availability of genetic resources is important for genetic improvement of any crop. Mutation breeding is a major tool to create new genetic variability, especially for some of the traits not available in natural germplasm like determinate trait and Phytophthora resistance in sesame (Ashri and Singh, 2007). Gamma ray and combination treatment (gamma + EMS) have been found to be effective mutagens in sesame. The aim of this present study was creation of new genetic variability in sesame with desirable trait value to utilize in crop improvement programme.

Genetically pure seeds (5000 seeds) of the white seeded sesame variety, VRI 3 were treated with following doses of mutagen: gamma ray treatment - 300 Gy, 350 Gy and 400 Gy and combination treatment- 300 Gy + 10 mM EMS, 350 Gy + 10 mM EMS and 400 Gy + 10 mM EMS. The treated seed were raised in field with low inputs of fertilizers to avoid multiple branching. In M₁ generation, five capsules from main stem of each plant were harvested for raising M₂ generation. M₂ generation was raised with optimum spacing and inputs to facilitate effective expression of all the traits. In M₂ generation, different kinds of qualitative, quantitative and chlorophyll mutants were identified and isolated.

A total of 99 number of macro mutants with 14 different types were identified in all doses of mutagens. Important qualitative mutants identified were

determinate plant type, early maturity, closed capsules, multiple capsules per axis, profuse branching and tri leaf mutant. Similarly, important quantitative mutants identified are mutants with high number of capsules, long capsules, tall and dwarf mutants. Among different treatments, 400 Gy gamma ray was found to have high effectiveness. In the present study, gamma ray induced higher number of macro and micro mutants than combinational treatments. However, Anbarasan *et al.* (2015) reported combined treatment exhibited higher effectiveness than gamma treatment. The identified mutants with special features have to be further forwarded to next generation so that they attain homozygosity and also to check their true breeding behavior in order to utilize them in future sesame breeding programmes.

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Heterosis for seed yield in sesame (*Sesamum indicum* L.)

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ABSTRACT

Sesame is one of the most important oilseed crops grown in tropical regions like Africa and India. In this study a line × tester analysis was conducted using four lines and six testers to identify the best heterotic combination for seed yield. Among 24 cross combinations studied, TMV 7 × RT 127 showed the highest positive significant heterosis for seed yield, 1000 seed weight and total number of capsules.

Keywords: Heterosis, Line x Tester, Sesame

Sesame is one of the nine major oil seeds cultivated in India. Sesame is commonly known as *gingelly*, *benniseed*, *til*, *simsim*, and it belongs to the order Tubiflorae and family Pedaliaceae. Sesame is rich in its nutritional value with high amount of oil content, protein, minerals like calcium, iron, zinc, sodium, potassium etc, vitamin E and with enriched unsaturated fatty acids. It also contains antioxidants like sesamin and sesamol which helps in resistance against oxidative rancidity. All these components make sesame a nearly perfect food. Exploitation of heterosis has become one of the important techniques in plant breeding to maximize the yield in different crops.

Four lines *viz.*, VRI 3, SVPR 1, TMV 6, TMV 7 and six testers *viz.*, Thilathara, Thilak, TKG 55, RT 125, RT 127 and Thilottama were crossed in line × tester mating design during 2019. The F₁ seeds of 24 crosses were sown along with 10 parents in randomized block design during *kharif*, 2019 in Agriculture College and Research Institute, Tamil Nadu Agricultural University, Madurai. Biometrical characters were recorded for yield and its attributing traits in all the hybrids including parents. Standard heterosis was worked out to identify the best heterotic combinations. In this study VRI 3 was used as standard check. Heterosis was analysed using TNAU STAT software.

The cross combination TMV 7 × RT 127 ranked first and showed the highest positive significant heterosis for yield (186.39), 1000 seed weight (33.79) and total number of capsules/plant (103.20) followed by TMV 6 × RT 125 with significant heterosis for seed yield (149.58), total number of capsules/plant (128.71) and

TMV 6 × RT 127 with significant heterosis for seed yield (135.68), 1000 seed weight (28.46), total number of capsules/plant (78.27). Among twenty four hybrids, TMV 7 × RT 127 is considered as the best heterotic combination on the basis of standard heterosis.

Generation mean analysis in maize (*Zea mays* L.)

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ABSTRACT

Generation mean analysis in maize was performed using the progenies (F₁, F₂, BC₁, BC₂) of the cross IC-328883 × IC-541068. Significant differences among parents and generations were observed for all the 12 traits studied. Dominance × dominance epistatic gene effects were most important in governing maturity traits and yield attributing traits whereas additive × additive type gene action was important for ear girth. Dominance gene effects were prominent for number of kernel rows per cob. Duplicate type of gene action was more frequent than complementary type. Non applicability of simple additive-dominance model revealed the importance of epistatic/inter allelic components in maize which can be exploited through heterosis breeding or recurrent selection.

Keywords: Generation, Maize, Mean analysis

Maize kernel oil could be an alternate source of vegetable oil. Since maize has a much higher grain yield compared to most oil crops, and even with a significant reduction in grain yield, high-oil maize would still produce more oil per acre and more overall value than other oil crops. Increasing the productivity of maize could indirectly provide more scope for the exploitation of maize for kernel oil. The knowledge on the way genes act and interact will determine which breeding system can optimize gene action most efficiently. For this purpose, generation mean analysis was undertaken. Six generations of the cross IC-328883 × IC-541068 were analysed for 12 metric characters.

The parents (IC-328883 and IC-541068) were crossed to produce single cross hybrid during *kharif* 2010-11. The crosses along with parents were sown during summer 2012 to produce BC₁, BC₂ and F₂ generations. The six generations of the cross and the commercial variety Maharaja (Hybrid) as check were evaluated during *kharif* season 2012-13 at the Experimental Farm, Department of Agricultural Botany, College of Agriculture, Latur.

Additive-dominance model was adequate to explain the importance of both additive and dominance components. For maturity traits (days to 50% tasseling, days to 50% silking and days to maturity) the additive-dominance model was inadequate revealing importance of inter-allelic interactions in expression of these traits. Epistasis resulting from dominance × dominance component was significant and larger in magnitude than

additive × additive and additive × dominance component in most of the yield contributing traits. The opposite signs of [h] and [l] components in most of the yield/reproductive traits indicated duplicate type of gene interaction. Thus recurrent selection can be resorted to this cross for the traits which will facilitate selection of best recombinants in several hybrids. Earliness traits like days to 50 per cent tasseling and days to 50 per cent silking manifested significant and desirable heterobeltiosis in the cross IC-328883 × IC-541068. The remaining traits were non-significant over better parent and none of the traits significant over check Maharaja. Negative and significant inbreeding depression was observed for days to 50 per cent tasseling (-5.71%), days to 50% silking (-5.69%) and days to maturity (-3.66%). Low positive non-significant inbreeding depression was observed for plant height (3.11%) and ear height (7.19%). Further lowest positive significant inbreeding depression was observed in the traits number of kernel rows per cob (6.10%), 100 grain weight (10.75%), ear girth (13.99%), ear length (25.19%), number of grains per row (25.45%), fodder yield per plant (34.55%) and grain yield per plant (38.04%). Low level of heritability was observed for days to 50 per cent tasseling, days to 50 % silking, days to maturity, ear height and ear girth, whereas moderate level of heritability was observed in the traits plant height and number of kernel rows per cob. High level of heritability was observed in the traits, ear length, and 100-grain weight, number of grains/rows, fodder yield/plant and grain yield/plant.

Association of characters for yield and yield components in soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

To study genetic association of character for yield and yield components over different environments, 20 soybean genotypes and 5 checks were evaluated in a RBD with three replications during *kharif* 2014 at three environments. Data were recorded on 10 characters. Significant negative association was observed between seed yield and days to 50% flowering at genotypic and phenotypic level whereas positive correlation was observed between seed yield and 100-seed weight.

Keywords: Association, Characters, Genetic, Soybean

Soybean [*Glycine max* (L.) Merrill] is the world's leading source of oil and protein. This study was conducted to understand the genetic relationship of different characters in soybean. A set 20 soybean genotypes and five checks, MAUS 71, MAUS 81, JS 335, MAUS-162 and MAUS 158 were evaluated in RBD with three replications. The research was undertaken at three environments *viz.*, Experimental Farm, Department of Agricultural Botany, Latur (E1), College of Agriculture Ambejogai (E2) and Agriculture Research Station, Somnathpur (E3) during *kharif* 2014. A plot size of 11 x 22.5 m² was assigned to each genotype with 45 cm spacing between rows. Days to 50% flowering, days to maturity, number of primary branches, number of secondary branches, plant height, number of pod/plant, number of seed/pod, oil content, 100 seed weight, and grain yield/plant were recorded for all the genotypes.

The genotypic correlation coefficients for ten characters derived from the data taken at Latur are presented in Table 1. Generally genotypic correlation coefficients were higher than their corresponding

phenotypic correlation coefficient in all three environments. This indicates that genotypic expression of the correlation was comparatively less influenced by the environment. These results are in agreements with the findings of Agrawal *et al.* (2001). Seed yield/plant had high significant negative correlation with days to 50% flowering at both genotypic and phenotypic levels. This character exhibited highly significant positive correlation with 100-seed weight. Characters such as seed/pod, number of primary branches and plant height have positive effect on yield/plant. Significant negative association was observed for trait days to 50% flowering at genotypic and phenotypic level. The characters such as oil content and 100 seed weight showing positive significant effect on yield of plant at genotypic and phenotypic level, so that these two characters could be selected for the improvement of seed yield of soybean crop. The character days to 50% flowering will be important for the developing early maturing varieties of soybean.

Table 1 Genotypic correlation of soybean yield with yield contributing characters at Latur

Characters	Days to 50% flowering	Days to maturity	Number of primary branches/plant	Number of secondary branches/plant	Plant height (cm)	Number of pods/plant	Seeds/pod	Oil content (per cent)	100 seed weight (g)	Yield/plant (g)
Days to 50% flowering	1.000	0.3162*	-0.1372	0.3375*	-0.3546**	0.0168	-0.8978**	0.0326	0.4306**	-0.7148**
Days to maturity		1.000	0.1336	0.0910	-0.1292	-0.1964	-0.1192	-0.2138	0.0483	-0.1672
Number of primary branches/plant			1.000	0.2760	0.5590**	0.7959**	0.2871*	0.5268**	0.5564**	0.2210
Number of secondary branches/plant				1.000	0.1803	0.0826	-0.4200**	-0.5544**	0.3377*	-0.2008
Plant height (cm)					1.000	0.2642	0.3226*	0.6205**	-0.0815	0.2174
Number of pods/plant						1.000	0.3356*	0.3255**	0.3431*	0.0237
Seeds/pod							1.000	-0.1973	-0.0796	0.2689
Oil content (per cent)								1.000	0.4080**	0.3395*
100 seed weight									1.000	0.1765*
Yield/plant (g)										1.000

* and ** indicates significance at 5 and 1/cent level, respectively

Genetic studies on high lignan content in sesamum (*Sesamum indicum* L.)

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ABSTRACT

Lignans especially sesamin and sesamolins are secondary metabolites having therapeutic value. The sesame germplasm were screened for lignan content. A set of four low lignan and four high lignan lines were crossed in Line x Tester mating design. Based on the evaluation of F₁s, the genotype KRISHNA was identified as good combiner and the cross (JLS 57 x PKDS 12) showed high sca effects. The crosses (JLS-57 x GUN-18), (KRISHNA x GUN-18), (JLS 57 x PKDS 12) and (KRISHNA x PKDS-12) showed high heterosis for yield and lignan content.

Keywords: GCA, Lignans, Line x tester, Sesame, Sesamin, Sesamolins

In this study, four low lignan lines *viz.*, PKDS-12, IC-131651, SI-3478, GUN-18 and four high lignan lines *viz.*, IC2050-71, JLS-57, SI-3099, KRISHNA were selected and crossed in Line x Tester mating design. The hybrids and parents along with three checks CO-1, TMV-7, VRI-3 were raised during *kharif* 2019 under RCBD design with three replications. Observations were recorded for ten characters. Quantification of sesamin and sesamolins in seeds was achieved by HPLC-DAD system (Agilent 1220 Infinity II LC). The data obtained for all characters were analysed through TNAU STAT software for combining ability components.

The analysis of variance for combining ability revealed the general combining ability (gca) of lines, tester and crosses showed significant differences for almost all characters studied. gca and sca variance

revealed the preponderance of non-additive gene action for days to 50% flowering, plant height, number of primary branches, number of secondary branches and number of capsules/plant, seed weight, sesamin and sesamolins content. This was further supported by low magnitude of gca/sca ratios. These findings were in confirmation with several previous reports. The estimates of gca effects of the parents JLS-57, KRISHNA indicated that they were good combiner for almost all characters except for 1000 seed weight. The tester PKDS-12 showed high significance in sesamin and sesamolins content. The crosses (JLS-57 x GUN-18), (KRISHNA x GUN-18), (JLS 57 x PKDS 12) and (KRISHNA x PKDS-12) exhibited high heterosis for yield and lignan content.

Table 1. Estimates of GCA effects

Parents	Days to 50% flowering	Plant height	No. of primary branches	No. of sec branches	Capsules/plant	1000 seed weight	Yield/plant	Sesamin	Sesamolins
Lines									
IC-205071	0.51	1.47	0.41 *	0.43 *	-3.07	0.09	-0.39 **	-0.26 **	-0.35 **
JLS-57	1.11 *	-3.62 **	-0.47 *	-0.47 *	-13.66 **	0.06	-0.75 **	-0.02	0.12 **
SI-3099	0.10	-2.06	0.43 *	0.28	-7.73 *	-0.15 **	-0.34 *	-0.10 **	-0.23 **
KRISHNA	-0.70	4.21 **	-0.38 *	-0.24	24.47 **	-0.01	1.48 **	0.38 **	0.46 **
Tester									
PKDS 12	0.81	-3.35 *	-0.34	-0.48 *	-16.29 **	0.09	-0.37 **	0.25 **	0.57 **
SI-131651	0.11	-0.58	0.47 *	0.31	-0.40 ns	-0.04	0.04	-0.27 **	-0.46 **
SI-3478	-1.04 *	-1.14	0.08	0.31	-1.59 ns	0.06	-0.20	-0.20 **	-0.14 **
GUN-18	0.11	5.06 **	-0.22	-0.15	18.27 **	-0.11 *	0.53 **	0.22 **	0.03 ns

New high oil yield safflower variety SSF 12-40 for rainfed and irrigated conditions of India

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ABSTRACT

Safflower variety SSF-1240 was derived by hybridization followed by pedigree selection method from the cross Bhima x A1. It has semi-spreading habit with medium bold seeds. The variety is moderately tolerant to aphids and

moderately resistant to wilt. In various multi-location trials conducted during 2015-16 to 2017-18, it consistently recorded better performance over national check A1 and PBNS-12. It has also recorded 19.21% higher oil yield over A1 and 13.23% over the check PBNS-12. The variety was notified during 2019 for cultivation in Maharashtra, Karnataka and Telangana states.

Keywords: Pedigree method, SSF-1240, Safflower, Variety

Safflower (*Carthamus tinctorius* L.) is an important rabi oilseed crop of India. The area under this crop is declining due to several reasons including the non-availability of seed of high yielding varieties. In an attempt to develop high seed and oil yielding variety, a spiny genotype SSF-1240 developed by AICRP on Safflower, Solapur was found promising.

The spiny variety SSF-1240 was developed by pedigree method from the cross between Bhima x A1. It was tested at 27 locations in the coordinated trials viz., IVT, AVT-I and AVT-II during rabi 2015-16 to rabi 2017-18 under irrigated and rainfed conditions. The data on seed yield, oil yield and ancillary characters were recorded and comparison was made with spiny checks A1 and PBNS-12. The recommended packages of practices were followed while conducting the trial. The variety was also screened for its agronomical adaptability for different cropping situation disease and pest reactions under artificial and natural conditions at different coordinated centres all over India.

It recorded higher oil yield (564.5 kg/ha) compared to the checks A1 (473.54 kg/ha) and PBNS-12 (498.54 kg). The oil content of the new variety was 32.86, which

was 4.94% and 3.56% higher over the check A1 (27.92) and PBNS 12 (29.3). It was moderately tolerant to aphid. The incidence of alternaria leaf spot and wilt in SSF-1240 was comparable with the check. In agronomic trial, the spacing of 45 x 20 cm was found optimum. The 50% higher dose than recommended fertilizer recorded higher seed yield at different fertilizer trials indicating better response to higher fertilizer application. In the trial on sowing date, it showed better performance up to mid October sowing. The yield attributing ancillary characters are given in Table 1. The variety SSF-1240 has rosette period for 32 days; the plant start flowering in about 74-78 days after sowing and mature within period of 120-130 days after sowing. The plants have dark green broad leaves with scattered margin. The plant grows to the height of 78-80 cm with 25 capitula/plant. The capitulum is of medium size with 20-25 seeds/capitulum. The seed is white in colour. Considering the higher oil yield and performance in agronomic adaptability trials, SSF-1240 was identified by the Varietal Identification Committee during 2019 for cultivation in both irrigated as well as rainfed situations of the country.

Table 1 Ancillary character of safflower variety SSF 12-40

Characters	SSF-12-40	Characters	SSF-12-40
Plant height (cm)	78.6	No. of seeds/capitula	24.7
Days to flowering	75.3	Hull content (%)	44.6
Days to maturity	123	Volume/weight (g/Lit)	554
100 grain weight (g)	5.35	Biological yield (kg/ha)	6277
No. of effective capitula/plant	25.0	Harvest index(%)	25.6

SSF 1371 : A new spiny safflower variety for rainfed and irrigated conditions of India

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ABSTRACT

SSF 1371 is a spiny variety derived through pedigree selection method from the cross Bhima x NARI 44. In the multi-location trials, SSF 1371 recorded 9.84% and 17.47% higher yield over the checks A1 and PBNS 12, respectively. It has also recorded 14.98% and 18.67% higher oil yield over the check A1 and PBNS 12, respectively. Oil content of SSF 1371 was 29.2%. It was responsive to higher doses of fertiliser and late sown conditions. It was identified during 2019 for cultivation in Maharashtra, Karnataka and Telangana states.

Keywords: Pedigree method, High seed and oil yield, SSF 13-71, Safflower variety

Safflower (*Carthamus tinctorius* L.) is an important *rabi* oilseed crop of the country and is mainly cultivated for its seed which is the source of rich in polyunsaturated fatty acids (Linoleic acid 78%). A number of high yielding spiny varieties have been released for commercial cultivation. The area under safflower is declining due to several reasons including the non-availability of seed of high yielding variety. In an attempt to develop high yielding variety the spiny genotype SSF-1371 developed by AICRP on Safflower, Solapur was found promising.

The spiny variety SSF 13-71 was developed by pedigree method from the cross Bhima X NARI 44. It was tested at 20 different location in the coordinated trials *viz.*, IVT, AVT-I and AVT-II during *rabi* 2016-17, 2017-18 and 2018-19 under irrigated and rainfed conditions. The observation was recorded for seed yield, oil yield and ancillary data and comparison was made with spiny checks A1 and PBNS-12. The recommended packages of practices were followed while conducting the trial. The variety was also screened for its agronomical adaptability for different cropping situations, disease and pest reactions under artificial and natural conditions at different coordinated centres across India.

The seed yield performance of SSF 13-71 was presented in Table 1. It recorded higher seed yield (1999 kg/ha) compared to the checks A1 (1820 kg/ha) and

PBNS-12 (1702 kg). It has also recorded higher oil yield (591 kg/ha) compared to the checks A1 (514 kg/ha) and PBNS-12 (498 kg). The oil content of SSF 13-71 was 29.2%, which was 5.03% and 1.38% higher over the check A1 (27.8) and PBNS 12 (28.8), respectively. It is moderately tolerant to aphid. The incidence of alternaria leaf spot and wilt in SSF 13-71 was comparable with the check. In agronomic trials, the spacing of 45 x 20 cm was found optimum. The 50% higher dose than recommended fertilizer recorded higher seed yield at different fertilizer trials indicating better response to higher fertilizer application.

The variety SSF 13-71 has rosette period for 34 days. The plant starts flowering in about 74-78 days and matures in 124-128 days. The plant grows to the height of 78-80 cm with 25-27 capitula/plant. The capitulum is of medium size with 24-25 seeds/capitulum. The capitula remain in closed condition and have non shattering characters. The seed is without papus and is white in colour. Considering the higher seed yield and oil yield and oil content the entry SSF-13-71 was identified for cultivation in Zone-I (Maharashtra, Karnataka and Telegana state) of safflower growing areas of the country by Varietal Identification Committee meeting held on 4-6 September 2019 at CSAUA &T, Kanpur during Annual Research Workers Group Meeting on Safflower and Linseed.

Table 1 Summary of seed yield of SSF 13-71 in Co-ordinated trials

Year of testing	Number of trials	Seed yield (kg/ha)			% increase over	
		SSF 13-71	A1 (c)	PBNS12(c)	A1 (c)	PBNS12 (c)
2016-17	09	2178	2123	1857	02.6	17.28
2017-18	07	2029	1819	1778	11.54	14.12
2018-19	04	1543	1142	1218	35.11	26.68
Total	20					
Weighted mean		1999	1820	1702	9.84	17.47

Identification of resistant genotypes against *Fusarium* wilt of safflower

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ABSTRACT

Field evaluation of 36 advanced generation breeding material and parental lines of safflower was carried out under wilt sick plot condition at Solapur, Tandur and IOR, Hyderabad for identifying resistant sources against *Fusarium* wilt. Three genotypes *viz.*, SAF-1717, SAF-P-1603 and SAF-P-1608 were found moderately resistant to *Fusarium* wilt at all three locations. These resistant sources can be used in breeding programme for development of a variety resistant to *Fusarium* wilt.

Keywords: *Fusarium* wilt, Safflower genotypes, Screening, Wilt resistant

The safflower wilt causes yield loss of up to 93% in susceptible varieties (Sastry and Ramchandram, 1994). Use of wilt-resistant cultivars is the most effective strategy for sustainable safflower cultivation (Kalpana Sastry and Ramchandram, 1992). To fulfil this need, efforts were made to test the promising safflower genotypes in wilt sick plots of different locations for identifying the resistant sources to *Fusarium* wilt.

A field experiment was conducted during *rabi* season of 2017-18 and 2018-19 testing 36 promising safflower genotypes against *Fusarium* wilt disease in the wilt sick plots of different AICRP safflower centres *viz.*, Solapur (M.S.), Tandur (T.S.) and IIOR, Hyderabad (T.S.) in India employing randomized block design with three replications. The inoculum load of *Fusarium oxysporum* f.sp. *carthami* in the wilt sick plot was 5 X 10⁵ cfu/g of soil.

At Solapur, the entry SAF-1717 was resistant with 6.3% wilt incidence. At Tandur, two entries *viz.*, SAF-P-1601 and SAF-1717 were free from wilt incidence and four entries *viz.*, SAF-P-1603, SAF-P-1606, SAF-1607 and SAF-1517 were resistant (wilting < 10%) to *Fusarium* wilt. At IIOR, Hyderabad, the entry SAF-1717

was resistant and six entries *viz.*, SAF-P-1603, SAF-P-1608, ISF -102-16, 1703, 3404 and DSI-116 were moderately resistant to *Fusarium* wilt.

Six entries *viz.*, SAF-1717, DSI-116, SAF-P-1603, SAF-P-1608, SAF-1711 and R-Sel-05-63-4-5-19 found promising against *Fusarium* wilt at all three locations (Solapur, IIOR, Hyderabad and Tandur) were further screened in confirmation trial during 2018-19 (Table 1). Out of six entries screened against *Fusarium* wilt disease, three entries *viz.*, SAF-1717, SAF-P-1603 and SAF-P-1608 were found moderately resistant against *Fusarium* wilt at all three locations (Solapur, IIOR, Hyderabad and Tandur).

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Table 1 Screening for confirmation of resistance to *Fusarium* wilt of safflower (2018-19)

Entry	Wilt incidence (%)		
	Solapur	Tandur	IIOR, Hyderabad
SAF-1717	16.3	5.6	5.0
DSI-116	15.7	0.0	31.7
SAF-P-1603	9.6	12.2	20.0
SAF-P-1608	9.7	36.7	10.0
SAF-1711	18.5	25.2	10.0
R-Sel-05-63-4-5-19	47.8	24.3	11.1
Nira (SC)	100.0	100.0	100.0
TSF-1 (RC)	11.2	0.0	10.8

SC = Susceptible check TC= Tolerant check

Character association studies for morph-biochemical mechanisms of resistance against powdery mildew (*Golovinomyces cichoracearum*) of sunflower (*Helianthus annuus* L.)

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ABSTRACT

Eighteen hybrids and two checks *viz.*, LSFH-35 and LSFH-171 of sunflower were evaluated for their morphological and biochemical traits imparting tolerance/resistance to powdery mildew during *rabi*, 2018-19. A Field experiment in Randomized Block Design with three replications was carried out. The results revealed that sunflower hybrids *viz.*, LSFH-2026, LSFH-216, LSFH-3008 and LSFH-1225 exhibited moderately resistant to moderately susceptible reaction to powdery mildew. The character association studies of host resistance indicated

that powdery mildew had positive and significant correlation with the amount of reducing sugar and stomatal frequency and size while negatively correlated with trichome density, chlorophyll, total phenols and total sugars.

Keywords: Phenol, Powdery mildew, Resistant, Stomata, Sunflower, Total sugar, Trichome

Average productivity of sunflower (*Helianthus annuus* L.) in India is quite low, which may be due to several biotic and abiotic factors. Among the biotic factors, diseases alone cause 10 to 20% yield losses in the field itself. During recent past, powdery mildew has become a serious threat to sunflower crop grown in various regions of India. The disease is more common under high temperature and dry environment and results into senescence of the plants at flowering or post flowering stages. Therefore, exploitation of host resistance and study of their association would be an ideal approach of subsistence farming under resource limited semi-arid tropical regions of the world.

Twenty hybrids of sunflower including two checks viz., LSFH-35 and LSFH-171 were evaluated against powdery mildew in Randomized Block Design (RBD) at College of Agriculture, Latur during *rabi*, 2018-19. Observations on powdery mildew incidence and intensity were recorded at 60 days after sowing (DAS) and computed their percentages. Powdery mildew disease intensity on foliage was graded by applying 0-9 disease rating scale. Total sugars and phenols were determined from healthy and diseased leaves of sunflower. Structural and anatomical traits viz., number and size of stomata and trichome frequency in different hybrids were studied. Five plants per entry were randomly selected, from these second leaf on main stem was plucked off, subjected to estimation of chlorophyll by SCMR technique and finally computed average chlorophyll content. The data of various studies was subjected to statistical analysis (Panse and Sukhatme 1978) and also correlation analysis (Dewey and Lu 1959).

On the basis of per cent powdery mildew intensity, sunflower test hybrids were categorised into five groups viz., resistant (1 to 10%), moderately resistant (11 to 25%), moderately susceptible (26 to 50%), susceptible (51-75%), and highly susceptible (76-100%). Morphological and anatomical features of the leaves of test sunflower entries varied. The results revealed that powdery mildew severity had positive significant

correlation with reducing sugar ($G=0.878$, $P=0.863$), adaxial stomata frequency ($G=0.655$, $P=0.625$), adaxial stomata length ($G=0.462$, $P=0.457$) and breadth ($G=0.442$, $P=0.431$). These findings are in confirmation with the reports of Chattopadhyay *et al.* (2011) who have reported highly significant correlation between mulberry powdery mildew severity and micro-morphological traits like stomata density and stomata size in mulberry test entries. Powdery mildew severity exhibited negative and significant association with total phenols ($G=-0.649$, $P=-0.611$), SCMR ($G=-0.464$, $P=-0.452$), total sugars ($G=-0.433$, $P=-0.432$) and trichome frequency. Similar finding were reported earlier Muhammad and Khan (2014) for phenols in flax. Based on present study, it is concluded that the correlation coefficient studies revealed positive and significant correlations between powdery mildew severity reducing sugars, stomata frequency and stomata size; whereas, there was negative correlation with trichome density, SCMR, total phenols and total sugars. Thus simultaneous selection of these characters could incorporate resistance against powdery mildew disease in sunflower.

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Combining ability analysis for yield and its components in sunflower (*Helianthus annuus* L.)

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ABSTRACT

The present experiment involved four CMS line and six tester crossed in a line x tester fashion to estimate the combining ability for seed yield and yield contributing traits in sunflower. The resulting 24 hybrids were evaluated in two replications of RBD design. CMS-234A and CMS-243A exhibited good GCA for day to 50% flowering, hull

content and oil content. From testers, EC-601951R and 99RT were with GCA effect for 50% flowering, days to maturity, plant height, hull content, head diameter, 100 seed weight, seed yield/plant. Cross combinations, CMS-243A x 99RT and CMS-17A x EC-279309 recorded good SCA effect for maturity, oil content and seed yield. Good SCA for seed filling and seed yield/plant was reported in PET-89-1A x RHA-1-1 combination.

Keywords: Combing ability, Line x tester, Non-additive, Sunflower

Selection of parents is one of the important aspects in developing the potential hybrids which is practiced after testing of parents for their combining ability effects. It is also useful in understanding the type of gene action controlling various traits to develop suitable breeding strategy.

The experiment was conducted at the experimental fields Oilseed Research Station, Latur during 2017-18 by adopting line x tester mating design with four lines (CMS-17A, CMS-234A, CMS-243A and CMS-PET-89-1A) and six testers (EC-623008, EC-601951, EC-601957, EC-279309, 99RT and RHA-1-1). The resultant 24 hybrids along with their 10 parents and two checks viz., LSFH-35 and LSFH-171 were evaluated in RBD with two replications. Observations were recorded on randomly selected 5 plant for ten characters viz., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed filling (%), seed yield/plant (g), 100 seed weight (g), volume weight (g/100 ml), hull content (%) and oil content (%).

The mean sum of squares due to line x tester interaction was highly significant for all the characters. This indicates the existence of sufficient variability for yield and yield contributing characters in the material under studied. The CMS-17A was found to be good general combiner for plant height, CMS-234A for day to 50% flowering, hull content and oil content, CMS-243A for head diameter and oil content. Tester, EC-601951R was with good GCA effect for 50% flowering, days to maturity, plant height, hull content, head diameter, 100

seed weight, seed yield/plant. 99RT was a good combiner for days to maturity and volume weight. Such type of GCA for economic traits was reported by Ortis *et al.* (2005) and Binodh *et al.* (2008). The hybrid CMS-234A x EC-601951R was with good SCA effect for plant height, seed yield/plant CMS-17A x EC-279309 R for oil content (%). The hybrid CMS-17A x EC-623008 R recorded good SCA effects for day to 50% flowering, hull content. Cross CMS-17A x RHA-1-1 was identified with good SCA effects for days to maturity, hull content and oil content (%). The hybrid CMS-234A x EC-601951R was with good SCA effect for plant height, 100 seed weight, oil content and volume weight. The cross CMS-234A x 99RT was with good SCA effect for head diameter, hull content and seed yield/plant CMS-243A x 99RT was recorded good SCA effect for maturity oil content and seed yield. The cross combination PET-89-1A x RHA-1-1 registered good SCA effect for seed filling percent and seed yield.

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Genotype × environment interaction studies in summer groundnut (*Arachis hypogaea* L.)

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ABSTRACT

A field experiment was carried out at All India Co-ordinated Research Project on Groundnut, Cotton Project, MPKV, Rahuri during summer 2016, with ten groundnut genotypes. The present study indicated that sowing of groundnut varieties on the date E2 (15th February) was most favorable for expression of yield and yield contributing traits. It is concluded that groundnut genotypes Phule Unnati, SB-XI, Phule-6021, Phule Bharati, TAG-24 and JL-501 from average yield group were observed to be stable for yield and yield contributing characters.

Keywords: Genotype environment interaction, Groundnut, Stability

The consistent performance of a genotype over a range of environments is essential for a wide stability of a variety. Studying of G x E interaction is very important

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to plant breeders because this interaction it can limit the progress in the selection process and since it is a basic cause of differences between genotypes for yield

stability. Therefore, an attempt has been made in present study to evaluate different groundnut genotypes across the different date of sowing to know the role of G×E interactions and also to analyze the stability of genotypes for different traits.

A field experiment was carried out at All India Co-ordinated Research Project on Groundnut, Cotton Project, MPKV, Rahuri during summer 2016, with ten groundnut genotypes. These genotypes were evaluated for fourteen different expressions under three dates of sowing to study their stability. Genotype × environment interactions were found to be significant for seven out of fourteen characters under study. Data was subjected to statistical analysis by following the linear regression model of Eberhart and Russell (1966). Both linear and non-linear components exhibited significance for all the traits, considered for stability analysis.

The genotypes SB-XI, TPG-41 and RHRG-1189 were found to be superior and stable for the trait days to

50% flowering. The maximum number of mature pod per plant were reported in the genotypes Phule Unnati, Phule Bharati and TAG-24 and these were superior and possessed average stability, for the trait mature pod per plant. The genotypes Phule Unnati, TAG-24 and JL-501 showed average stability for pod yield/plot. The genotypes Phule Unnati, Phule Bharati, TAG-24 and JL-501 showed average stability for haulm yield/plot and hundred kernels weight. The maximum shelling per cent was reported by genotypes Phule Unnati, Phule-6021 and RHRG-1142. The genotypes Phule Unnati, Phule-6021 and RHRG-1189 were found superior and with average stability for mature kernels percentage.

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Principal component analysis for yield attributing traits of sunflower (*Helianthus annuus* L.) genotypes

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ABSTRACT

In order to evolve the potential heterotic hybrids in sunflower, efforts are on in plant breeding programmes to select promising parental inbreds for various yield related traits. Ninety one sunflower germplasm accessions were evaluated for seven quantitative traits during rabi 2018-19 and data were subjected to biometric analysis for correlation and principal component analysis. PCA analysis revealed that, out of 7 PCs, only 3 PCs exhibited more than 1.0 Eigen value and showed 71.45% variability for 91 genotypes. PC1 reported for highest variability in traits like days to 50% flowering and days to maturity. PC3 showed the positive load on yield attributing traits like 100 seed weight and single plant yield. PC1 and PC3 allowed for simultaneous selection of yield related traits.

Keywords: Germplasm, PCA, Sunflower

In order to advance the crop improvement studies, research in plant breeding and genetics is being carried out to evaluate genotypes for important traits influencing the productivity (Chandirakala and Manivannan 2014). Principal component analysis is a well known method of reduction of large number of data sets. Therefore, present investigation aimed at evaluating and ranking of promising inbreds based on PCA analysis for further utilization of inbreds in hybridization programme.

The experimental material consisted of ninety one sunflower germplasm accessions including seven checks maintained at Department of Oilseeds, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in Augmented Block Design during rabi 2018-19. Each accession was raised in single row of four meter length with a spacing of 60 x 30 cm. All the recommended agronomical practices were followed to raise a good and healthy crop throughout the experimental period. Observations like plant height, days to 50% flowering,

days to maturity, head diameter, hundred seed weight, volume weight and single plant yield were recorded for quantitative characters on five randomly selected plants from each genotype. Data were analysed for principal component analysis using statistical package STAR (Statistical Tool for Agricultural Research) - IIRI Plant Breeding software.

Among the 91 genotypes evaluated, the plant height ranged between 48 and 196 cm and duration ranged from 84 (TSG-349) and 118 (EC-601780) days. Single plant yield ranged from 15 (TSG-349) to 28.1g (GP6-313). Significant and high order correlation was observed between days to 50% flowering and maturity (0.9994**). Significant positive correlation was observed for plant height and head diameter (0.5053**); plant height and volume weight (0.252**); head diameter and 100 seed weight (0.3549**) and 100 seed weight and single plant yield (0.2821**). Hence high 100 seed genotypes can be used for hybridization purpose to get best heterosis. Positive correlations for both the traits were already

reported by Komuraiah *et al.* (2004). PCA analysis was performed for 7 quantitative traits. Out of 7 PCs, only 3 PCs exhibited more than 1.0 Eigen value and showed 71.45% variability for 91 genotypes. PC1 and PC2 accounted for more than 50% of total variability. PC1 reported highest variability for days to 50% flowering and days to maturity. PC3 showed the positive load on yield attributing traits like 100 seed weight and single plant yield. Earlier studies confirmed that high value PC scores can be selected for further utilization in breeding programme (Arshad *et al.*, 2010).

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Assessment of combining ability with elite genotypes in sesame (*Sesamum indicum L.*) by half diallel mating design

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ABSTRACT

The present investigation was undertaken with the objective of studying the extent of heterosis and to estimate general and specific combining ability effects in 28 hybrids of sesame obtained by crossing 8 x 8 genotypes in half diallel fashion. The analysis of variance revealed that significant differences among treatments, parents, hybrids and parents v/s hybrids for all characters except days to maturity and capsule width. Among parents, LOCAL and G-1 was good general combiners for seed yield/plant. Considering both per se and GCA effect, the parents LOCAL and AKT-306 were the best. The highest SCA effect for seed yield/plant was exhibited by cross G-1 x IC-204025 along with superior SCA effect for plant height, number capsule/plant and seed/capsule. The crosses AKT-306 x YLM-17 and LOCAL x AKT-101 with significant SCA effects indicated the predominance of additive gene action for seed yield hence progeny selection in the segregating generation is more useful.

Keywords: Combining ability, GCA, Heterosis, Sesamum

Sesame is a short-day plant and is normally self-pollinated, although cross pollination ranging from 5 to over 50% occurs. It is an erect herbaceous annual plant that has two growth characteristics indeterminate and determinate, with the plants reaching heights of up to two meters. The experimental material for the present study comprised of eight parent *viz.*, LOCAL, G-1, AKT-306, AKT-101, IC-205283, IC203871, IC-204025 and YLM-17 by using 8x8 half diallel fashion with two checks namely Phule Til-1 and JLT-408. Experiment was conducted at the College of Agriculture, Latur during *kharif* 2018-19. A total of 28 crosses were obtained. A spacing of 45 cm between rows and 20cm between plants was maintained. The experimental material was evaluated in Randomized Block Design (RBD) in two replications. The analysis was based on the model suggested by Panse and Sukhatme (1985).

The results of GCA effects indicated that the parents, AKT-306, G-1 and LOCAL proved as good general combiners for no. of seed/capsule, 1000 seed weight (g), seed yield/plant and their contributing character. Parent IC-203871 and IC-204025 registered good general combining ability for oil content. Among

the crosses studied, G-1 x IC-204025, AKT-306 x YLM-17 and LOCAL x AKT-101 were identified potential specific combiners for seed yield/plant and other yield contributing traits. Highly significant positive SCA effect for number of capsule/plant was exhibited by the crosses G-1 x IC-204025 (24.221), LOCAL x AKT-101 (20.786). The hybrids G-1 x IC-204025, and AKT-306 x YLM-17 were found to be good specific combiners for number of seed/capsules and AKT-306 x IC-205283 for number of branches/plant. Good specific combiners for oil content were G-1 x IC-205283, LOCAL x IC-204025 and AKT-306 x IC-205283. Positive SCA in crosses between good and poor combiners could be ascribed to better complementation between favorable alleles of the parents involved. The highest SCA effect for seed yield/plant was exhibited by cross G-1 x IC-204025 along with superior SCA effect for plant height, number capsule/plant, no. of seeds/capsule.

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Breeding for large seed size in sesame (*Sesamum indicum* L.)

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ABSTRACT

During the year 2018-2019 a total of three F₂ generation population was evaluated during *rabi* season. The experiment was conducted in randomized block design replicated twice. Observations were recorded on the yield and yield contributing traits. Heterobeltiosis up to a maximum of 96.4% was recorded for seed length, 92.98% for seed breadth, 101.98% for thousand seed weight, 109.81% for thousand seed volume, 111.55% for seed density, 117.19% for oil content and 137.63% for seed yield per plant. The result indicated that there was practically no inbreeding depression.

Keywords: Full diallel, Heterobeltiosis, Inbreeding depression, Sesamum

The seed yield of sesame is influenced by so many factors. One of the prime important factors is the crop stand establishment. The crop stand establishment in the farmer's field is reduced when compared to the experimental farm due to uneven rainfall. The sesame seed size is small and so, the germination and vigour are less when compared to the bold seeded crops. In this context, it is necessary to improve the seed size of sesame, as bold seed size can tolerate uneven rainfall when compared to the small seeded sesame genotypes. Hence, the present investigation was formulated to evolve large seeded sesame genotypes.

One thousand one hundred and sixty eight genotypes of sesame were grown on uniform environment during September 2018. The genotypes were classified into three seed sized groups *viz.*, large, medium and small based on mean 1000 seed weight \pm 1Sd. Accordingly, the largest seed size genotype (>3.21 g), one medium seed size genotype (in between Mean \pm 1Sd; 2.53 to 3.21 g) and the smallest seed size genotype (<2.53 g) were culled out. They were raised during January 2019, and mated in full diallel fashion. The resulting six F₁ hybrids were sown during June 2019, selfed to evolve F₂ seeds as well as back crossed with both the parents. The F₂ progenies as well as back cross progenies were evaluated during September 2019. The experiments were conducted in randomized block

design replicated twice. A single row of 4.5 meters length was allotted for each variant with a spacing of 13 to 15 centimeters. Recommended agronomical practices and need based plant protection measures were judiciously followed. Observations were recorded on the following traits *viz.*, length of seeds, breadth of seeds, weight of 1000 seeds, volume of 1000 seeds, density of seeds, oil content and seed yield per plant.

Heterobeltiosis up to a maximum of 96.4% was recorded for seed length, 92.98% for seed breadth, 101.98% for thousand seed weight, 109.81% for thousand seed volume, 111.55% for seed density, 117.19% for oil content and 137.63% for seed yield per plant. In general F₂ transgressed their F₁ parents, as well as recorded higher heterobeltiosis than the back cross progenies. A maximum of 107.06% heterobeltiosis for length of seeds (F₂s of P₃ x P₂), 111.03% of heterobeltiosis for breadth of seeds (F₂s of P₃ x P₂); 132.68% of heterobeltiosis for weight of thousand seeds (F₂s of P₁ x P₃); 160.13 of heterobeltiosis for volume of thousand seeds (F₂s P₁ x P₂); 201.68% heterobeltiosis for seed density (F₂s of P₁ x P₃); 108.82% heterobeltiosis for oil content (F₂s of P₃ x P₁); 276.35% of heterobeltiosis for seed yield (F₂s of P₁ x P₃) were recorded. The result indicated that there was practically no inbreeding depression.

Studies on genetic variability, correlation coefficient and path analysis in niger (*Guizotia abyssinica* L. Cass)

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ABSTRACT

Analysis of variances indicated the presence of substantial amount of genetic variability in the genotypes for all the characters. The GCV and PCV were of high magnitude for the character number of capitula/plant followed by

number of seeds/capitulum, number of secondary branches/plant and harvest index. The estimate of high heritability coupled with high genetic advance as per cent of mean has been noticed for number of capitulum/plant, number of seeds/capitulum, number of secondary branches/plant, harvest index, number of primary branches/plant, seed yield/plant, oil content and 1000 seed weight indicating the pre dominance of additive gene action in there expressions. Seed yield exhibited positive significant association with 1000 seed weight, number of capitulum/plant, number of seeds/capitulum, number of secondary branches/plant and harvest index.

Keywords: Character association, GCV, Heritability, Niger, Path analysis

Niger oil is slow in drying and is used in foods, paints, soaps and as illuminant and the press cake from oil extraction is used as livestock feed. In the present investigation, efforts were made to find out the genetic variability, heritability and character association for yield and yield contributing traits in forty one genotypes.

Forty one niger genotypes were grown in a randomized block design with three replications during *kharif* 2018-19 at Research Farm, College of Agriculture, Latur, Maharashtra. Each genotype was sown in two rows of 4 m length with the spacing of 30 cm within rows and 10 cm between plants. Observation was taken on 11 characters on ten randomly selected plants in each entry. The phenotypic and genotypic coefficient of variability was computed according to the method suggested by Burton (1952). Heritability and genetic advance were estimated as per Johnson *et al.* (1995). Path coefficient analysis was carried out with genotypic correlations following the method of Dewey and Lu (1959).

The analysis of variance recorded significant differences among genotypes for all the traits indicating the presence of considerable amount of variability. The estimates of phenotypic coefficient of variations and genotypic coefficient of variations were relatively high for number of capitulum/plant, number of seeds/capitulum, number of secondary branches/plant and harvest index. Whereas, it was moderate for number of primary branches/plant, seed yield/plant, oil content and 1000 seed weight and lowest for plant height, days to 50% flowering and days to maturity. The results are in agreement with the earlier finding of Patil *et al.* (2013). In the present study high heritability coupled with high

genetic advance as per cent of mean has been noticed for number of capitulum/plant followed by number of seeds/capitulum, number of secondary branches/plant, harvest index, number of primary branches/plant, seed yield/plant, oil content and 1000 seed weight indicating the pre dominance of additive gene action in there expressions. These results are in accordance with earlier result of Suryanarayana *et al.* (2018). The selection for improvement of their characters would be effective. Seed yield exhibited positive association with 1000 seed weight, number of capitulum/plant, number of seeds/capitulum, number of secondary branches/plant and harvest index and negative significant association with days to 50% flowering and days to maturity.

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Studies on genetic diversity in sesame (*Sesamum indicum* L.) over seasons

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ABSTRACT

D² analysis of the sixty genotypes based on sixteen characters confirmed the presence of high diversity. Genotypes of different eco-geographic origins were grouped in a single cluster as well as in different clusters. Out of these twelve genotypes only five genotypes *viz.*, G27, G32, G35, G39 and G40 showed high mean seed yield.

Keywords: D² analysis, Genotypes, Mahalanobis, Variability, Sesamum

Genetic diversity is important in any crop improvement programme. Genetically diverse parents are likely to give good combiners which turn result in high heterosis as well as high yielding segregants in the later generations. Studies on genetic diversity in sesame are usually conducted in one season or environment. As diversity is also influenced by season and environment, the present study was formulated to find out consistent genetic divergence over seasons.

Sixty genotypes of sesame were raised in three subsequent seasons namely September 2018, January 2019 and June 2019 and data were utilized for the diversity analysis. The experiments were conducted in randomized block design replicated twice.

A single row of 4.5 meters length was allotted for each variant with a spacing of 13 to 15cm. Recommended agronomy practices and need based plant protection measures were judiciously followed. Observations were recorded on sixteen traits viz., days to maturity, height of the plant at the maturity, number of branches/plant, number of lowers/plant, number of capsules/plant, volume of capsules, number of seeds/capsule, length of seeds, breadth of seeds, weight of 1000 seeds, volume of 1000 seeds, density of seeds, oil content (%), seed yield/plant (g), total dry matter production/plant (TDMP), harvest index (%). Diversity analysis was done following methodology of Mahalanobis (1936) and clusters were conducted based on Rao (1952).

D² analysis of the sixty genotypes based on sixteen characters confirmed the presence of high diversity among the types by their resolution into twelve clusters in SI, six clusters in SII and pooled analysis and eight clusters in SIII. Genotypes of different eco-geographic origins were grouped in a single cluster as well as in different clusters. Thus, the pattern of clusters demonstrated that the genetic diversity was not fully related to geographical diversity. Selection of parents has been suggested in three ways i.e., on the basis of (a) genetic divergence exhibited under the best season, (b) consistent values of divergence over all the seasons and (c) divergence exhibited in the pooled analysis. The twelve genotypes, G21, G27, G29, G32, G35, G37, G39, G40, G47, G52, G55 and G58, were grouped in cluster I consistently in all the analyses. Out of these twelve genotypes only five genotypes viz., G27, G32, G35, G39 and G40 showed high mean seed yield. By crossing among these genotypes high yielding genotypes with a response similar to the parents can be obtained.

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Studies on genetic parameters in sesame (*Sesamum indicum* L.) over seasons

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ABSTRACT

Sixty genotypes of sesame were studied for sixteen traits over three seasons to understand the magnitude and direction of genetic variability, heritability and genetic advance for the traits of interest. Genotypic variance and genotypic coefficient of variation were higher for number of flowers, number of capsules, total dry matter production and harvest index. High heritability estimates coupled with high genetic advance as percentage over mean was observed for the traits number of flowers, number of capsules, volume of capsules, volume of 1000 seeds, density of seeds, seed yield, total dry matter production and harvest index.

Keywords: GCV, Genetic advance, Genotypes, Heritability, PCV, Sesamum

The success in any crop improvement programme depends upon the genetic variability available in the population. Estimation of genetic parameters is of paramount importance. As the estimates of genetic parameters do depend upon environment and season, any study which ascertains the genetic variability should be conducted over seasons and environments. As sesame is a traditional and ancient oil seed crop, the yield

improvement coupled with high oil content will reduce the import bill on edible oil. It will fetch high foreign exchange. Hence the present study was formulated over seasons.

Sixty genotypes of sesame were raised in three subsequent seasons namely September 2018, January 2019 and June 2019 and data were utilized for the estimation of genetic parameters. The experiments were

conducted in randomized block design replicated twice. A single row of 4.5 meters length was allotted for each variant with a spacing of 13 to 15 cm. Recommended agronomy practices and need based plant protection measures were judiciously followed. Observations were recorded on sixteen traits *viz.*, days to maturity, plant height, number of branches/plant, number of lowers/plant, number of capsules/plant, volume of capsules, number of seeds/capsule, length of seeds (cm), breadth of seeds, weight of 1000 seeds (g), volume of 1000 seeds (g), density of seeds, oil content (%), seed yield/plant (g), total dry matter production/plant (TDMP), harvest index (%). Genetic parameters were estimated by following the standard procedures given by Snedecor and Cochran (1961); Lush (1940); Burton (1952) and Johnson *et al.* (1955).

Sixty genotypes of sesame were studied for sixteen traits over three seasons to understand the magnitude and direction of genetic variability, heritability and genetic advance for the traits of interest. Genotypic variance and genotypic coefficient of variation were higher for number of flowers, number of capsules, total dry matter production and harvest index. Genotypic variance alone was higher for height of the plant at maturity and GCV alone was higher for seed yield. This explained their remarkable share to the total variability. These characters could be reasonably relied upon for successful isolation of desirable recombinants and segregants. High heritability estimates were consistently observed for all the traits studied excepting for plant height which exhibited low to high values. The genetic advance as percentage over mean was high for seed yield, number of capsules, 1000 seed volume, harvest index, number of flowers, total dry matter production, seed density and capsule volume. High heritability estimates coupled with high genetic advance as percentage over mean was

observed for most of the traits, namely, number of flowers, number of capsules, volume of capsules, volume of 1000 seeds, density of seeds, seed yield, total dry matter production and harvest index. High heritability coupled with medium genetic advance as percentage over mean was observed for number of branches, and 1000 seed weight. High heritability coupled with low genetic advance as percentage over mean was observed for days to maturity, number of seeds per capsule, seed length, seed breadth and oil content. High genotypic coefficient of variation, coupled with high heritability and high genetic advance as percentage over mean was observed for number of flowers, number of capsules, seed yield, total dry matter production and harvest index. This clearly explained the existence of additive genetic variability and the predominance of additive gene action in the expression of these traits. This suggested that quick improvement can be expected in a short time for these characters in the breeding programme.

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Correlation and path coefficient analysis for seed yield and its component traits in castor (*Ricinus communis* L.)

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ABSTRACT

A field experiment was conducted during *kharif* 2018 with 15 genotypes of castor at AICRP on Castor, RRTTS, Bhawanipatna, Odisha to study the relationship between castor seed yield and its nine component traits. Four characters showed significant positive correlation with seed yield/plant at both genotypic and phenotypic level while four characters had higher positive direct effect on seed yield. Three characters *viz.*, number of capsules/primary spike, number of effective spikes/plant and oil content (%) with high positive correlations with seed yield/plant and positive direct effect on seed yield, can be used as selection criteria in breeding for higher seed yield in castor.

Keywords: Castor, Correlation, Path coefficient analysis

Success of any crop improvement programme depends on correlation between yield and its components, both at phenotypic and genotypic level while path analysis provides the exact picture of direct and indirect cause of such associations. An attempt is made in the present study to assess the correlations and path coefficient analysis in 15 genotypes.

Fifteen genotypes (varieties and hybrids) of castor received through ICAR-Indian Institute of Oilseeds Research, Hyderabad were evaluated in a randomized block design with three replications at research farm of AICRP on Castor, RRTTS, Bhawanipatna, Odisha. Each genotype was grown in four rows of 6.0 m length with a spacing of 90 x 60 cm. The recommended package of practices of crop production and protection were followed for successful crop growth. Observations were recorded from randomly selected five competitive plants of each genotype in each replication for nine component characters in addition to seed yield/plant. The correlation coefficient were worked out to understand the association among characters by adopting method described by Singh and Chaudhary (1977) and path analysis was done according to the procedure suggested by Dewey and Lu (1959).

Correlation studies indicated that genotypic correlations were stronger than the phenotypic correlations for majority of the characters (Deepika and Tummala, 1981). Among the nine characters, oil content, number of capsules/primary spike, number of effective spikes/plant and plant height upto primary raceme showed significant positive correlation with seed yield/plant at genotypic and phenotypic level, indicating possibility of improving these characters simultaneously.

Oil content showed significant and positive association with effective length of primary spike, number of capsules/primary spike and plant height up to primary raceme at both genotypic and phenotypic levels. Number of capsules in primary raceme indicated positive and significant association with effective length of primary spike and plant height upto primary raceme. High positive phenotypic correlations on seed yield/plant were shown by number of capsules/primary spike, number of effective spikes/plant, oil content and plant height. The results of path coefficient analysis indicated that days to 50% of flowering of primary raceme, number of effective spikes/plant and number of capsules/primary spike had higher positive direct effect on seed yield. Since the number of capsules in primary spike, number of effective spikes/plant and oil content were having high positive correlations with seed yield/plant and also having higher positive direct effect on seed yield, these three characters can be used as selection criteria in breeding for higher seed yield in castor.

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Utilization of dwarf dura mother palms for production of high yielding and dwarf oil palm (*Elaeis guineensis*) hybrids

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ABSTRACT

The present investigation was carried out to search for source of high yielding and short stature mother palms in India. We identified palm that has the highest yield of 181.70 kg, more number of bunches (20.50) and less height increment (18 cm) in comparison to other progenies by taking moving average (yield: 98.13 kg, no. of bunches: 13.38, height increment: 32.48 cm) of the same cross. The mesocarp content of this accession also more (72.20%) when compared with the standard duras. Another palm selected (Palm NO: 47) has the highest yield (221.30 kg) and medium height increment (33.00 cm) in comparison to other progenies by taking moving average (yield: 103.77 kg, height increment: 31.81 cm) of the same cross. The utilization of high-yielding genetic base as a planting material has been proven to be the most efficient and sustainable means of increasing the yield output of existing oil palm genetic base. This genetic stock recorded highest yield and short stature compared with other progenies. However, it can be used as a mother parent for the development of high yielding and dwarf oil palm hybrids

Keywords: Dwarf, Dura, Genetic, Oil palm, Yield

African oil palm has the highest productivity amongst cultivated oilseeds crops. The Asian oil palm industry has developed at a great rate, and now leads the world. Indonesia became the global leader in palm oil. Nearly 90% of the world's oil palm seed production is based on Deli Dura, which originated from the four Bogor palms. The oil palm planting material currently used worldwide is mainly Tenera hybrid obtained from D (Dura) × P (Pisifera) crosses. The crude palm oil and kernel palm oil have different fatty acid profiles, which increases versatility of the crop in industrial applications. Plantations of the current varieties have economic life-span of around 25–30 years and produce fruits round the year. Thus, predictable annual palm oil supply enables marketing plans and adjustments in line with the economic forecasts. Oil palm cultivation is one of the most profitable land uses in the humid tropics. Oil palm fruits are the richest plant source of pro-vitamin A and vitamin E. Hence, crop both alleviates poverty, and could provide a simple practical solution to eliminate global pro-vitamin A deficiency. Oil palm is a perennial, evergreen tree adapted to cultivation in biodiversity rich equatorial land areas. The growing demand for the palm oil threatens the future of the rain forests and has a large negative impact on biodiversity. Plant science faces three major challenges to make oil palm the key element of building the future sustainable world.

The selected palms from the progeny of two D x D crosses (44 CD (ZS-1) x 435 CD (CA-12) and 60 CD x 62 CD (ZS-8 inter se cross) constituted the experimental material. Dura material from two D x D crosses (selected for high yield and dwarfness) were evaluated during 2019-20 and the best performing palms with more yield

and less height increment were selected based on the mean of 2 years.

The identified palm in the present investigation has the highest yield (181.70 kg), more number of bunches (20.50) and less height increment (18 cm) in comparison to other progenies by taking moving average (yield: 98.13 kg, no. of bunches: 13.38, height increment: 32.48 cm) of the same cross. The mesocarp content of this accession also more (72.20%) when compared with the standard duras. Another palm selected (Palm N0: 47) has the highest yield (221.30 kg) and medium height increment (33 cm) in comparison to other progenies by taking moving average (yield: 103.77 kg, height increment: 31.81 cm) of the same cross. A medium height palm (Palm No: 72) having more number of bunches (22.00) with medium height increment (30 cm) in comparison to other progenies by taking moving average (No. of bunches: 15.40, height increment: 31.56 cm) of the same cross. We produced nearly 3000 sprouts by utilizing these palms as a mother palms for further evaluation. The utilization of high-yielding genetic base as a planting material has been proven to be the most efficient and sustainable means of increasing the yield output of existing oil palm genetic base (Arolo *et al.*, 2017). These genetic stocks recorded highest yield and short stature compared with the other progenies.

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Best management practices for yield maximization in rainfed castor

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ABSTRACT

A field experiment was conducted for yield maximisation through best management practices in castor at RARS, Palem during *khariif*, 2018. The results revealed that adoption of Best Management Practices (BMPs) in rainfed castor resulted in significantly higher growth and yield attributes such as plant height, effective spike length thus significantly higher seed yield (1555 kg/ha) as compared to that of farmers practice. Thus, higher net returns (₹ 27251/ha) and B:C ratio (1.9) was accrued due to adoption of BMPs.

Keywords: Best management practice, Castor, Cost benefit ratio, Farmers' practice

Castor oil plant, is one of the world's most useful and economically important plant as its seed contains 48-52% of oil, the highest among cultivated oilseeds.

Castor oil has more than 700 industrial uses. Though castor is a traditional crop in Telangana, its productivity is very low (937 kg/ha) as compared to Gujarat (1902

kg/ha) and India average (1652 kg/ha). Hence, there is an imminent need to enhance castor productivity through adoption of best management practices developed over years.

The experiment was conducted on a red chalka soil of B6 block at RARS, Palem during *kharif* 2018, with two treatments i.e., best management practices and farmers practice. The treatment details are mentioned in Table 1.

The data on growth parameters, yield attributes and yield were subjected to t-test and the treatment are compared.

The results revealed that adoption of BMPs in rainfed castor resulted in significantly higher seed yield (1555 kg/ha) which is 18% more than that of farmers'

practice (1303 kg/ha). The reason for this was mainly due to increase in plant height, number of nodes/plant (12), number of effective spikes/plant (7.0), effective spike length (33.3 cm) due to BMPs. The most important practices like ridge and furrow method of land configuration for better moisture conservation, timely management of weeds by integrated weed management and effective control of pest contributed significantly towards higher yield than that of farmers' practice. Such results were earlier reported by Singh (2002) and Sardana *et al.* (2008). Thus, higher net returns (₹27,251) and B:C ratio (1.9) were realised due to best management practices as compared to farmers' practice (₹ 19,705/-) and B:C ratio is (1.7).

Table 1 Yield maximisation of castor through Best Management Practices

Particulars	BMPs	Farmers Practice
Soil and Water conservation Measures	Soil and water conservation measures for preventing runoff (bunding) Ridge and furrow method of planting	Flat bed
Seed hardening & Seed treatment	Seed hardening with bioinoculants (<i>Azospirillum/Azatobacter</i> +PSB @ 500 g/ha) protectants/seed treatment with recommended pesticide	Carbedndazim
Organics application	FYM@ 5t/ha	FYM@ 5t/ha
Weed Management	Recommended Integrated weed management module should be followed by respective centre (pre-em. spray of Pendimethalin 1 kg a.i./ha+ 2 times Mechanical intercultivation + one or two hand weedings)	2 times Cattle pair and one or two hand weedings
Crop nutrition	Soil test and targeted yield based NPK, S and Zn 80-40-30 kg N, P ₂ O ₅ , K ₂ O/ha	40-46-30 kg N, P ₂ O ₅ , K ₂ O/ha
Water management	Grow the crop under rainfed conditions. Apply need based irrigations at critical stages/use drip in irrigated centres.	Rainfed/need based lifesaving irrigation
Plant protection	Adopt IPM/IDM based module Propiconazole 1 ml/l against <i>Botryotinia</i> gray mold before and after cessation of rains	No spray
Harvesting	Harvesting at physiological maturity through secateurs	Break with hand
Threshing	Threshing by mechanical thresher	Trampling with cattle or beating with broad wooden sticks

Character association and genetic divergence study in elite breeding lines of groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Character association and genetic divergence were carried out in a set of elite breeding lines of groundnut. Pod yield/plant showed significant positive correlation with days to first flowering, plant height, total number of gynophores/plant and 100 kernel weight both at phenotypic and genotypic level. Biological yield and harvest index had higher positive correlation as well as direct positive effect with seed yield. Thirty genotypes were distributed into eight clusters out of which four were mono-genotypic. Cluster I consisted of 16 genotypes, whereas cluster II, III and IV consisted four, four and two genotypes respectively. Cluster VIII showed highest pod yield/plant followed by cluster IV. Inter cluster distance between cluster VI and VIII was highest, whereas lowest inter cluster distance was observed between cluster III and I. Pod yield /plant contributed maximum towards genetic divergence followed by yield (q/ha).

Keywords: Character association, Cluster analysis, Genetic divergence, Groundnut

Pod yield in groundnut is a complex trait and it is determined by mutual relationship among the component morpho-agronomic traits. Prior knowledge of the mode and extent of character association can help in effective selection and successful utilization of germplasm resources. More often unfavourable linkages among the agro-economic traits do exist resulting in genetic slippage and limited genetic advance. Besides, cross combinations having diverse parents are expected to exhibit wide range of genetic variation in recombination breeding. Therefore, an attempt has been made to study the extent of character association and to quantify the magnitude and nature of genetic divergence in a set of groundnut genotypes for their possible use in further breeding programme.

Twenty seven advanced breeding lines along with three check varieties (Devi, TAG-24 and Smruti) were sown in Randomized Block Design with three replications, each entry consisting of 4.5 m² area. Observations were recorded on fourteen morpho-agronomic traits including pod yield. Routine statistical procedures were followed for the analysis of variance and covariance (Singh and Choudhury 1976). The correlation coefficients for each pair of characters were computed following Al-Jibouri *et al.* (1958) and the path co-efficients (direct and indirect effects) were calculated as per Dewey and Lu (1959). Mahalanobis (1936) D² statistics was used for assessing genetic divergence among all the genotypes.

Inter-relationship between pod yield and component characters as well as inter se association provides information for choice of characters in selection programme (Prabhu *et al.*, 2015). The results revealed significant differences among the genotypes for all the characters studied except number of branches/plant and number of kernels/pod. Pod yield/plant showed significant positive correlation with days to first flowering, plant height, total no. of gynophores/plant and 100 kernel weight at both phenotypic and genotypic levels. Biological yield and harvest index had higher positive correlation as well as direct positive effect with

seed yield. Thirty genotypes were distributed into eight clusters out of which four are mono-genotypic and highly divergent as also reported by Vivekananda *et al.* (2015). Cluster I consisted of 16 genotypes, whereas cluster II, III and IV consisted of four, four and two genotypes respectively. Cluster VIII showed highest pod yield/plant followed by cluster IV. Inter cluster distance between cluster VI and VIII was highest, whereas it was lowest between cluster III and I. Pod yield /plant contributed maximum towards genetic divergence followed by yield (q/ha). The breeding lines e.g., ICGV-15412, ICGV-15425 and ICGV-06423 in Cluster I; ICGV-15423 in cluster III; ICGV-00440 in Cluster IV; and ICGV-86564 in Cluster VIII exhibited 20% higher pod yield than best check variety Devi. These high yielding genotypes belonging to different divergent clusters could be used immediately as parents in recombination breeding for genetic improvement in productivity.

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Studies on heterosis, correlation and genetic advance parameters for seed yield and its related traits in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]

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ABSTRACT

Twenty eight genotypes (21 F1 + 7 parents) of Indian mustard were evaluated for 10 traits *viz.*, days to 50% flowering, days to maturity, plant height (cm), length of main raceme (cm), number of siliquae/plant, number of primary branches/plant, number of secondary branches/plant, oil content (%), 1000-seed weight (g) and seed

yield/plant (g). Analysis of variance revealed that the genotypes differed genetically for all the characters and thus has helped in selection of parents for the breeding programmes.

Keywords: *Brassica juncea*, Diallel Mating Design, Heterosis, Indian mustard, Quantitative traits

Selection of parents is the first step in recombination breeding approach where the main goal will be to bring the complementary traits from the two parents together to obtain a line with combination of desirable traits. Understanding the genetics of the traits also help in formulating appropriate breeding strategies. Selection of lines based on important yield component traits that has an effective bearing on the final yield.

An experiment was carried out at Oilseed Research Farm, Kalyanpur of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, during *rabi* season 2019. 7-parents (Varuna, Pusa Bold, RH-30, RLM-198, PR-15, Urvashi and B-85) were crossed in diallel mating design (excluding reciprocal crosses). 28 genotypes (21 F1 + 7 parents) were evaluated for 10 traits *viz.*, days to 50% flowering, days to maturity, plant height (cm), length of main raceme (cm), number of siliquae/plant, number of primary branches/plant, number of secondary branches/plant, oil content (%), 1000-seed weight (g) and seed yield/plant (g). The data collected was subjected to appropriate statistical analysis.

Among the hybrids tested, high heterosis over better parent was observed in varuna x PR-15, Pusa Bold x RH-30, Pusa Bold x PR-15, RH-30 x RLM-198 and RH-30 x B-85. Heterosis over mid parent was observed for the F1s, varuna x RLM-198, varuna x B-85, RH-30 x RLM-198, RH-30 x B-85 and Urvashi x B-85.

Significant positive correlations were founds for seed yield/plant with days to 50% flowering, plant height, length of main raceme, number of siliquae/plant, number of primary branches/plant, number of secondary branches/plant, oil content and 1000-seed weight at both genotypic and phenotypic level.

The genetic advance in percent over mean (GAM) was estimated for all the characters which ranged from 5.30% for oil content to 21.32% for 1000-seed weight (g). The high values of GAM were also observed for primary branches/plant (21.13%), length of main raceme (14.52%), number of secondary branches/plant (14.16%), seed yield/plant (12.02%) and days to 50% flowering (10.44%).

Identification of fruit forms using CAPS marker among the oil palm indigenous germplasm

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ABSTRACT

In the present study we aimed at molecular identification of three fruit forms among indigenous oil palm germplasm. We have developed CAPS marker that could be used for distinguishing all the three fruit forms of oil palm at seedling stage which saves a lot of time and space. The developed marker system was tried with 50 indigenous oil palm germplasm and the developed CAPS marker identified 20 genotypes as dura, 22 as tenera, 8 as pisifera lines. The results showed that the markers identified are able to clearly characterize the dura and pisifera genotypes.

Keywords: CAPS marker, Dura, Oil palm, Pisifera, Tenera

Elaeis guineensis is a species of palm commonly called as African oil palm (or) Macaw fat. It is the principle source of palm oil. It is now naturalized in Madagascar, Sri Lanka, Malaysia, Indonesia, Central America, West Indies and several islands in India and pacific ocean (Corley and Tinker 2003). Generally fruit form identification is possible only after 4-5 years after fruit ripening. But by using CAPS marker, it is possible to identify the fruit form at seedling stage itself which saves time and space.

Fresh tender spear leaf samples of oil palm genotypes were collected for extraction of DNA. Mid rib of each leaflet was removed and middle portion of the leaflet, which has fewer veins, without pigment was taken for DNA extraction. The DNA was extracted using modified protocol of Babu *et al.* (2017). The forward and reverse sequences of the primers as reported earlier (Babu *et al.*, 2017) were synthesized and used. Thermal reactions were carried out in a reaction mixture (20 µl) consisting of 10X buffer (HiMedia), 2 µl having 15 mM MgCl₂, 0.2 mM of each forward and reverse primers, 2

µl of 2 mM dNTPs, 0.2 µl of 1 U of Taq DNA polymerase (Invitrogen, USA) and about 25-50 ng of template DNA. Ten µL of the PCR product obtained in the amplification with SHELL gene specific primer were digested with 10 U of different restriction enzymes (Genetix, USA) along with given specific buffer. Digestion was performed overnight at 37°C. The digested samples were run on the gel and scored.

In the present study, CAPS marker EgSHP Forward-TTGCTTTTAATTTTGCTTGAATACC, Reverse – TTTGGATCAGGGATAAAAGGGAAG were used for the identification of fruit forms. Among 50 samples, 20 are dura form, 22 are tenera form, 8 pisifera. Dura, tenera and pisifera represented 40%, 44% and 16% of total progenies. The agarose gel pattern of the progeny using CAPS marker given in figure 1. Similarly Ritter *et al.* (2016) have used a molecular marker system comprising of three primer pairs and two restriction enzymes that allowed differentiation of three different Sh alleles. The developed marker system has been

validated in dura and pisifera genotype from different origins which covered the standard gene pool that is being currently used by most of the oil palm breeders. Recently, Babu *et al.* (2017) also reported validation of the CAPS marker, on 80 D x P cross progeny lines, 60 lines of T x T cross progeny (Pisifera improvement block). All the results confirmed that the tenera genotypes had allele from both the dura and pisifera.

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GJG 32 High oil and high yielding Spanish bunch groundnut variety for Gujarat

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ABSTRACT

A Spanish bunch groundnut variety GJG 32 was evaluated in twenty locations over five years during rainfed *kharif* seasons of 2011 to 2016. This variety recorded an overall mean pod yield of 3392 kg/ha, which was higher than the check varieties viz., GG 7 (2766 kg/ha), GJG 9 (2765 kg/ha), and TG 37A (2816 kg/ha). The variety GJG 32 exhibited 22.61%, 22.64%, and 15.38% increase in pod yield over the check varieties viz., GG 7, GJG 9, and TG 37A, respectively. The kernel yield (2324 kg/ha) of GJG 32 over the check varieties viz., GG 7 (1932 kg/ha), GJG 9 (1983 kg/ha) and TG 37A (1990 kg/ha) was better and higher by 16.86% (GG 7), 14.67% (GJG 9) and 14.37% (TG 37A) over the checks respectively. GJG 32 recorded a mean 100-kernel weight of 35.9g, shelling out-turns of 68.5% and oil content 53.9%. This variety was resistant to tikka and rust diseases as compared to the check varieties whereas; it showed comparable reactions against major diseases. Due to its consistent superior performance over locations and years, GJG 32 has been proposed for release for general cultivation in the rainfed *kharif* groundnut growing areas Gujarat state.

Keywords: GJG 32, Groundnut, *Kharif*, Spanish bunch, Yield

Gujarat is the leading groundnut growing state and contributes nearly 25 to 30% of the area and production of total groundnut grown in the country. In *kharif* season, 60% area is covered under Virginia group while, 40% area is covered under Spanish bunch group of groundnut. The area under groundnut in Gujarat during 2016-17 was 17.59 lakh ha having 31.57 lakh tones production and a productivity of 1795 kg/ha (Anonymous, 2019). The Spanish bunch variety GJG-9 was released in 2010 at state level for *kharif* cultivation. Lack of recently released high oil and high yielding Spanish bunch varieties is the main problem. Hence, with the objective of replacing the old varieties and to

develop high oil and high yielding Spanish bunch varieties suitable for *kharif* cultivation in Gujarat state the breeding programme was taken up.

The Spanish bunch groundnut variety GJG 32 (ICGV 00343) was developed by hybridization [(F 334 A-B-14 x NCAc 2214) x ICG 2241) x (ICGMS 42 x Kadiri 3) x ICGMS 28 x (F 334A-B-14 x NCAc 2214)] x LI x (Robut 33-1-1-5) followed by pedigree method of selection at ICRISAT, Patancheru, Telangana. It was isolated from the segregating populations and evaluated for its yield performance. The genotype was tested in station trials at Junagadh during *kharif*, 2012 and 2013. Later, it was evaluated under multi location trials at 11

locations in Gujarat state during *kharif*, 2014 and 2015. It was screened for reaction to major pests (thrips, jassids and *Spodoptera*) as well as major diseases (rust, ELS, LLS, stem rot and collar rot) under field conditions. The recommended packages of practices were followed to raise the healthy crop. The yield data were analyzed as per randomized block design as suggested by Panse and Sukhatme (1985).

Over 20 testing trials, this variety has given 3392 kg/ha pods yield as compared to 2766 kg/ha (GG 7) and 2765 kg/ha (GJG 9) of pod yield in check varieties respectively. Pod yield increase over the two check varieties was 22.61% and 22.64% respectively. Mean kernel yield of GJG 32 was 2324 kg/ha, which was 16.86%, 14.67% and 14.37% higher over the check varieties GG 7 (1932 kg/ha), GJG 9 (1983 kg/ha) and TG 37A (1990 kg/ha), respectively in *kharif* seasons. The variety GJG 32 was resistant against tikka and rust diseases as compared to check varieties while, for stem rot and collar rot it was comparable to the check varieties under field conditions. Thus, the entry GJG 32

was recommended for general cultivation in the *kharif* bunchy type groundnut growing areas of Gujarat. The genotype also expressed higher oil content (52.47%) as compared to check varieties GG 7 (49.46%), GJG 9 (48.64%) and TG 37A (49.42%). Based on its consistent superior performance over locations and years, GJG 32 (ICGV 00343) has been released as for general cultivation in the *kharif* groundnut growing areas of Gujarat.

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Mean performance of newly developed restorer lines of sunflower (*Helianthus annuus* L.) for different agronomical traits

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ABSTRACT

The investigation was carried out at ICAR-Indian Institute of Oilseeds Research, Hyderabad. The material for present study consisted of 25 newly developed restorer lines including two checks. The data for agronomic and yield traits was recorded. Four genotypes namely CMS-1010B, RGP-58-P4-S2, RGP-26-P2 and RGP-26-P2-S2 were identified as the most promising for yield and yield contributing traits and can be utilized in hybridization program to realize high heterosis for these traits.

Keywords: Agronomic traits, Heterosis, Restorer lines, Sunflower

Sunflower (*Helianthus annuus* L.) as a source of vegetable oil is grown in many parts of India. Low productivity of the crop is a major problem hence development of new trait specific parental lines through population improvement is a need of the hour. With this background, the present investigation was aimed to identify promising inbreds for each trait among 25 genotypes for further utilization in heterosis breeding program.

The field experiment was conducted during *kharif*, 2019 at ICAR-Indian Institute of Oilseeds Research, Hyderabad. The material consisted of 25 inbred lines including existing maintainer (B) lines and newly developed restorer lines along with two checks (ARM-243B and RHA-6D-1). Each genotype was sown in 2 rows of 3 m length by adopting a spacing of 60 cm x 30

cm in Randomized Block Design in 3 replications. In each genotype, five plants were randomly selected and used for collection of data on yield and yield related characters like days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), 100 seed weight (g), seed yield per plant (g), volume weight (g/100 ml) and oil content (%).

The genotypes showed a large variability for all the traits studied. With respect to plant height, it ranged from 87 to 182.6 cm. The highest plant height was reported in ARM-243B whereas lowest was in RGP-50-P1-S4. In the case of head diameter, the range was 9.3 to 17.3 cm. For head diameter promising genotypes were RGP-21-P4-S-1-3 (17.3) and CMS-1010B (17.2). Days to 50% flowering ranged from 48-62 days. Among all the genotypes, RGP-21-P1 and RGP-30-P3-S1 (48 days)

were early and ARM-243B and HA-430B (62 days) were late. With respect to seed yield/plant the range was 1.86-19.8 g. Among all the genotypes the highest seed yield was obtained in RGP-26-P2-S2 (19.8 g), ARM-243B (17.6 g) and CMS-1010B (16.9 g), respectively. While in the case of 100 seed weight the range was from 3.2-6.7 g and highest among them was in CMS-234B (6.7 g) followed by RGP-30-P3-S1 (6 g) and RGP-44-P1 (6 g). For volume weight the range was from 26.5-44.4 g and the promising genotypes were RGP-50-P1-S4 (44.4

g/100 ml), RGP-58-P4-S2 (41.5 g/100 ml) and CMS-234B (40.65 g/100 ml). The range for oil content was found to be from 29.5-39.1%, among them the highest oil content was in new CMS-1010B (39.1%) followed by RGP-58-P4-S2 (38.4%) and RGP-26-P2 (37.7%) compared to best check RHA-6D-1 (36.5%) (Table 1). Results indicated that genotypes CMS-1010B, RGP-58-P4-S2, RGP-26-P2 and RGP-26-P2-S2 were promising for yield and yield contributing traits which can be exploited in hybrid breeding programmes.

Table 1 Range, mean and identified promising genotypes for different traits

Character	Range	Mean	Promising genotype
Plant height (cm)	87.0 - 182.6	122.0	ARM-243B (182.6 cm), HA-430B (161.5 cm), CMS-1010B (158.2 cm)
Head diameter (cm)	9.3 - 17.3	14.6	RGP-21-P4-S1-3(17.3 cm), CMS-1010B (17.2 cm)
Days to 50 % flowering	48 – 62	54	RGP-21-P1(48 days), RGP-30-P3-S1(48 days), HA-430B (62 days), ARM-243B (62 days)
Days to physiological maturity	78 – 92	84	RGP-21-P1 (78 days), RGP-30-P3-S1(78 days), HA-430B (92 days), ARM-243B (92 days)
Seed yield (g/plant)	1.86-19.8	9.3	RGP-26-P2-S2 (19.8 cm), ARM-243B (17.6 cm), CMS-1010B (16.9 cm)
100seed weight (g)	3.2 - 6.7	5.02	CMS-1010B (5.4 g), RGP-58-P4-S2 (5.8 g) and RGP-26-P2 (5.4 g)
Volume weight (g/100 ml)	26.5 - 44.4	35.6	RGP-50-P1-S4 (44.4 g), RGP-58-P4-S2 (41.5 g), CMS-234B (40.6 g)
Oil content (%)	29.5 - 39.1	33.7	CMS-1010B (39.1%), RGP-58-P4-S2 (38.4%) and RGP-26-P2 (37.7%)

Performance of newly developed sunflower inbred lines for yield and yield contributing traits under rainfed condition

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ABSTRACT

The present investigation was carried out at ICAR-Indian Institute of Oilseeds Research, Hyderabad. The material consisted of 25 newly developed mono and multi headed restorer lines. The data for agronomic and yield traits was recorded. The genotypes, COSF-6B, COSF-7B, RGP-11-P1-S2, RGP-58-P4-S1-1 and RGP-46-P3 were identified as the most important genotypes for different traits and should be utilized in hybridization program to realize high heterosis for yield and yield contributing traits.

Keywords: Genotypes, Heterosis, Hybridization, Sunflower, Traits

Involvement of genetically divergent parents in hybridization will result in enhanced vigour or heterosis in the resultant hybrid. With this background, the present investigation was carried out to identify promising inbreds for each trait among 25 inbred lines of sunflower for further utilization in hybrid breeding program.

The field experiment was conducted during *kharij*, 2019 at ICAR-Indian Institute of Oilseeds Research, Hyderabad. Twenty three inbred lines including existing maintainer (B) lines and newly developed restorer lines with two checks (ARM-243B and RHA-6D-1) were evaluated. Each genotype was sown in 2 rows of 3 m

length by adopting a spacing of 60 cm x 30 cm in randomized block design in 3 replications. In each genotype, five plants were randomly selected and used for collection of data on yield and yield related characters (days to 50% flowering, days to physiological maturity, plant height, head diameter, 100 seed weight, seed yield/plant, volume weight and oil content).

The genotypes showed a large variability for all the traits studied. Range and mean value for eight traits are presented in Table 1. RGP-50-P2 was early (45 days to 50% flowering) followed by RGP-61-P1 and RGP-32-P1 whereas RGP-60-P1 mono was medium (56 days to 50% flowering). Range for plant height was from 76.8 to 162.1 cm. Shortest height was reported in genotype RGP-21-P4-S3 (76.8 cm) followed by RGP-50-P2 (78.9 cm) and RGP-60-P2 Br (85.2 cm) while tallest was RGP-60-P1 N. Br (162 cm). Head diameter was in the range of 8.0 cm to 15.6. Four genotypes namely RGP-46-P3 (15.6 cm), FMS-852B (15.6 cm), CMS-38B (15.5

cm), COSF-7B (15.4 cm) were found promising for head diameter. On the basis of days to maturity, all entries were in the range of 75 days (RGP-50-P2) to 89 days (RGP-21-P4 and COSF-3B). 100 seed weight range was from 1.9 g (RGP-21-P4-S2) to 6.1g (ARM-248B). Volume weight was in the range of 22.8 g/100ml (RGP-32-P1) to 40.0 g/100ml (COSF-7B). Seed yield/plant was in the range of 3.7 g to 24.8 g. Highest seed yield was observed in RGP-46-P3 (24.8 g) followed by RGP-60-P1 NBr (18.9 g) and COSF-3B (17.6 g). Oil content the range was from 27.2% to 39.3%. Highest oil content was reported in RGP-58-P4-S1-1 (39.3%) followed by RGP-11-P1-S2 (39.2%), COSF-6B (38.8%) and COSF-7B (37.6%). Results indicate that genotypes COSF-6B, COSF-7B, RGP-11-P1-S2, RGP-58-P4-S1-1 and RGP-46-P3 were promising for yield and yield contributing traits which could be exploited in hybrids breeding program.

Table 1 Range, mean and promising genotypes for different traits

Character	Range	Mean	Promising genotype
Plant height (cm)	76.8-162.1	116.4	RGP-21-P4-S3 (76.8 cm), RGP-61-P1Br (88.0 cm), RGP-60-P2 Br (85.2 cm), RGP-60-P2NBr (98.4 cm), RGP-50-P2 (78.9 cm)
Head diameter (cm)	8.0-15.6	11.9	RGP-46-P3 (15.6 cm), FMS-852B (15.6 cm), CMS-38B (15.5 cm), COSF-7B (15.4 cm)
Days to 50% flowering	45-61	53.2	RGP-50-P2 (45 days), RGP-21-P8 (51 days), RGP-32-P1 (51 days) COSF-6B (52 days), COSF-7B (52 days)
Days to physiological maturity	75-89	83.2	RGP-50-P2 (75 days), RGP-21-P8 (81 days), RGP-32-P1 (81 days) COSF-6B (82 days), COSF-7B (82 days)
Seed yield (g/plant)	3.7-24.8	12.1	RGP-46-P3 (24.8 g), RGP-60-P1 NBr (18.9 g), COSF-3B (17.6 g), RCR-72 (18.5 g)
100 seed weight (g)	1.9-6.1	3.9	COSF-6B (4.2 g), COSF-7B (5.5 g), RGP-11-P1-S2 (4.2 g), RGP-58-P4-S1-1 (3.6 g)
Volume weight (g/100 ml)	22.8-40.0	32.5	COSF-6B (39.9 g), COSF-7B (40.0 g), FMS-852B (36.7 g)
Oil content (%)	27.2-39.3	34.0	COSF-6B (38.8%), COSF-7B (37.6%), RGP-11-P1-S2 (39.2%), RGP-58-P4-S1-1 (39.3%)

Genotype x environment interaction through AMMI analysis in sesame genotypes

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ABSTRACT

The present study investigates the magnitude of GxE interaction and stability of sesame genotypes over the environments. The results indicated that for seed yield/plant, the ASV values ranged from 0.186 to 2.363. Accordingly, genotypes SAVITRI, TMV-4, SSD-5, DSS-9 and RAJESHWARI were considered to be most stable, while YLM-17, CHANDANA, NIRMALA, USHA and PT-1 were less stable genotypes.

Keywords: Analysis, Environments, Sesame, Yield stability

To improve the production and productivity of sesame in India, evaluation of genotypes across different environments or the G x E interaction study might be important for supplying area specific or widely adapted improved seeds. Thus, the present investigation was carried out to determine the magnitude of G x E interaction and stability of sesame genotypes over the environments.

The present investigation consisted of sixty sesame genotypes collected from PC UNIT (Sesame & Niger), JNKVV Jabalpur and the trial was conducted in four environments during both *kharif* and summer season during 2017 and 2018. The seed yield data were subjected to AMMI analysis which combines analysis of variance (ANOVA) with additive and multiplicative parameters in to a single model.

The AMMI model for seed yield detected significant variation ($p < 0.001$) for both the main and interaction effects indicating the existence of a wide range of variation between the genotypes, seasons and their interactions. The genotype, environment and genotype x environment interaction accounted for 17.87%, 14.15% and 67.99% of the total variation, respectively. The AMMI model extracted two significant ($p < 0.001$) IPCAs from the interaction component which accounted for 44.78% and 35.09% of the total G x E interaction sum of squares percentage for both IPCA1 and IPCA2, respectively.

According to AMMI1 biplot, genotypes SWETHA TIL-1, YLM-11, TMV-4 and KANAK were identified as stable. In AMMI 2 biplot, the genotypes SAVITRI was nearer to IPCA origin, it was considered stable over environments.

Genotypes adaptability and stability analysis: The average seed yield of the tested sesame genotypes over the four environments was 10.98 g/plant. Genotype

TMV-7 (17.31 g/plant) had the highest average yield followed by N-8 (13.94 g/plant) and Vinayak (13.17g/plant) while, DSS-9 (7.49 g/plant) was the poorly yielding genotype. Genotypes with greater magnitude of IPCA1 such as Chandana (1.832), Usha (1.811) and Nirmala (1.713) were the more responsive and contributed largely to the interaction component and may be considered as specifically adapted genotypes.

AMMI Stability Value (ASV) analysis: For seed yield/plant, the ASV values ranged from 0.186 to 2.363. Accordingly, genotypes SAVITRI, TMV-4, SSD-5, DSS-9 and RAJESHWARI were considered to be most stable, while YLM-17, CHANDANA, NIRMALA, USHA and PT-1 were less stable genotypes. AMMI analysis has been carried out in sesame genotypes of Ethiopia (Fiseha *et al.*, 2014).

Environmental performance and stability: The environments had different mean seed yields and this indicates that the different environments were not equally favorable or unfavorable for the genotypes grown under them. Accordingly, E1 had a negative environmental index (-2.022) and was classified as the least favorable environment while E2 had the highest positive environmental index (1.663) and considered as the most favorable environment. In general E1 and E4 both with negative environmental index were considered as unfavorable environments and E2 and E3 with positive and significant environmental index were classified as favorable environments.

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Effect of intermittent water stress on oil quality in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

An RIL population generated from the cross TMV-2 × GM 6-1 was evaluated by imposing intermittent water stress during post-flowering crop growth of consecutive seasons of summer 2013 and 2014 at the UAS, Dharwad. Intermittent water stress had positive effect and mean of traits increased for oleic acid content, oleic to linoleic acid ratio. Moderate GCV, PCV, high heritability together with moderate to high GAM were noticed for oleic acid, linoleic acid, oleic/linoleic acid ratio indicating less influence of environment and ample scope in selection of these traits.

Keywords: Drought, Groundnut, Intermittent

Intermittent drought is more scattered, irregular and most common type of drought affecting groundnut productivity in the rainfed regions of semi-arid tropics in Andhra Pradesh. Groundnut, being a key legume crop, mainly grown for oil purpose. Hence, effect of water stress on oil quality is a prime issue to be addressed.

The experimental material for this investigation was a set of 299 RILs generated from TMV-2 x GM 6-1 cross. This material was evaluated in raised beds along with the parents and checks in a factorial experiment in RCB design with two replications under both well watered (WW) and water stress (WS) conditions during consecutive seasons of summer 2013 and summer 2014.

Intermittent water stress showed positive effect on oleic acid content, oleic to linoleic acid ratio and increased the mean of these traits while negative effect was noticed for total oil content and linoleic acid during both seasons. Contrast to these traits, total protein content was affected by water stress in consecutive seasons indicating larger G x E interaction.

Low PCV and GCV for oil content and protein content during both the seasons as represented in Table 1 indicates low variation in the population for the traits which may be due to the little variation in the parents for

these traits used for development of the RILs. Moderate GCV and PCV were observed for oleic acid and linoleic acid contents in both the seasons. Whereas, high PCV and GCV for O/L ratio was observed during both the seasons indicating wide variability for these traits as represented by the wide variation among parents.

High heritability and moderate to high GAM during both the seasons for most of the oil quality traits viz., oleic acid, linoleic acid, oleic/linoleic acid ratio indicated less influence of environment and ample scope in direct selection of these traits. Similar studies have been reported earlier (Sarvamangala *et al.*, 2010; Noubissie *et al.*, 2012)

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Table 1 Mean, Range and Genetic parameters for oil quality traits in groundnut RILs of TMV-2 x GM 6-1 population during summer 2013 and 2014

Character	Season	Mean of WW	Mean of WS	Range in WW treatment	Range in WS treatment	PCV (%)	GCV (%)	h ² (Broad Sense)	GA	GAM
Total oil content	S-2013	47.19	44.32	51.03-43.14	48.44-39.89	3.74	3.62	93.34	3.29	7.2
	S-2014	47.18	45.21	50.73-43.47	53.78-40.12	3.17	3.02	90.97	2.74	5.93
Total Protein Content	S-2013	30.7	32.91	38.72-24.96	42.22-28.17	6.5	6.22	91.51	3.9	12.26
	S-2014	33.43	33.17	40.56-28.65	42.84-24.63	5.43	5.1	88.46	3.29	9.89
Oleic acid	S-2013	45.97	50.87	75.31-31.28	79.51-37.41	14.8	14.55	96.65	14.27	29.46
	S-2014	45.96	51.08	73.39-31.97	77.78-38.89	13.38	13.1	95.86	12.82	26.41
Linoleic acid	S-2013	31.28	27.96	43.19-6.62	39.56-7.44	18.41	18.01	95.69	10.75	36.28
	S-2014	31.58	27.5	43.47-6.73	37.99-6.36	18.98	18.6	96	11.09	37.54
O/L	S-2013	1.62	1.99	12-0.74	10.03-1.01	53.52	50.05	87.43	1.74	96.4
	S-2014	1.6	2.05	11.5-0.74	11.61-1.02	57.94	54.32	87.9	1.92	104.92

Studies on combining ability and heterosis for seed yield and its attributing traits in sunflower

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ABSTRACT

Field experiment was conducted to estimate the combining ability and heterotic effects of sunflower hybrids. Twelve lines and six testers were crossed in Line×Tester mating design to generate 72 hybrids, which were further evaluated in *kharif* summer 2018 along with checks KBSH-41, KBSH-42, KBSH-44 and KBSH-53 at UAS, GKVK, Bengaluru. The seed parent, CMS 17B was a better general combiner for stem diameter, head diameter, seed yield/plant, hundred seed weight and oil content followed by CMS103B (B). The tester, RHA 95 C-10 was identified as desirable general combiner for stem diameter, head diameter, seed yield/plant, volume weight, hundred seed weight, oil content and oil yield. The cross combination CMS 335 A × RHA 95 C10 exhibited better per se

performance and standard heterosis for seed yield/plant and oil content followed by CMS 56 A × RHA GMU 762 and CMS 911 A × RHA GMU 755. Further the lines (CMS 17, CMS 335, CMS 597) and the testers (RHA 95C-10, RHA 278) should be preferentially used in hybrid development and testing for commercial exploitation. The cross combinations like CMS 335A × RHA 95C-10 and CMS 911A × RHA GMU 755 with high SCA need to be confirmed for their superiority by large scale testing as multi locational trials.

Keywords: Combining ability, GCA, Heterosis, Hybrids, SCA, Sunflower

Sunflower oil is an abundant source of (PUFA) polyunsaturated fatty acids like linoleic acid (55 to 60%) and oleic acid (25 to 30%) hence, considered as good quality oil which is known to reduce the risk of coronary diseases. A study was conducted identify good parents to generate high yielding hybrids in sunflower.

The experiment was conducted at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru. The experimental material comprised of twelve cytoplasmic male sterile lines derived from the *Helianthus petiolaris* source were used to cross with the six RHA lines in Line × Tester fashion (Kempthorne, 1957) during *rabi*/summer 2018.

The resultant 72 hybrids along with the checks *viz.*, KBSH-41, KBSH-42, KBSH-44 and KBSH-53 were evaluated in RCBD during *kharif* 2018. Simultaneously, 18 parental lines were evaluated in separate trial following RCBD during *kharif*. The evaluation of the hybrids and the parents was conducted in separate trials, as the hybrids are more vigorous compared to parents and may suppress the expression of the parents.

The ANOVA revealed there existed highly significant differences among genotypes, parents, lines, crosses and parents v/s crosses for all the traits under the study. Within the parents, the testers showed highly significant variances for all the traits except days to 50% flowering and stem diameter. Significant variances for parents vs crosses suggested the presence of heterotic effects in breeding material, indicating the use of these parental lines for the development of hybrids. Significant variances due to lines, testers and between lines vs testers were also reported by Khandagle *et al.* (2013) and Sapkale *et al.* (2016) on PET 1 based sunflower.

Five lines showed significant negative gca effects for days to 50% flowering i.e. CMS 597 B (-1.79), CMS 103 B (B) and CMS 850 B both the lines exhibited the same gca effect of -3.20. The testers RHA GMU 755 (-0.75) exhibited significant negative gca effects followed by RHA GMU 755 (-0.70). Out of the six lines that showed gca effects in desirable direction for plant height, the top two lines are *viz.*, CMS 275 A (-1.66) and CMS 59 A (-4.88) and the testers *viz.*, RHA GMU 762 (-5.82), RHA-278 (-3.69), RHA GMU 755 (-1.53) and RHA GMU 763 (-1.39) exhibited gca effects in desirable direction.

Four lines exhibited significant positive gca effects for head diameter among which the highest gca of 1.48 was exhibited by CMS 103 B (B) and the only tester that exhibited significant positive gca effect is RHA GMU 755 (1.35). Six lines exhibited significant positive gca effect

for seed yield/plant. The line CMS 17 B (8.63) exhibited highest gca effects and the testers RHA 95 C 10 (2.81) followed by RHA-278 (0.79) for seed yield/plant

The line CMS 335 A followed by CMS 850 A registered the highest gca effects of 1.74 and 1.26 respectively for oil content and the tester RHA GMU 756 exhibited highest gca of 0.8.

Among the seed parents utilized in the current investigation, the lines that appeared to be desirable general combiners for multiple traits of which the line CMS 17 A showed desirable direction for volume weight, head diameter, seed yield/plant, test weight and stem diameter. Another well performing line, CMS 103 (B) was found to exhibit desirable gca effects for days to 50% flowering, plant height, head diameter, seed yield/plant and hundred seed weight. Among the testers, RHAGMU755 appeared to be desirable general combiner for days to 50% flowering.

Twenty four hybrids exhibited negative significant sca effects for flowering among which CMS 56 A × RHA GMU 756 manifested highest sca effect of (-6.66) followed by CMS 597 A × RHA 95 C 10 with sca effect of (-4.41). The cross-combination CMS 335 A × RHA 95 C 10 with sca of 25.53 topped among the hybrids followed by CMS 911A × RHA GMU 755 with sca effect of 17.98 for seed yield/plant. The hybrids CMS58A × RHA 278 (5.68) and CMS 103 A × RHA 95C 10 (2.63) exhibited highest significant sca effects for oil content. Among the 72 hybrids generated in the current investigation, the cross combination CMS 335 A × RHA 95 C-10 was found to be desirable for maximum number of traits *viz.*, head diameter, test weight, days to 50% flowering, 100 ml volume weight, oil content and stem diameter. It is interesting to note that, another hybrid CMS 911 A × RHA GMU 755 performed in desirable direction only for stem diameter and head diameter despite of exhibiting higher sca effects for seed yield.

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High zinc density groundnut cultivars: A solution to Zn malnutrition

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ABSTRACT

Analysis of a number of groundnut cultivars for several years showed variation in Zn concentration in seed with year, field and crop responsiveness to Zn fertilizers. Its concentration ranged from 21 to 67 mg/kg with a mean value of 42 mg/kg and with application of 1-2 kg Zn, increased to 24-78 mg/kg with a mean of 49 mg/kg. Twenty high Zn density groundnut cultivars with more than 50 mg/kg were identified for use as food.

Keywords: Essential nutrient, Groundnut, Human health, Malnutrition, Uptake, Zn

Zinc is an essential nutrient for human health and nearly half of the world population, is at the risk of its deficiency. Groundnut, an important food legume with high energy and protein, with 2-3 times higher Zn than cereals can be a solution to combat the Zn malnutrition (Lal and Singh 2007; Singh *et al.*, 2018). Through a number of experiments, efforts were made to identify high Zn density groundnut cultivars to be used as food.

A total of 190 groundnut cultivars were studied during last 10 years with and without application of Zn (1-2 kg/ha, Zn as zinc sulphate) at ICAR-DGR farm in a medium black calcareous clayey soil containing 1.2-1.4 mg/kg DTPA extractable Zn under recommended package of practices. Seed samples were analyzed for Zn content using atomic absorption spectrophotometer. Based on the mean and standard deviation (SD) values of seed Zn concentration, cultivars were categorized as high, medium and low in Zn density.

For first five years, 100-110 older cultivars with medium seed size were tested for seed Zn concentration that ranged from 30 to 65 mg/kg with an average of 45 mg/kg without Zn. With application of 2 kg/ha Zn, content increased to 39-78 mg/kg with a mean of 51 mg/kg and the cultivars above 55 mg/kg were categorised as high Zn cultivars.

Later, 170-190 newer cultivars with larger seed were studied and seed Zn content ranged from 21 to 67 mg/kg with a mean of 40 mg/kg which with application of Zn increased to 24-76 mg/kg with a mean of 48 mg/kg and the cultivars above 50 mg/kg were categorised as high Zn cultivars in this group. Among these, 20 cultivars *viz.*, GG 7, CO 2, CO 1, ICG (FDRS) 4, R 9251, MH 1, VRI (GN) 6, MH 4, OG 52-1, GG 20, Gangapuri, Kopargaon 3, Jyoti, Tirupati 4, CSMG 884, SB XI, ICGV 86590, GJG 31, Kadiri 5, VRI 2 recorded consistently >50 mg/kg Zn under balanced nutrition. These high Zn density cultivars need extensive cultivation and consumption as food to combat Zn malnutrition.

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Evaluation of different mustard varieties under northern Telangana zone

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ABSTRACT

A field experiment was conducted to identify suitable variety among 6 mustard varieties (NRCHB 101, RH 406, DRMRIJ 31, NRCDR 2, Black gold and Local variety) in terms of growth characteristics, yield and its attributing components in a randomized block design (RBD) at Regional Agricultural Research Station (RARS), Jagtial, during *rabi* seasons of 2017-18 and 2018-19 respectively. The result of the experiment revealed that among six varieties Black gold variety (1474 kg/ha) recorded significantly superior yield over other varieties and it was on par with NRCHB 101 (1369 kg/ha).

Keywords: Mustard, Oilseeds, Randomized block design, Varieties

Oilseeds play a pivotal role in Indian economy, accounting for 5% of the gross national product and 10% of the value of agricultural products. Amongst the oilseed crops, rapeseed-mustard (*Brassica* spp.) ranks second in area next only to soybean in India as well as in the world. It is cultivated in an area of 5.74 m ha with an average production of 6.79 m t with productivity of 1.18 t/ha, while in Telangana it is grown in an area of 0.01 m ha with production of 0.02 m t and productivity of 2.00 t/ha (CMIE, 2016). In districts of northern Telangana, viz., Adhilabad, Jagtial, Karimnagar and Nizamabad, it is grown as a *rabi* crop. Improved varieties have been evolved, which can yield better than local cultivable varieties with best agronomic practices. In this connection, there is an urgent need to identify suitable mustard varieties for Northern Telangana Zone. Four mustard

genotypes from ICAR-DRMR, Rajasthan and two checks (Local and Private variety of Black gold) were evaluated in a randomized block design with three replications at Regional Agricultural Research Station, Polasa, Jagtial during *rabi* 2017-18 and 2018-19 (Somondal, 2012).

Among six varieties the variety 'Black gold' (1474 kg/ha) recorded significantly superior yield over other varieties except for NRCHB 101 which was on a par with 'Black gold'. The seed yield of this genotype was 1369 kg/ha.

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Table 1 Yield and its attributes of different mustard varieties during *rabi* 2017-18 and *rabi* 2018-19

Variety	Plant height (cm)	Number of primary branches/plant	Number of siliquae/plant	Seed yield (kg/ha)
NRCHB 101	138	4.1	137	1369
RH 406	151	3.5	107	1129
DRMRIJ 31	133	3.7	116	1233
NRCDR 2	149	3.8	125	1255
BLACK GOLD	148	4.2	181	1474
LOCAL	138	3.8	118	1241
SEm ±	5.8	0.1	13	61
CD (P = 0.05)	NS	0.3	41	193

Transgressive segregation for high shelling percentage in summer groundnut (*Arachis hypogaea* L.)

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ABSTRACT

The present investigation on transgressive segregation for high shelling percentage in summer groundnut (*Arachis hypogaea* L.) was undertaken to study eight characters. The crosses were evaluated during summer, 2017, in a randomized block design with three replications. Observations were recorded on number of mature pods/plant, dry pod yield/plant (g), dry haulm yield/plant (g), 100- kernel weight (g), shelling outturn (%), oil (%) and protein (%) contents, sound mature kernel (%). On the basis of performance of transgressive segregants, it was concluded that, transgressive breeding can be successfully used to extend the limit of expression of traits. This could be possible by accumulation of favourable genes in hybrid derivatives from both parents involved in hybridization. The superior segregants may be identified as improved varieties after adequate evaluation or used in future breeding programme for amalgamation of desired genetic constellations.

Keywords: Groundnut, Shelling percentage, Summer, Transgressive segregants

Production of transgressive segregants for yield and its components like dry pod yield, harvest index and mature pod number, plays a vital role in breeding programme of groundnut. Although transgressive segregants include lines which fall outside the range of performance of either parents, but only those being superior to better parent in desirable direction are of practical value. The present study was undertaken to access transgressive segregants in a set of groundnut genotypes irrespective of their growth habit for yield and other component characters.

The material used in the present study consisted of two crosses involving two female, ICGS-11 and TAG-24 and one male parent, SB-XI. The crosses and F₁'s were raised along with parents during 2016 at AICRP on groundnut. The experiment was conducted in a randomized block design with three replications. Each plot consisted of 5 row of 5 m length with a spacing of 30 cm between rows and 10 cm between plants. One border row was sown at both the sides of block to reduce the border effect. The parents and F₂ generations of two crosses for the transgressive segregation were used for conducting an experiment during summer 2017. Eight agronomic characters, individually and for combination of characters along with number of mature pods per plant, have been observed separately for each of the two crosses namely, ICGS-11xSB-XI (Cross 1) and TAG-24xSB-XI (Cross 2).

With respect to transgressive segregants for dry pod yield/plant in the cross ICGS-11 x SB-XI, plant No.246 was found to be most promising as it has given 23.72 per cent more number of mature pods/plant in addition to higher expression of shelling (%), 100 kernel weight (g), dry haulm yield (g) per plant and oil (%) than the increasing parent (Table 1). Besides, this transgressant had higher intensity of expression than the increasing parent for one character and also higher value for all characters

than decreasing parents. The transgressive segregants No.297 was most promising in cross TAG-24 x SB-XI which out yielded the better parent by 23.94 per cent more number of mature pods per plant in addition to higher expression of dry haulm yield, dry pod yield per plant, 100 kernel weight (g), shelling percentage and sound mature kernel. These segregants had higher values for all other traits than the decreasing parents (Girase and Deshmukh, 2002).

On the basis of performance of transgressive segregants, it is concluded that transgressive breeding can be successfully used to extend the limit of expression of characters. This could be possible by accumulation of favourable plus genes, in a hybrid derivatives from both parents involved in hybridization. In most of the transgressive segregants, in each of the two crosses, better parent yield was transgressed simultaneously with transgression of one or several other characters. Simultaneous transgression of number of mature pods per plant in association with dry pod yield per plant, dry haulm yield per plant was observed more frequently (Smith, 1966). It may be that either number of mature pods per plant is dependent on this character or there may be linkage drag so that genes responsible for these characters move together. These transgressants needs to be evaluated further for their consistency in their performance.

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Table 1 Promising transgressive segregants having combinations of desirable attributes

Characters	Plant No.	NMP	DHY	DPY	100 K	SH (%)	SMK (%)	Oil (%)	Protein (%)	% yield increased over increasing parent
Cross-1 : ICGS-11 x SB-XI										
F ₂	246	28	34.00*	18.00	34.24*	72.22*	92.00	46.63*	22.68	23.72
ICGS-11		22.40	25.47	17.60	32.00	66.42	90.97	46.12	22.02	
SB-XI		20.63	25.33	18.70	30.96	69.05	90.17	46.10	22.66	
Cross-2 : TAG-24 x SB-XI										
F ₂	297	25.00	35.00*	23.00*	34.58*	72.31*	95.00*	48.11	22.36	23.94
ICGS-11		17.20	21.90	16.80	30.85	67.36	90.30	46.71	22.79	
SB-XI		20.17	25.33	18.33	30.96	68.84	90.10	46.90	23.21	
1) NMP = No. of mature pods; 2) DPY = Dry pod yield (g)/plant; 3) DHY = Dry haulm yield (g)/plant; 4) SMK = sound mature kernel;										
5) SH % = shelling percentage; 6) 100K = weight of 100 kernel (g) * Intensity of expression of character higher than the increasing parent										

Response of castor (*Ricinus communis* L.) to polymeric bio-formulation based seed coating for drought stress

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ABSTRACT

Polymer based bio-formulations for seed treatment is one of the strategies to mitigate drought stress. Drought tolerant strain of *Trichoderma asperellum* N13 (TN13) along with polymers was evaluated in castor under drought conditions in both glass house and field.

Keywords: Bio-formulation, Castor, Polymer, *Trichoderma*

Polymers are derived from bio-macromolecules such as polysaccharides and have emerged as promising materials for multifarious applications owing to their porous structure, bio-degradability and bio-compatibility, and good mechanical integrity. Cross linked polymers which can form networks for active ingredients are finding extensive applications in drug-delivery systems (Jin *et al.*, 2007).

Bio-polymer type of delivery system involving drought tolerant *Trichoderma asperellum* N13 (TN13) was immobilized in polymers which can create a protective micro-environment around the seed, assuring adhesion of microbe to seed and may improve the plant growth (Chandrika *et al.*, 2019). These materials were evaluated in castor under drought conditions in both green house and field.

The polysaccharides: cross linkers (1:0.33% w/v) was prepared by dissolving in distilled water. Plasticizer was added to the above liquid and was kept on magnetic stirrer overnight at 60-80°C and 300 rpm. The blended system was utilized for *Trichoderma* dry impregnation of conidial spores @ 1% w/v (10^{8-10} CFUs). This combination was treated to castor seeds (Hybrid DCH-519) @ 10 ml/kg. In greenhouse conditions, watering was withheld from first true leaf stage of seedling till 9th day (drought stress). Data on vigour, dry weight, chlorophyll content, relative water content (%), membrane stability index were recorded on 9th day from

first true leaf stage. Under field conditions, irrigation was withheld from 30-90 Days after sowing (drought stress). Seed yield of different spike orders were recorded.

Castor seedlings showed greater vigour index when seed was coated with TN13 + polymer (4390) than untreated control (1755) under drought stress conditions. Similar trend was noticed with respect to total dry weight (g/plant), SCMR, membrane stability index and relative water content (%) (Table 1). Under field conditions, seed coating with TN13 + polymer combination recorded greater seed yield (45.6 g/plant) than untreated control (25.7 g/plant) from the harvest of primary spike. The reduction in seed yield with TN13 (32.2%) and TN13 + polymer (33.9%) seed coating was less compared to untreated control (40%) (Table 2) under drought stress conditions.

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Table 1 Castor seedling response seed treatment (TN13 + polymer) both under irrigated and drought stress conditions (glass house study)

Treatments	Vigour index	Total dry weight (g/plant)	SCMR	Membrane Stability Index	Relative water content (%)
Control (Irrigated pots)					
Untreated control	1510	0.36	44.8	66.6	88.8
TN13 + polymer	3800	1.18	45.0	84.6	91.7
Drought stress					
Untreated control	1755	1.56	48.5	34.5	68.6
TN13 + polymer	4390	2.78	50.8	77.1	71.4

Table 2. Castor response to seed treatment (TN 13 + polymer) under drought stress conditions (field study)

Treatments	Reduction in yield (%)	Drought susceptibility index (DSI)
Untreated control	40.0	1.0
TN13	32.2	1.2
TN13 + polymer	33.9	1.2

Influence of conservation agricultural practices on performance of castor (*Ricinus communis* L.) based intercropping systems in shallow Alfisols under rainfed conditions

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ABSTRACT

A fixed-plot field experiment was initiated during *khariif* 2018 to study the influence of conservation agricultural practices on performance of castor based intercropping systems in rainfed Alfisols. Different tillage practices (conventional tillage, reduced tillage and zero tillage) did not show significant influence on growth, yield attributes, seed yield and quality of castor. Seed yield of castor was significantly influenced due to different intercropping systems under the background of conservation agricultural practices. Sole castor recorded significantly higher castor seed yield (1064 kg/ha) followed by castor + groundnut (813 kg/ha); castor + greengram and castor + redgram (635 kg/ha).

Keywords: Castor, Crop residues, Reduced tillage, Zero tillage

In India, conservation agriculture (CA) adoption is still in the initial phases. Though, a host of benefits can be achieved through employing components of conservation agriculture but the development of CA practices for oilseed based production systems in general and castor based cropping systems in particular are very limited and has to be addressed on priority.

A fixed-plot field experiment was initiated during *khariif* 2018-19 at ICAR-Indian Institute of Oilseeds Research, Hyderabad on Alfisols under rainfed conditions. The eco-region is characterized as semi-arid tropical (SAT) climate and the soil has been classified as red sandy loam. Initial soil fertility analysis indicated that the soil reaction (pH 8.1) and salinity levels (EC 0.29 dS/m) are normal for the cultivation of oilseed crops. The experimental soil was low in O.C (0.38%) available N (212 kg/ha); medium in available P (17.2 kg/ha) and high in available K (280 kg/ha).

Three tillage treatments viz., conventional tillage - one disc plough+ two cultivators + rota tiller; reduced tillage - one cultivator + one rota tiller (no disc plough); zero tillage - no tillage and herbicidal weed management in main plots and four intercropping systems in sub-plots viz., sole castor; castor + redgram (for grain and the plant cut and *in situ* spread) (1:1); castor+ greengram (for grain and uprooted and *in situ* spread) (1:3) and castor + groundnut (1:3) were imposed in shallow Alfisols. Sowings were taken up in zero and reduced tillage treatments through till-planter cum herbicide applicator designed especially for zero and reduced tillage conditions.

During the crop growth period a rainfall of (454 mm) was received in 42 rainy days as against normal (730 mm in 51 days) resulting in about 38% deficit rainfall. Long dry spell during seed filling stage coupled with high temperatures (36-38°C) has influenced the performance of castor and associated crops.

Different tillage practices did not show significant influence on growth, yield attributes and seed yield of castor under rainfed conditions. Sole castor recorded significantly higher castor seed yield (1064 kg/ha) followed by castor + groundnut (813 kg/ha); castor + greengram and castor + redgram (635 kg/ha) intercropping systems.

Soil moisture content was relatively higher in conventional tillage systems (16.2% at 0-15 cm; 18.7% at 15-30 cm depth respectively). The lowest soil moisture content was recorded in zero-tillage system (13.4% at 0-15 cm and 16.1% at 15-30 cm). Among inter cropping systems; at 0-15 cm depth, castor-groundnut recorded highest soil moisture content (15.8%). This was followed by castor + greengram (15.6 %), sole castor (14.2%) and castor + redgram (13.6%). Similar trend followed at 15-30 cm soil depth.

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Low temperature stress dictates the success of rice fallow sesame in Odisha - An analysis

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ABSTRACT

Rice fallow areas are the potential regions for extending the oilseed area horizontally to utilize the residual moisture and nutrients. The temperature regimes in the region dictates sesame sowing. An analysis of the temperature profile in the chief sesame growing region *viz.*, Mahisapet (Dhenkanal) has indicated that the minimum temperature prevailed during the months of December and January provides low temperature induced stress for sesame in this region. The minimum temperature recorded during the month of December during 2016, 2017 and 2018 were 15.4, 13.2 and 13.7°C respectively, while in January it still dropped to 13.5, 11.1 and 11.5°C respectively. Concerted research efforts are needed to develop new technologies for this low temperature management.

Keywords: Germination, Low temperature, Rice fallow, Sesame

Rice fallow/follow sesame in the state of Odisha is an opportunity for horizontal expansion of sesame area and its production in the country. Unlike rice fallow pulses cultivation, sesame cultivation needs specialized efforts to enhance the productivity. Major districts under sesame in Odisha are Angul, Malkangiri, Sundargarh, Sambalpur, Dhenkanal and Bolangir where in Angul and Dhenkanal have summer irrigated sesame crop. In the true sense, the system is not rice fallow rather rice follow *i.e.*, rice-sesame cropping system. The rice system in the Mahisapet, the traditional sesame belt was analyzed in terms of rice and sesame cultivation. Different weather data of the December and January months of 2016, 2017 and 2018 was analyzed which was collected from agro-meteorological observatory, Mahisapet. In Mahisapet, Odisha, the rice fallow is the result of 150 days rice which is harvested during November. To utilise residual nutrients and the moisture immediately after rice harvest, sesame needs to be seeded in cold, wet soil immediately after rice harvest which are not suitable for germination of sesame. The annual sesame area of Odisha hovers around 203 thousand ha. A snapshot of the minimum temperature prevailed during the months of December and January

have described the low temperature induced stress for sesame in this region. The minimum temperature recorded during the month of December during 2016, 2017 and 2018 are 15.4, 13.2 and 13.7°C, respectively, while in January it was 13.5, 11.1 and 11.5°C respectively. Since the low temperature induced stress couldn't allow the sesame to germinate, the land remains fallow for another 45 days so that the temperature crosses 15°C. As a sequel, no tillage sowing of sesame becomes practically impossible. Hence, farmers do go for conventional ploughing and by the time soil moisture is lost. Unlike pulse crops sown in the standing rice crop just 5-7 days before harvest, the sesame seed ecology does not fit to the microclimate and the sesame crop is poorly adapted to rice fallow regime (Harisudan and Sapre, 2019). Our analysis has indicated that concerted research efforts are needed to develop new technologies for this low temperature management.

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Yield compensation in castor (*Ricinus communis* L.) with nipping of different order spikes

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ABSTRACT

An experiment was conducted at IIOR to study sink strength and partitioning of assimilates to sink with nipping of different order spikes at initiation or at full expansion stage. Nipping of one spike order at any stage did not show significant reduction in castor seed yield and compensated from next order spikes.

Keywords: Castor, Nipping, Seed yield, Spikes

Improvement in yield potential in any crop could be associated with greater production of biomass, increased partitioning to harvestable organs or both. By regulating the number of racemes per plant, castor plants adjust to environmental aberrations (Severino, 2012). To study the sink strength and dry matter partitioning into sink organs and extent of compensation with sink limitation, an experiment was conducted with nipping of different order spikes at spike initiation or at full expansion on seed yield of castor. Experiment was conducted during *khariif* 2012 at Narkhoda farm of ICAR-IIOR with DCS-107 variety in RBD with three replications.

Different treatments included control (keeping all spikes), nipping of primary, secondary or tertiary spikes just after initiation or after full expansion. Data on total dry matter (TDM) at harvest, seed yield of different order spikes were recorded and subjected to standard statistical analysis. Analysis of the data indicated that the traits quaternary spike seed yield, total seed yield, stem dry weight, total dry matter and harvest index did not differ significantly among the treatments (Table 1).

Nipping of primary spike at any stage increased seed yield of secondaries by increasing effective spike length, capsule number and capsule weight but reduced tertiary seed yield. Secondary spike nipping at full expansion increased tertiary seed yield and tertiary spike nipping also increased secondary seed yield though not significantly. Nipping of any order spike at any stage reduced total seed yield compared to no nipping control and reduction was more with secondary spike nipping. Contrary to this, it is reported that nipping of secondary and tertiary spikes either alone or in combination increased seed yield (Hanumantha *et al.*, 1981) in castor. Harvest index (HI) was more in control and less when

primary spike was nipped at the initiation stage. In spite of more TDM produced, stem reserve mobilization was less when the primary spike was nipped at the initiation stage as there was no demand from sink.

Dry matter partitioning into sink organs of a plant is known to be determined by the product of sink activity and sink size. The contribution from different spike orders to total seed yield differ depending on growth phase as castor has very good compensation capacity (Venkat, 1992). When there was demand for assimilates, there was photosynthate mobilization from stem and when one spike was removed, due to reduced demand there was less reserve transport from stem. Reduced translocation was shown by more stem dry weight in nipping treatments and low harvest index compared to no nipping control. Thus, nipping of one spike order at any stage did not show significant reduction in castor seed yield and compensated from next order spikes. As stem reserve is more in castor, it is necessary to have plant type characters with higher partitioning efficiency supported by sink strength.

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Table 1 Seed yield of different order spikes (g/plant)

Treatments	Seed yield of different order spikes (g/plant)				Total seed Yield	Stem weight	TDM	HI (%)
	Primary	Secondary	Tertiary	Quarternary				
Keeping all spikes (control)	53.9	49.7	62.9	90.6	252.3	211.2	628.7	41.3
Nipping of spikes								
Primary at initiation	0.0	72.2	46.0	92.5	210.6	258.7	668.3	31.5
Primary at full expansion	0.0	70.3	49.8	105.0	225.1	220.8	586.8	38.3
Secondary at initiation	56.4	0.0	55.3	94.2	209.5	261.6	630.7	33.2
Secondary at full expansion	51.2	0.0	66.6	87.3	205.2	237.0	600.1	34.2
Tertiary at initiation	54.3	63.4	0.0	100.1	220.0	225.0	590.0	37.2
Tertiary at full expansion	53.3	55.9	0.0	94.3	202.5	200.7	525.0	40.6
mean	38.4	44.5	40.1	94.9	212.1	234.0	600.1	35.8
SEm(±)	3.48	6.40	4.1	9.07	15.6	29.3	47.2	2.0
CD (p=0.05)	10.7	19.7	12.5	NS	NS	NS	NS	NS
CV(%)	15.6	25.0	16.4	16.9	12.3	21.3	13.3	9.5

Plant geometry and nitrogen effect on fatty acid composition of sesame (*Sesamum indicum* L.) seed

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ABSTRACT

A field experiment was conducted to determine the effect of fertiliser N on seed fatty acid composition (palmitic, stearic, oleic and linoleic acid content) of sesame. Nitrogen (N) application had a profound effect on the fatty acid composition. An increase in N application from 0 to 45 kg/ha increased linoleic acid but reduced oleic acid and palmitic acid contents.

Keywords: Fatty acid composition, Nitrogen fertilizer, Linoleic acid

Majority of farmers do not apply chemical fertiliser for sesame cultivation which hampers the productivity as well as the quality of oil. With this background, an experiment was conducted to determine the effect of different doses of N on the oil quality of sesame in terms of fatty acid profile.

A field experiment was conducted at ICAR-Indian Institute of Oilseeds Research, Hyderabad's research farm at Narkhoda during *rabi*-summer 2017. Main plots had 5 planting geometry (broadcasting, 30 × 30 cm, 45 × 30 cm, 45 × 45 cm and 45 cm solid row) with sub plot three N doses (0, 30 and 45 kg/ha) replicated thrice in a split-plot design. Other nutrients (phosphorous and potassium) were common to all the treatments. Standard crop management practices were followed with need-based irrigation and plant protection measures. The plants were harvested at 90 DAS and seeds were analysed for the fatty acid composition.

The results indicated that planting geometry had no effect on the fatty acid composition except an insignificant change in the palmitic acid content. On the other hand, application of N at different doses had profound effect on the contents of palmitic acid, oleic acid and linoleic acid. Fertilizer use is one of the most important factors responsible for increasing crop yield and quality (Reddy *et al.*, 2003) in several crops. Among the major nutrients, N is the most important element involved in metabolic processes and leads to increases in growth, and yield of

crops (Koutroubas *et al.*, 2008). A reduction in the contents of palmitic and oleic acid was noticed due to the application of higher doses of nitrogen from 0 to 45 kg/ha. But linoleic acid content increased due to higher N dose. Our findings corroborate the reports of Aguirrezábal *et al.* (2015) stating that the quantity of saturated fatty acids increases linearly with C allocated to the grains, while oleic acid increases exponentially and linoleic acid increases up to a maximum. Hence it is concluded that to increase the content of linoleic acid in the oil of sesame seeds, N application is necessary.

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Effect of lime and FYM on growth, yield and quality of soybean (*Glycine max*) grown in acid soils of Nagaland

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ABSTRACT

The experiment was conducted during *kharif* season for three years to assess the impact of lime and FYM on soybean. Application of lime and FYM enhanced grain yield by 79% and 33%, respectively over control. Similar trend was observed with respect to haulm yield, oil content, protein content and nutrient NPK uptake.

Keywords: Soybean, Lime application, Acid soils, Seed yield

The acidic nature of soils of North Eastern Hills (NEH) region is one of the major factors contributing to poor plant growth and yield. Application of FYM combined with lime counteracts aluminum toxicity and increases microbial activities resulting in improvement in yield of leguminous crops. No such type of information is available regarding soybean. Therefore, present investigation was conducted to study the effect of lime and FYM on growth, yield and quality of soybean in acid soils of Nagaland.

The experiment was conducted at AICRP on Soybean Farm, SASRD, NU, Medziphema. The experiment was conducted in RBD with two levels of FYM (No FYM and 2.5 t/ha) and five levels of lime (0, 200, 400, 600 and 800 kg/ha). Data of plant and soil

samples were recorded and analyzed as per standard procedures.

FYM application significantly increased the grain and haulm yield which might be due to supply of sufficient amount of plant nutrient by FYM. Maximum seed and haulm yield were recorded with lime 800 kg/ha. Oil content was not significantly influenced either by FYM or lime. FYM and lime increased protein content by 5.9% and 15.6%, respectively over control. FYM and lime also significantly increased NPK uptake. Interaction effect was not significant.

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Table 1 Effect of FYM and lime on yield, quality and nutrient uptake on soybean

Treatment	Seed yield (kg/ha)	Haulm yield (kg/ha)	Oil content (%)	Protein content (%)	Nutrient uptake (kg/ha)		
					N	P	K
FYM							
No FYM	1185	1748	16.2	34.9	90.3	7.3	55.7
2.5 t/ha FYM	1574	2010	17.8	37.0	123.2	10.6	65.8
SEm±	57.8	69.1	0.6	0.08	4.63	0.41	3.25
CD(P=0.05)	171	205	NS	0.2	13.8	1.2	9.7
Lime (kg/ha)							
0	995	1568	15.4	33.4	72.0	5.7	44.6
200	1264	1733	15.9	34.4	92.3	7.2	55.3
400	1213	1814	16.8	35.9	94.7	7.9	59.4
600	1639	2110	18.0	37.6	130.8	11.0	62.0
800	1785	2170	19.0	38.6	144.0	12.5	82.2
SEm±	91.4	109.3	1.0	0.1	7.32	0.65	5.14
CD (P=0.05)	271	325	NS	0.4	21.7	1.9	15.3

Seed setting and filling under pollination with stored pollen in sunflower (*Helianthus annuus L*)

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ABSTRACT

The challenge of weather and soil variation in block method of planting male and female parents differ, often resulting in delay of flowering up to 3 to 5 days affecting pollination. Four pollen storage periods (3, 4, 5 and 6 days) was compared for seed setting and filling in female parent. The study revealed the potential of stored pollen at 4°C up to 5 days with about 80% seed setting in DRS-1 hybrid.

Keywords: Hybrid seed production, Pollen viability, Storage, Seed setting, Sunflower

The seed setting in female parent (CMS line) occur with pollen from male parent transferred by hand pollination in block method of planting. The challenge of weather and soil variation in block method of planting male and female parents differ, often resulting in delay

of flowering up to 3 to 5 days affecting pollination. The present study assesses the storability of pollen for effective seed setting and filling to tide over aberrant situations of pollen shortage and/or delays in flowering in female parent. The earlier studies (Sudhir *et al.*, 1996)

indicated the pollen viability under natural conditions up to 48h and this study planned to assess the pollen viability in terms of seed setting percentage by storing at 4°C.

The experiment was carried out using the parental lines (A & R) of sunflower hybrid DRSH-1 viz., ARM 243A (Female parent) x 6D-1 (male parent) during *rabi* 2019 at ICAR-Indian Institute of Oilseeds Research. Four pollen storage periods (3, 4, 5 and 6 days) was compared for seed setting and filling in female parent. The effect of each treatment was checked on 10 female heads. Necessary care was employed to select uniformity in flower anthesis (stigma opening stage) at each stage. On day 0, enough pollen was collected from R lines as stock and stored in butter paper cover and stored in refrigerator at 4°C. Ten male sterile plants (243A female parent) of same age group were selected and bagged a day before flowering (R-4 stage). Next day morning the outer boundary of opened disc florets (whorls) on the day were marked with help of pins. With the stored pollen stock, the capitula was pollinated each day as per the treatments on 3, 4, 5 and 6 days. After effecting pollination to the opened whorls, the capitula were covered with pollen proof nylon bag to avoid any further

out-crossing. At physiological maturity the bagged/pollinated capitula were harvested, the number of seeds formed in the pollinated disc florets was counted and percent seed set was calculated.

The percent filled seeds due to application of stored pollen was more than 78% up to 5th day of storage while on 6th day, the filled seed was reduced to <50% indicating the potential of pollen storage at 4°C was up to 5 days. The highest (93%) filled seed percent was recorded on 3rd day.

It is concluded that the stored pollen at 4°C can be effectively used for pollination up to 5 days with about 80% seed setting in DRSH-1 hybrid seed production. This can protect for any possible delay in flowering in female parent up to 5 days.

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Evaluation of safflower (*Carthamus tinctorius* L) genotypes against salinity stress

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ABSTRACT

Safflower genotypes were evaluated for salinity stress using irrigation water with 5 EC levels through paper towel method. Among the 24 genotypes tried, performance of 5 genotypes was prominent in terms of shoot length and weight at 15 days growth. The genotype IC-406052 showed 23% reduction and genotype SSF-733 showed 65% reduction with EC of 10 dS/m against zero salinity. Highest reduction of shoot weight was noticed in SSF-733(54%) and minimum was recorded in IC-406052 (26%) with EC of 10 dS/m compared to zero salinity.

Keywords: Safflower, Salinity stress, Paper towel method

Salinity and drought have negative effects on safflower by disrupting the ionic and osmotic equilibrium of the plant cells. Identification of genotypes which can tolerate salinity stress is essential to develop tolerant cultivars.

Twenty four safflower genotypes were evaluated against salinity with paper towel method. This was conducted with 2 factor CRD. Factor 1 was genotypes (24) and factor 2 was irrigation water salinity levels (EC=0, 4, 6, 8 and 10 dS/m). Safflower seeds were properly wrapped in paper towel and thoroughly soaked with saline water and allowed to grow in seed germinator at 27±0.5°C up to 15 days through regular soaking with respective saline waters. All the treatments were duplicated. At 15 days, observations for shoot length, shoot weight, root length, root weight. Shoot

samples were properly dried and digested in di-acid on hot plate as described by Jackson (1973) while root samples were digested in microwave as described by Robert Miller (1998). The shoot Na and K, root Na and K contents were analyzed by using flame photometer. .

The growth of the seedlings at different salinity levels varied significantly and this was directly affected by the concentration of the sodium (Na) and potassium (K) content in the shoot and roots of the genotypes. With the increase in salinity, the Na content was highest in susceptible genotype (8.0%) compared to tolerant types. The K content in shoot remained almost the same at both low and high salinity in all the tolerant type genotypes. Root length decreased due to increased salinity levels for all the genotypes but the highest root length was observed in IC-406052 (30.1cm) and the shortest roots in

SSF-773 (27.4cm) at highest salinity. Similarly, the highest root weight at high salinity was seen in IC-406052 (0.06 g) and the minimum weight was seen in SSF-773 (0.03 g).

Relative high potassium (K) content in root against high sodium (Na) is very important character for salinity tolerance. IC-406052 had significantly low concentration of Na (6.1%) in the roots compared to all other genotypes, while highest Na ions in roots was noticed in SSF-733 (10.2%) at highest salinity. In contrary, the K was highest in IC-406052 (1.3 %) and lowest in check SSF-733 (0.75%).

It can be concluded that, the K content in shoot and root was high in five genotypes (IC-406143, EC-661173,

IC-406052, A-1, PBNS-12) compared to others. Further, the genotype IC-406052 had the ability to maintain sufficient concentration of K against high gradient of Na in both shoot and root.

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Foliar application of water soluble fertilizers in summer groundnut in a Vertisols

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ABSTRACT

A field experiment was carried out during summer season to know the effect of water soluble fertilizers on the performance of groundnut (cv. TAG 24) in Vertisols of Northern Transition Zone of Karnataka. Application of FYM + 100% RDF + foliar spray of fertilizers at 30, 45 and 60 days after sowing (DAS) recorded 7.35% higher pod yield over application of 100% RDF and was on par with the treatment receiving FYM + 85 % RDF + foliar spray of fertilizers at 30, 45 and 60 DAS and recorded the highest B:C ratio.

Keywords: Foliar spray, Fertilizers, Summer groundnut, Vertisols

Groundnut being a leguminous crop fixes substantial quantity of atmospheric nitrogen. The response of crops to applied phosphorus is not encouraging particularly in medium to high phosphorus status soils. The phosphorus fixation is observed in soils which receives phosphorus every year. Regular application of FYM leads to the supply of essential nutrients in minute quantities besides improving the soil physical properties. Foliar application is a technique of feeding plants by applying liquid fertilizer directly to the leaves. It enables the supply of nutrients as and when the crop is required. Hence, the present study is carried out to know the effect of foliar application of water soluble fertilizers in summer groundnut.

The study was conducted during three successive summer seasons under irrigation. Ten treatment combinations included combinations of FYM and reduced recommended dose of NPK through soil application as basal and foliar spray of soluble fertilizers at 30, 45 and 60 DAS. Foliar application of water soluble grade fertilizer @ 2% as starter dose (11:36:24+trace element) at 30 DAS and booster dose (8:16:39) at 45 and 60 DAS were tried. The experiment was laid out in a completely randomized block design with three replications.

Application of FYM + 100% RDF + foliar spray of fertilizers at 30, 45 and 60 DAS recorded higher pod yield (4671 kg/ha) which was 7.35% higher pod yield over application of 100% RDF (4351 kg/ha). However, it was on par with the treatment receiving FYM + 85 % RDF + foliar spray of fertilizers at 30, 45 and 60 DAS. This implied that at reduced recommended basal dose of nitrogen, phosphorous and potassium from 100 to 35%, foliar application of water soluble grade fertilizer @ 2% as starter dose (11:36:24+trace element) at 30 DAS and booster dose (8:16:39) at 45 and 60 DAS was beneficial in increasing pod yield of groundnut. The nutrient status of the soil after harvest of the groundnut was higher in the treatment receiving FYM + 100% RDF + foliar spray of fertilizers at 30, 45 and 60 DAS. It might be due to higher microbial activity in the INM treatments which favoured the conversion of the organically bound nutrients to inorganic form (Panwar, 2008). Application of FYM + 85 % RDF+ foliar spray of fertilizers at 30, 45 and 60 DAS recorded the highest B: C ratio.

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Yield performance and quality of Indian mustard (*Brassica juncea*) as influenced by various nutrient management options

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ABSTRACT

A field experiment was carried out during winter season of 2017-18 at Sardarkrushinagar to study the effect of different nutrient management practices on performance of Indian mustard. Results revealed that the oil content, oil yield and seed yield were significantly higher with the crop fertilized by 150% NPK with the corresponding value of increment to the tune of 5.03, 78.98 and 77.64 per cent higher over control/ no fertilizer treatment.

Keywords: High seed yield, Nutrient management, Rapeseed-mustard

The mustard productivity in India is quite lower than other developed nations, which is mainly due to imbalance application of fertilizers and cultivation under rainfed conditions (Singh and Pal, 2011). Hence, the present study was carried out to study the effect of nutrient management on growth and yield of Indian mustard.

A field experiment was conducted during *rabi* season of 2017-18 at Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India. The soil of the experimental field was loamy sand in texture. The experiment was laid out in randomized block design and comprised ten nutrient management treatments *viz.*, Control, 100% PK, 100% NPK, 150% NPK, 100% NPK + S @ 40 kg S/ha, 100% NPK + Zn @ 25 kg ZnSO₄/ha, 100% NPK + B @ 1 kg

B/ha, 100% NPK + FYM @ 2.5 t/ha (dry weight basis), 100% NP and 100% NK with replicated thrice. The recommended dose of fertilizer for mustard crop is N₅₀, P₅₀, and K₂₀ kg/ha. Full dose of P, K, S, micronutrient and half dose of nitrogen fertilizers were drilled just before the sowing as a basal application through urea, DAP, MOP and elemental sulphur as per treatments and remaining half dose of nitrogen was top dressed at 25-30 DAS in earmarked plots after thinning. Other crop management practices were followed as per standard package of practices. However, heavy infestation of mustard aphid was observed during flowering to maturity and which was managed through sprayed insecticide in periodical interval but yield was declined. Hence a reported yield of this experiment was low as compared to average yield of the region and state.

Table 1 Effect of nutrient management on growth, yield and quality of Indian mustard during 2017-18

Treatments	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	No. of siliquae/plant	No. of seeds/silique	Test weight (g)	Oil content (%)	Oil yield (kg/ha)	Seed yield (kg/ha)
T1: Control	155.5	3.80	9.40	191.9	10.2	5.06	39.7	289.04	729
T2: 100% PK	164.8	4.20	11.07	204.1	12.4	5.25	39.9	368.73	924
T3: 100% NPK	165.5	4.20	12.47	239.5	12.9	5.12	39.8	438.53	1104
T4: 150% NPK	160.6	4.20	10.87	205.1	11.1	5.24	39.9	517.34	1295
T5: 100% NPK + S @ 40 kg S/ha	161.7	4.27	12.40	210.9	11.3	5.20	39.9	452.07	1134
T6: 100% NPK + Zn @ 25 kg ZnSo ₄ /ha	170.9	4.27	14.13	221.9	11.9	5.13	39.6	455.89	1150
T7: 100% NPK + B @ 1 kg B/ha	175.4	4.67	15.40	234.4	12.6	5.12	39.6	408.15	1030
T8: 100% NPK + FYM @ 2.5 t/ha (dry weight basis)	173.3	4.73	16.13	247.2	12.3	5.25	39.2	448.80	1143
T9: 100% NP	158.1	4.53	16.33	219.7	12.1	4.99	39.4	400.86	1020
T10: 100% NK	154.5	4.47	13.60	191.8	11.7	5.16	38.7	316.38	818
SEm±	5.32	0.28	0.87	15.23	0.43	0.14	0.24	35.35	89.17
CD (P=0.05)	NS	NS	2.55	NS	1.28	NS	0.71	105.04	264.95

The different fertility treatments had no significant effect on plant height, number of primary branches/plant, no. of siliquae/plant and test weight. Application of 100% NPK + 1 kg Boron recorded significantly more number of seeds/silique (Table 1). These results are in accordance with the findings of Tripathi *et al.* (2010). The fertility treatments had significant influence on number of secondary branches/plant which was observed higher under 100% NP application. The application of 150% NPK was significantly out yielded over control

with produced 77.64% higher seed yield and it was performed statistically at par with 100% NPK alone and its conjunction with sulphur, zinc, and 2.5 t/ha FYM but significantly superior over rest of the treatments (Table 1). Simultaneously the value of oil content was recorded statistically on par to each other with application of 100, 150% NPK and 100% NPK + 40 kg S/ha. Whereas, oil yield was recorded significantly higher with 150% NPK and it was remained at par with the application of 100% NPK alone and in integration with S, Zn and FYM.

These findings are in conformity with those of Tripathi *et al.* (2010) and Rathore *et al.* (2016).

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Conversion of castor shell into a value added compost

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ABSTRACT

Castor shell is rich in lignin material and takes a long time to decompose. Therefore, it is necessary evolve procedures that can hasten this process so that the shell could be used as compost. The compost heaps were prepared in four treatment combinations (T1: castor shell + 10% dung slurry; T2: castor shell + dung slurry + 2% urea solution + 0.5% SSP; T3: castor shell + dung slurry + microbial consortium @ 1 kg/t; and T4: castor shell + dung slurry + 2% urea solution + 0.5% SSP + microbial consortium @ 1 kg/t. The N (1.2%) and P (1.4%) in T4, and K (1.5%) T1 were maximum. Micronutrients, Fe (4000 ppm) in T3 and Zn (68 ppm) in T4 were maximum.

Keywords: Castor, Castor shell, Compost, Nutrient

It is estimated that, castor to castor shell ratio is 65:35, i.e., in each 1000 kg of castor capsule weight the portion of castor shell is 350 kg which is going as waste. The castor shell is rich in lignin material and takes long time to decompose (Shah *et al.*, 2015) and hence, it is not preferred by the farmers to incorporate in the field. Therefore, the present study was initiated to prepare compost from castor shell with different combinations.

The compost heaps were prepared in four treatment sets (T1: castor shell + 10% dung slurry; T2: T1 + 2% urea solution + 0.5% SSP (weight basis); T3: T1 + microbial consortium @ 1 kg/t; and T4: T2 + microbial consortium @ 1 kg/t. All the treatments were imposed at the time of compost heap preparation. The dimension of the each heap was kept 15 ft x 3.5ft x 3.0 ft. Moisture content was maintained at saturated condition by watering on weekly basis while turning of heaps was done on fortnightly basis. From all four heaps, random samples were collected and total N, P, K, S, Fe, Mn, Zn and Cu were analyzed using standard methods. Total six turnings were done in the process of composting.

Maximum N and P were found in treatment T4 which was on par with T2. The maximum K was found in T1 which was on par with that of T3. Maximum S content was found in T2 which was on par with that of T3 and T4. These values are similar to the findings of Javiya, 2019. The micronutrients, Fe was the highest in T3 while Mn and Zn were significantly high in T4. With respect to Cu there were no significant differences among the four treatments (Table 1).

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Table 1 Nutrient content in compost prepared with four methods

Treatments	Nutrient content (%)				Nutrient content (ppm)			
	N	P	K	S	Fe	Mn	Zn	Cu
T1	0.7	0.9	1.5	1.9	3100	77	33	8
T2	1.1	1.3	1.3	2.6	3600	84	48	13
T3	0.9	1.0	1.4	2.4	4000	86	40	11
T4	1.2	1.4	1.2	2.5	3300	96	68	8
SEm±	0.02	0.03	0.02	0.10	67	1.5	1.6	0.2
CD(P=0.05)	0.1	0.1	0.1	0.3	223	5	4	NS
Initial values	0.5	0.5	0.8	0.7	1000	52	23	7

Role of biopolymer based *Trichoderma* in plant growth promotion and mitigation of drought stress in groundnut

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) is frequently subjected to drought stress. Pre-treatment of seeds with Chitosan + *Trichoderma harzianum* (Th4d), polymer1 + Th4d showed significantly greater levels of germination percentage, seed vigor index, soil moisture, shoot fresh and dry weight, relative water content, chlorophyll content, proline content and total sugar levels than Th4d and control treated plants.

Keywords: Drought, Groundnut, Proline, Total sugars

Trichoderma spp. are known to confer abiotic stress tolerance like drought, salinity and are potent biocontrol agents against major soil borne diseases like wilt, stem and root rot, color rot. About 80% of the world groundnut production comes from seasonally rainfed areas in the semi-arid tropics, where climate is characterized by the low and erratic rainfall. Seed coating of groundnut with biopolymer based *Trichoderma* could have a potential application in dryland agriculture.

Groundnut seeds were pre-treated with bio-polymer based *Trichoderma harzianum* (Th4d) such as chitosan + Th4d, polymer 1 + Th4d and Th4d alone along with untreated control and grown in growth chamber (25°C, 70% relative humidity) in sterile soil. The plants were watered for forty days after sowing and thereafter water was withheld to impose drought stress. Seedlings were observed closely for appearance of stress symptoms (rolling and wilting of leaves). Plants were harvested 7 days after withholding water. Observations were made on germination percent, seed vigor index, shoot length, shoot fresh and dry weight, relative water content (RWC), chlorophyll content, proline and total sugars

(Bodhankar *et al.*, 2019) and amplification of drought tolerant genes (Drame *et al.*, 2017).

Seed coating with chitosan + Th4d, polymer 1 + Th4d and Th4d showed significantly higher percent of germination, seed vigor index, shoot length, shoot fresh and dry biomass, proline, total sugars, RWC and soil moisture content over control (Table 1). Efforts are on to understand the genes and the pathways that are up-regulated during the interaction of bio-polymer, chitosan and Th4d with the plants when applied singly or in combination.

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Table 1 Effect of bio-polymer combinations on plant growth, physiological and soil moisture content under drought stress condition

Treatments	Germination (%)	Seed vigor index	% increase over control treatment							
			Shoot length	Shoot fresh weight	Shoot Dry weight	Soil moisture content	Relative water content	Proline	Total Sugar	Chlorophyll content
Chitosan + Th4d	93	8044	42.8	64.7	83.8	43	26.1	50	72.8	10.1
Polymer 1 + Th4d	92	7820	42.6	51.1	59.6	37.5	19.6	45	44	7.5
Th4d	86	7052	34.2	17	35.4	4.1	11.1	1.2	2.6	4.4

Yield and economics of soybean based cropping systems as influenced by different cropping systems, crop establishment method and residue management practices

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ABSTRACT

Significantly higher yield of soybean was registered under soybean-chickpea system. The increase in yield was up to 21.5% under permanent broad bed and furrow (PBBF) + residue retention (R) and 14% under PBBF + without R (WR) as compared to conventional flatbed (CTFP) + WR. Similarly, significantly higher yield of wheat and chickpea were registered under PBBF + R followed by PBBF + WR.

Keywords: Soybean, Cropping system, Broad bed and furrow, Residues

Resorting to improving soil organic carbon content that dictates improvement in soil quality parameters and increased nutrient mobilization for crop assimilation can be achieved through proper resource conservation technologies such as reduced tillage/no till and residue management and assessing the best cropping system is the way forward. In this regard, efforts were made to identify the best land configuration, residues management under soybean-based cropping systems.

The experiment comprised of three cropping systems (C1: soybean-wheat, C2: soybean-maize; C3: soybean-chickpea) and four crop establishment methods (permanent broad bed furrow with residue (T1: PBBF + R), permanent broad bed furrow without residue (T2: PBBF + WR), conventional tillage with residue (T3: CTFP + R) and conventional tillage without residues (T4: CTFP + WR). Residue retention practices that were followed were 50% soybean residue retained during rainy season in the respective treatment, and 30% for wheat and maize; and 50% of chickpea residue retained during winter season in the respective treatment. This trial was conducted for two years (2017-18 and 2018-19).

Among the cropping systems, significantly higher yield of soybean was registered under C3 followed by C2 and C1 (Table 1). Seed yield of soybean was increased by 22% under T1 followed by 14% increase with T2 as compared to T4 under soybean-chickpea

system. Similarly, an increase of 25% and 17% increase were recorded under T1 in soybean-maize and soybean-wheat, respectively as compared to T4. Significantly highest wheat and chickpea yield were registered under T1 followed by T2 as compared to T3 and T4. However, in case of maize the significantly highest yield was registered under T1 followed by T3 and significantly lower yield under T4. Improved crop establishment technologies and residue retention/incorporation under soybean-based cropping systems might have increased the organic carbon content, microbial proliferation and diversity paving way to improvement in soil physical, chemical and microbiological characteristics thereby influencing crop productivity (Hernández *et al.*, 2016; Khaliq and Abbasi, 2015).

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Table 1 Effect of resource conservation technologies on seed yield and economics of soybean based cropping systems

Treatment	Seed yield (kg/ha)			
	Soybean	Wheat	Maize	Chickpea
Cropping systems				
C1: Soybean-maize	2250	-	6110	-
C2: Soybean-chickpea	2200	-	-	988
C3: Soybean-wheat	2160	5650	-	-
Crop establishment methods				
T1: PBBF + R	2430	6260	6820	112
T2: PBBF + WR	2280	6050	5940	113
T3: CTFP + R	2110	5470	6130	894
T4: CTFP + WR	2000	4820	5540	809

Influence of terminal drought stress on root and biochemical parameters in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

A study on influence of terminal drought stress on biochemical and root responses in forty genotypes was conducted. Due to drought stress imposition at 90 days after sowing (DAS), phenolic content of seeds and root length of treated plants were decreased, whereas, oil content, phenolic content of leaves, protein content of both leaves and seeds and root to shoot ratio were increased compared to normal plants. This indicates that physio-biochemical and root responses of groundnut are influenced by soil moisture during growth stages and it also affects duration of crop growth period as all these are inter-related with one another.

Keywords: Root to shoot ratio, Phenolic content, Protein content

Drought is the major yield reducing factor in the rain-fed ecosystem of groundnut in India. Better understanding of the stress induced responses of biochemical and root traits are useful to screen drought tolerant genotypes and to improve the nutritional quality. Better yield can be achieved in groundnut by management of drought (Sunitha *et al.*, 2015; Aninbon *et al.*, 2016).

A field trial was conducted with forty groundnut genotypes in RCBD with 3 replications under irrigated and moisture stress conditions at ZAHRS, Hiriyyur. The moisture stress was imposed for 20 days from 90 days after sowing (DAS).

Table 1 Comparative performance of 40 groundnut genotypes

Characters	Normal Moisture	Moisture stress
Phenols in leaf ($\mu\text{g/g}$)	370	376
Phenols in seeds ($\mu\text{g/g}$)	644	619
Proteins in leaves (%)	0.74	0.79
Protein in seeds (%)	24.5	27.5
Oil content in seeds (%)	46.0	48.1
Root to shoot ratio	0.47	0.49
Root length (cm)	12.3	11.1

The leaf phenolic content increased marginally by 1.8% under drought but the seed phenolic content decreased. However, the protein content in both leaf as well as in seeds had increased by 6.8 and 12.6% respectively, under moisture stress condition. Further,

the seed oil content increased by 4.3% under moisture stress compared to normal moisture. Although there was decrease in root length, the root /shoot ratio had increased under moisture stress.

The increase in leaf phenolic content under moisture stress is an indicative of the response of plant defense to stress environment (Aninbon *et al.*, 2015). Further, increase in the protein content of leaf supports the notion that the plants under stress synthesise more proteins or enzymes which are involved in plant defense and signaling pathways to counter the effect of moisture stress (Sunitha *et al.*, 2015). The increase in the root/shoot ratio under moisture stress indicates that the increase in the root length compared to shoot length could be because of the search of the plant roots for moisture in deeper layers of soil under stress wherein the plant has diverted its energy towards the growth of roots than the shoots for its survival under drought stress. These results are indicative of biochemical and root responses in groundnut and as triggered by soil moisture during growth stages. This observation is in line with the results of Sunitha *et al.* (2015).

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Effect of imposed terminal drought on yield, yield attributing traits and aflatoxin contamination in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Sixty six genotypes of groundnut were screened under drought stress conditions. Yield, yield attributes and aflatoxin content were estimated at harvest. Reduction in yield and yield attributing traits, except for number of primary branches and amount of aflatoxin contamination under drought stress as compared to normal moisture condition, was observed.

Keywords: Aflatoxin contamination, Moisture stress, *Aspergillus flavus*, Terminal drought

Groundnut is affected by several production constraints. Since the crop is mostly grown under rainfed and low input conditions, it is essential that new groundnut varieties should carry resistance to multiple stresses operating in a region in the appropriate maturity backgrounds. Since groundnut is used as food, it is essential that, quality traits receive adequate attention in genetic enhancement. Hence, drought tolerance and resistance to aflatoxin contamination are major objectives in groundnut breeding.

A total of 66 genotypes were used for field screening in RCBD design. The moisture stress was imposed by withdrawing irrigation for 20 days at pod development stage. ICGV-91114 was used as tolerant check for drought tolerance. Root zone soil of both moisture stressed and normal moisture plots were made sick by applying *Aspergillus flavus* broth culture first at flower initiation stage and second at peg initiation stage @ spore concentration of 4 10⁶ spores/ml. Pathogen population in root zone was confirmed by isolation of the pathogen at 10⁶ times dilution levels. Aflatoxin content was estimated by using Indirect ELISA at ICRIASAT, Hyderabad which was expressed as µg/kg.

Under moisture stress condition, highest reduction was observed in kernel yield (58.2%) followed by pod yield (52.7%) and kernel yield/plant (54.5%) indicating that the economic yield is majorly affected by moisture stress. All the yield attributes showed reduction whereas number of primary branches/plant (+3.48%) and aflatoxin contamination (+11.53%) increased under moisture stress condition (Table 1). Plant height, pod yield, kernel yield and other traits showed reduction under moisture stress condition compared to the normal moisture condition as reported earlier by Arunachalam and Kannan (2013).

Decreased seed moisture under drought, hampers capacity of seed to produce phytoalexins resulting in *Aspergillus* invasion and aflatoxin production. Breeding

for drought tolerance can be accepted as one of the strategies for developing aflatoxin tolerant groundnut cultivars, which would not only minimize water usage but also help expand groundnut production in marginal and sub-marginal soils.

Table 1 Performance of groundnut genotypes under moisture stress and normal moisture condition

Characters	Normal moisture	Moisture stress
Plant height at 90 DAS (cm)	38.1	37.2
No. of primary branches/plant at 90 DAS	6.2	6.4
No. of days to maturity	121	120
Plant height at harvest (cm)	38.6	37.2
No. of primary branches/plant at harvest	6.4	6.4
Pod yield per plant (g)	20.5	11.3
Pod yield (kg/ha)	4409	2085
Kernel yield (g/plant)	13.5	6.1
Kernel yield (kg/ha)	2683	1123
Test weight (g)	38.8	30.2
Harvesting index	0.6	0.5
Shelling percentage (%)	59.5	53.8
Aflatoxin content (µg/kg)	0.26	0.29

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Effect of dates of sowing and cutting for fodder on fodder yield, seed yield and oil yield of oilseed rape genotypes

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ABSTRACT

A field study was conducted with three genotypes, three dates of sowing and three time of cutting for fodder. Genotype OS-1 and sowing date of 10th October without any cutting for fodder resulted in highest seed, stover and oil yield. However, sowing on 25th September with OS-1 and GSC-7 genotypes produced highest fodder yield at 35 days after sowing (DAS) and 50 DAS cutting, respectively.

Keywords: Fodder yield, Oilseed rape, Time of cutting, Time of sowing

Berseem and rye grass are the major fodder crops grown during *rabi* season but fodder yield from their first cutting is low. Canola oilseed rape (*Brassica napus*) having superior quality edible oil and seed meal has the ability to regenerate after first cut and therefore offers opportunities to use the same crop for both green fodder and oil in areas facing scarcity of green fodder during winters. Agro-climatic conditions of the Punjab are quite suitable for its cultivation.

A field investigation was conducted at Punjab Agricultural University, Ludhiana during *rabi* 2018-19. The experiment was replicated three times in a split plot design. In the main plot, there were 9 treatments (genotypes-OS1, Z8 and GSC 7; sowing dates 25th September, 10th October and 25th October). Three time of cutting for fodder (no cutting, cutting for fodder at 35 DAS, cutting for fodder at 50 DAS) were subplots.

OS-1 genotype and sowing date of 10th October resulted in highest seed, stover and oil yield. In comparison to cutting for fodder at 35 and 50 DAS, no fodder cutting yielded higher seed, stover and oil. Highest fodder yield was however obtained under 25th September sowing at both the time of cutting, 35 DAS and 50 DAS which was significantly at par with fodder yield under 10th October sowing (Table 1). Interaction effect of genotypes, dates of sowing and time of cutting was significant. Therefore, it could be concluded that, sowing on 25th September with OS-1 and GSC-7 genotypes produced highest fodder yield at 35 DAS and 50 DAS cutting, respectively.

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Table 1 Effect of dates of sowing and cutting for fodder on fodder yield, seed yield, stover yield and oil yield of oilseed rape genotypes

Treatments	Fodder yield (t/ha)		Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Oil content (%)	Oil yield (t/ha)
	35 DAS	50 DAS					
Genotypes							
OS 1	3.184	11.547	2.44	10.65	18.8	39.68	0.970
Z 8	3.475	10.999	2.37	9.32	20.5	39.61	0.942
GSC 7	3.891	11.58	2.21	8.49	20.6	40.00	0.884
CD (P=0.05)	NS	NS	0.08	0.53	0.63	NS	0.035
Sowing dates							
25 September	4.038	13.981	2.40	9.86	19.8	39.87	0.957
10 October	3.820	12.491	2.61	10.23	20.6	39.73	1.038
25 October	2.693	7.655	2.02	8.36	19.5	39.69	0.800
CD (P=0.05)	0.244	0.680	0.08	0.53	0.63	NS	0.035
Time of cutting for fodder							
Uncut	0.000	0.000	2.91	12.16	19.5	39.89	1.161
35 DAS	3.517	0.000	2.19	8.56	20.4	39.93	0.876
50 DAS	0.000	11.376	1.92	7.74	20.0	39.47	0.760
CD (P=0.05)	-	-	0.09	0.42	0.49	0.35	0.038

Effect of long term application of fertilizers on soil nutrient status in groundnut (*Arachis hypogaea* L)

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ABSTRACT

An experiment was conducted in long term fertilizer experiments (initiated in 1981) plot with groundnut as test crop to study the soil nutrient availability at harvest of groundnut. There were 11 treatments arranged in RBD with four replications. The highest value of available N (87 kg/ha) was recorded in treatment T10 [NPK + lime (100 kg/ha) at flowering]. Depletion of available P was seen in seven treatments when compared with initial P (47.6 P₂O₅ kg/ha). Available K content of the soil decreased in all the treatments as compared with the initial status (216 K₂O kg/ha).

Keywords: Groundnut, Long term fertility experiment, Soil nutrient availability

Long-term fertilizer experiments (LTFE) play an important role in understanding the changes in physical, physico-chemical and chemical properties and productivity of the crop. Hence the present investigation was taken up to assess the effect of long-term fertilization on soil nutrient status in groundnut grown in Alfisol.

The present investigation was carried out in Alfisols at Regional Agricultural Research Station, Tirupati in *kharif*, 2018, in the long-term fertilizer experiment (initiated in 1981). The experiment was conducted with 11 treatments in RBD with four replications. The treatment details are provided in Table 1. The test crop was groundnut (Var. Dharani). The soil samples were collected at crop harvest at 0-15 cm and analyzed for major soil available nutrients as per standard procedures (Jackson, 1973).

Results indicated that, the highest value of available N was recorded in T10 which was on par with T11, T3, T4, T7, T8 and T9. Similar results were earlier reported by Kundu *et al.* (2017) that the available nitrogen content differed widely between the control and other treatments. Depletion of available P was seen in T1, T2, T3, T6, T7, T9 and T11 treatments when compared with initial P recorded in 1981.

The depletion of available P was mainly due to the crop uptake from soil since 38 years. This situation is ascribed to lower dose of P application to crop (10 kg/ha P) against the recommended dose of 17.5 kg/ha P. Available K content of the soil decreased in all the treatments as compared with the initial status (216 kg/ha K). This decrease in available K was mainly due to the more uptake of K from the soil.

Treatments	Available nutrient status (kg/ha)		
	N	P ₂ O ₅	K ₂ O
T ₁ : Control	65	33	129
T ₂ : FYM (5 t/ha) once in 3 years	66	38	150
T ₃ : N (20 kg/ha)	81	37	125
T ₄ : P (10 kg/ha)	78	57	118
T ₅ : K (10 kg/ha)	72	48	209
T ₆ : Gypsum (250 kg/ha) at flowering	62	44	109
T ₇ : N P	78	47	134
T ₈ : NPK	75	48	207
T ₉ : NPK + gypsum	75	47	164
T ₁₀ : NPK + lime (100 kg/ha) at flowering	87	52	142
T ₁₁ : NPK + gypsum + ZnSO ₄ (25 kg/ha) basal once in 3 years	84	44	174
Initial values in year 1981	NA	47.6	216
SEm±	4.7	3.6	19.3
CD(P=0.05)	14	10	56

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Assessment of bio-mulches on weed control in sunflower (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to evaluate bio-mulching to control weeds in sunflower during *rabi*, 2018-19. The experiment was carried out in RBD with three replications. The treatments comprised of *Terminalia chebula* powder @ 400 kg/ha, mango leaves @ 4 t/ha, tamarind leaves @ 4 t/ha, eucalyptus leaves @ 7 t/ha, mustard seed powder @ 160 kg/ha, neem leaves @ 2.5 t/ha, hand weeding at 30 and 45 DAS and un-weeded/unmulched. The results revealed that application of eucalyptus leaves mulch on the soil surface between the rows @ 7 t/ha was effective in controlling weeds and recorded lowest weed index (4.3) and produced seed yield of 2297 kg/ha which was on par with that of best treatment of hand weeding twice (2400 kg/ha). Crop yields were negatively correlated with weed index.

Keywords: Bio-mulching, Seed yield, Sunflower, Weed control

Weed management in sunflower is one of the major production constrains. Midst of various non-chemical weed control practices, bio-mulching is one that has outpaced other chemical methods in enhancing both sustainability and profitability.

Field experiment was conducted in black sandy loam soil at Eastern Block at TNAU, Coimbatore during *rabi*, 2018-19. It was laid out in RBD with three replications and ten treatments that comprised of different bio-mulches including un-mulched plot or weedy check. TNAU sunflower hybrid (CO-H3) was used as plant material. Observations on weed density were made using quadrat (0.5 m x 0.5 m) whereas weed index was calculated using the formula suggested by Gill (1969).

Increased yield reduction was found in un-mulched plot with a weed index of 40.1. Bio-mulching with eucalyptus leaves at 7 t/ha had considerably lowered weed index (4.3) and seed yield recorded was 2297 kg/ha. Increased yield reduction to an extent of 36.6% was exhibited due to higher weed index (40.1) in un-mulched plot. Weed index reflected upon the magnitude of weed interference that persisted during the cropping period and thus affected seed yields. Practice of two hand weeding at 30 and 45 DAS recorded the highest seed yield (2400 kg/ha) which was on par with that of mulching with eucalyptus leaves @ 7 t/ha (2297 kg/ha). Similar result of high seed yield under weed free conditions in sunflower was also reported by Dhanalakshmi (2015).

Table 1 Effect of bio-mulches on weed index and seed yield of sunflower

Treatments	Weed index	Seed yield (kg/ha)
T1: Live mulching with sunhemp @ 40 kg/ha	20.8	1900
T2: Multi-crops (Navathaniyam) @ 50 kg/ha	21.1	1893
T3: Terminalia chebula powder @ 400 kg/ha	13.0	2087
T4: Mango leaves @ 4 t/ha	14.4	2054
T5: Tamarind leaves @ 4 t/ha	25.0	1799
T6: Eucalyptus leaves @ 7 t/ha	4.3	2297
T7: Mustard seed powder @ 160 kg/ha	30.5	1669
T8: Neem leaves @ 2.5 t/ha	32.4	1623
T9: Two hand weeding at 30 and 45 DAS	0.00	2400
T10: Control (Un-mulched)	40.1	1456
SEd	-	89.9
CD(P=0.05)	-	189

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Evaluation of groundnut (*Arachis hypogaea* L.) advanced breeding lines under mid-season drought stress conditions for root traits

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ABSTRACT

Investigation was carried out to study genotypic variability for root morphological traits among 50 advanced breeding lines of groundnut including two drought tolerant varieties (K-9 and Dharani) under both control and mid-season drought stress conditions. Drought stress decreased the root length (RL), shoot length (SL), root dry weight (RDW), shoot dry weight (SDW), number of lateral roots (NLR) and root shoot ratio (RSR). Significant genotypic ranges with respect to RL, SL, RDW, SDW and NLR were 6.0-112.4, 3.9- 22.2, 0.63-2.17, 0.20-10.76 and 6.0-35.0 respectively.

Keywords: Groundnut, Drought stress, Root traits

Roots are an important determinant of groundnut productivity under water stress. Root length density in the deeper soil layers may contribute more to pod yield and harvest index (Jongrunklang *et al.*, 2012). The aim of the present study was to know the response of 50 advanced groundnut genotypes under drought stress conditions in comparison to control conditions.

The experiment was conducted in 2018 at RARS, Tirupati. Fifty advanced breeding lines of groundnut along with two checks (K-9 and Dharani) were grown in two root structures (control and mid-season moisture stress [40-80 Days after sowing (DAS)] during *rabi* 2018-19. There was no receipt of rainfall during drought stress conditions. Crop was harvested at 80 DAS to record root traits data both in drought stress and control.

Root length density and root distribution, the two drought adaptive traits in groundnut are influenced by soil water (Pandey *et al.*, 1984). In controlled condition, all the root traits exhibited higher mean values compared to drought stress condition. Analysis of variance revealed that highly significant differences for the root traits and the genotypic ranges with respect to RL, SL, RDW, SDW, NLR and RSR are 6.0-112.4, 3.9-22.2, 0.63-2.17, 0.20-10.76, 6.0-35.0 and 1: 0.04-1:0.61 respectively. This study showed the genetic variability of groundnut genotypes for root traits. High root lines which identified from this data could be used as donor source for drought tolerance.

Table 1 Response of advanced breeding lines of groundnut to drought and stress conditions

Genotypes	Root length (cm)			No. of lateral roots			Root weight (g)			Shoot weight (g)		
	Control	Drought stress		Control	Drought stress		Control	Drought stress		Control	Drought stress	
Checks												
K 9	90.1	23.1		24.6	8.0		0.48	0.41		4.92	2.87	
Dharani	57.4	35.2		18.0	7.7		0.67	0.63		5.15	5.89	
Advanced breeding lines												
Maximum value	117.6	112.4		42.3	35.0		4.68	2.17		16.70	10.76	
Minimum value	11.0	6.0		7.0	6.0		1.62	0.63		0.23	0.20	
Mean	55.0	19.6		17.2	9.8		0.56	0.45		5.32	4.09	
	SEm±	CD	CV	SEm±	CD	CV	SEm±	CD	CV	SEm±	CD	CV
		(P=0.05)	(%)		(P=0.05)	(%)		(P=0.05)	(%)		(P=0.05)	(%)
Treatments	1.25	3.5	28	0.4	NS	31	0.19	0.52	19	1.25	3.47	28
Genotypes	6.17	17.2		2.0	5.7		0.93	2.59		6.17	17.2	
Interaction	0.72	24.3		2.9	8.0		1.32	3.67		0.72	24.3	

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Effect of phosphorus biofertilizers and foliar spray of potassium fertilizers on growth and yield of sunflower (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was conducted during *kharif* to study the effect of phosphorus biofertilizers and foliar spray of potassium fertilizers along with RDF on sunflower. Application of 100% RDF along with soil application of VAM and foliar spray of 1% KNO₃ at 45 DAS recorded significantly higher plant height, no. of green leaves/plant, leaf area, relative chlorophyll content, total dry matter production, seed yield (2019 kg/ha), stalk yield (3397 kg/ha) and harvest index (37%) followed by application of 75% RDF along with seed treatment of PSB at 20g/kg or soil application of 12 kg/ha VAM and foliar spray of 1% KNO₃ at 45 DAS.

Keywords: VAM, PSB, KNO₃, Sunflower

Considering the importance of P nutrition in sunflower and the need for economising P fertilizer use, microbial P-solubilization as well as mobilization would be the only possible way to increase plant-available P (Peix *et al.*, 2001). Vesicular-Arbuscular Mycorrhizae (VAM) fungi provides significant amount of nutrients to the plants (copper, zinc, phosphorus and sulphur) by making their widely extended hyphal network on the upper or lower side of the soil layer. Foliar application addresses the issues associated with excessive use of chemical fertilizers in conventional soil application method.

Field experiment was conducted at University of Agricultural Sciences, Dharwad, under rainfed conditions. The soil was medium black clayey in texture, medium in organic carbon (0.52%), medium in available N (265.6 kg/ha), medium in available phosphorus (34.35 kg/ha) and high in available potassium (405 kg/ha) with pH of 7.3. Sunflower hybrid KBSH-53, with duration of 100 days was used in the trial. Fertilizer was applied at the rate of 35:50:35 N:P₂O₅:K₂O kg/ha. Half dose of nitrogen and full dose of potassium and phosphorus were applied as basal dose to all the treatments. Remaining 50% of N was top dressed at 30 days after sowing. The experiment consisted of two levels of RDF as first factor (75% RDF, 100% RDF), two phosphorus biofertilizers as second factor (seed treatment with PSB, soil application of VAM) and foliar spray of potassium fertilizers as third factor (KNO₃ @ 0.5% spray at 45 DAS, F₂: KNO₃ @ 1% spray at 45 DAS, F₃: MOP @ 1% spray at 45 DAS) with one control (RDF only) and was laid out in randomized block design (factorial concept) with three replications.

Application of 100% RDF recorded significantly higher plant height (193 cm) over application of 75% RDF (182 cm). Biofertilizer application had no

significant effect on plant height. Spraying of KNO₃ @ 1.0% at 45 DAS recorded significantly higher plant height (192 cm) and was on par with KNO₃ @ 0.5% at 45 DAS (188 cm) and significantly lower plant height was observed in treatment received MOP @ 1% at 45 DAS (183 cm). Data on number of green leaves/plant and leaf area/plant followed the similar trend. These results are in conformity with the findings of Yadav *et al.* (2009).

Application of 100% RDF recorded significantly higher seed yield (2019 kg/ha) over 75% RDF (1868 kg/ha). Biofertilizer application had no significant effect on seed yield. Foliar application of potassium fertilizers also had significant effect on seed yield. Spraying of KNO₃ @ 1% at 45 DAS recorded significantly higher seed yield (2019 kg/ha) was on par with KNO₃ @ 0.5% at 45 DAS (1954 kg/ha) and significantly lower seed yield was recorded at MOP 1.0% foliar spray at 45 DAS (1858 kg/ha). Similar trend was noticed with respect to stalk yield.

It could be concluded that, application of 75% RDF along with seed treatment of PSB at 20 g/kg or soil application of 12 kg/ha VAM and foliar spray of 1% KNO₃ at 45 DAS found suitable for higher growth and yield of sunflower.

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Optimization of safflower sowing time in northern Karnataka

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ABSTRACT

Three safflower genotypes (A-1, NARI-6 and NARI-57) were tested across three sowing times (1 to 30 October) at fortnight interval during 2014-15 and 2015-16 with an objective to find out the best sowing time for safflower crop and to identify best performing variety in northern dry zone of Karnataka. It was concluded that early sowing (first fortnight of October) as well as variety A1 were the best to give higher seed yield.

Keywords: Date of sowing, Deccan plateau, Safflower, Seed yield, Varieties

Safflower is cultivated on medium to deep black soils of Deccan plateau during post-rainy season under receding moisture conditions. Therefore, average productivity (627 kg/ha) is very low in India (Tiwari, 2002). Safflower is a cool (*rabi*) season crop, although there is no winter in south India. The optimum temperature for germination is about 15.5°C and day temperature in the range 24-32°C at flowering are congenial for higher yields (Ahlawat, 2008). In contrast, as the crop get exposed to hot and dry climate during post-sown period in semi-arid regions of India sowing the crop at optimum time (preferably early) to make the best use of stored soil moisture for early growth and biomass accumulation as well as to escape pest load is very critical (Strasil and Vorlicek, 2002).

A field experiment was conducted at Agriculture Research Station, Annigeri (150 8" N, 750 7" E and 624.8 m amsl), University of Agricultural Sciences, Dharwad as part of All-India Coordinated Research Project on Safflower during *rabi* seasons of 2014-15 and 2015-16 under rainfed condition. The soil is clayey in texture (Vertisol) with pH of 7.95, bulk density of 1.27 dS/m, and available N:P:K of 224, 21 and 342 kg/ha. The experiment included two factors; three varieties and three sowing periods laid out in split-plot design with three replications. During 2014-15 first sowing was done on 15, Oct. 2015 whereas during 2015-16 on 1, Oct. 2015, but second and third sowing were taken up at 15 days interval after first and second sowing, respectively.

As 2014-15 (normal) and 2015-16 (drought) were quite contrast in weather, instead of pooled analysis each year analysis was done separately and discussed. Irrespective of the sowing dates and varieties, crop growth and yield were much better during 2014-15 than in 2015-16 (Table 1). Among the date of sowings, however, the crop sown during first fortnight of October recorded significantly higher seed yield (1572 and 937 kg/ha, respectively during 2014-15 and 2015-16)

compared with later sown dates. Among the safflower cultivars, significantly the highest seed yield was recorded with A-1 (1718 and 1033 kg/ha, respectively during 2014-15 and 2015-16) compared with the yield of NARI-6 and NARI-57. The newly released genotypes (NARI-6 and NARI-57) did not perform as well as age old and locally very popular cultivar (A-1) under dryland ecosystem of northern Karnataka. Although interactions between planting date and genotypes were non-significant early sowing (1-15 of October) with A-1 variety recorded higher seed yield of 1772 and 1127 kg/ha, respectively during 2014-15 and 2015-16 than other combinations. Further, late sowing not only exposed the crop to warmer temperature, especially during second year all through the growing period until maturity but also exhausted residual soil moisture much faster for the crop to experience soil moisture, thus affected seed yield.

During the two years of study, irrespective of initial stored soil moisture and rains during post-rainy season, early sowing (1-15, October) was found optimum to realize higher yields and among the three varieties tested the good old A-1 variety seems to be more adapted to extremes of northern dry zone and performed much better than NARI-6 and NARI-57.

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Table 1 Growth and yield of safflower varieties across sowing periods

Treatment	Plant height (cm)		100 seed weight (g)		Seed yield (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Main plots (Sowing time)						
D1	80.80	66.17	4.56	4.00	1572	937
D2	77.30	62.67	4.04	3.90	1365	928
D3	66.60	60.92	4.21	3.90	1247	783
S.Em.	2.30	1.85	0.1	0.1	60	38
CD (P=0.05)	8.00	NS	NS	NS	207	131
Sub plots (Varieties)						
V1 (A-1)	71.50	61.03	5.29	4.60	1718	1033
V2 (NARI-6)	84.90	66.97	3.82	3.30	1179	799
V3 (NARI-57)	68.30	61.75	3.69	3.90	1286	825
S.Em.	1.80	1.95	0.14	0.10	42	29
CD (P=0.05)	5.20	NS	0.41	0.40	124	87
Interaction (Sowing time x Varieties)						
D1V1	82.00	64.30	5.87	4.30	1772	1127
D1V2	87.50	67.95	3.99	3.40	1429	895
D1V3	73.10	66.25	3.81	4.30	1517	818
D2V1	72.40	59.50	4.65	4.80	1698	1019
D2V2	87.60	66.50	3.82	3.10	1168	793
D2V3	71.90	62.00	3.65	3.80	1228	972
D3V1	60.30	59.30	5.36	4.60	1686	955
D3V2	79.70	66.45	3.65	3.40	941	710
D3V3	59.90	57.00	3.61	3.70	1115	684
S.Em.	3.40	3.32	0.22	0.20	84	56
CD (P=0.05)	NS	NS	NS	NS	NS	NS

D₁= 1-15, October, D₂= 15-30, October, and D₃=30, October to 15, November

Influence of soil moisture conservation practices and planting geometry on growth, yield and economics of safflower (*Carthamus tinctorius* L.)

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ABSTRACT

A field experiment was conducted to study the influence of soil moisture conservation practices and planting geometry on growth, yield and economics of safflower under northern dry zone (Zone-3) of Karnataka. Tied ridges (1,061 kg/ha) and plant geometry of 45 x 20 cm (1,093 kg/ha) recorded significantly higher seed yield. Similar trend was noticed with respect to gross returns and net returns.

Keywords: Conservation, Economics, Planting geometry, Seed yield

There is need to adopt any conservation measures that would help to retain maximum rain water in the soil profile for better crop response during winter situations. Conservation of greater rain water in the soil profile is just not sufficient but the conserved moisture should be utilized most efficiently as result of better management practices.

A field experiment was conducted to study the influence of soil moisture conservation practices and planting geometry on growth, yield and economics of safflower under northern dry zone (Zone-3) of Karnataka

during *rabi*, 2017-18 at ARS Annigeri. The treatments were replicated thrice in split-plot design. The main plot treatments consisted of soil moisture conservation practices (flat bed, compartment bunding and tied ridges) and subplot treatments consisted of planting geometry (45 x 20 cm, 60 x 15 cm, 60 x 20 cm and 60 x 30 cm). The soil moisture conservation practices were implemented a month before of sowing with an objective of harvesting rain water.

Tied ridges recorded 1,061 kg/ha of seed yield, which was significantly higher than in compartment

bunding (940 kg/ha) and flat bed (924 kg/ha). Sowing of safflower at spacing of 45 x 20 cm recorded significantly higher seed yield (1,093 kg/ha) over a spacing of 60 x 30 cm (907 kg/ha). Number of branches/plant, number of heads/plants, test weight and seed yield/plant were significantly higher at wider row spacing. Hiremath *et al.* (1993) reported that sowing of safflower at spacing of 45 x 20 cm recorded significantly higher seed yield (1650 kg/ha) over a spacing of 60 x 30 cm. Saran and Turkhede (1981) also observed an increased yield with corresponding increase in plant population. Gross returns, net returns and B:C ratio followed the similar trend.

It could be concluded that, tied ridge and planting geometry of 45 x 20 cm found significantly superior in improving performance of safflower in terms of growth and seed yield.

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Optimization of tillage and fertilizers for productive and profitable sunflower in paddy fallows of deep Vertisols of Karnataka

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ABSTRACT

Study was conducted on deep Vertisols to evaluate the influence of tillage and fertilizer levels on performance of sunflower hybrids in paddy fallows. Sunflower hybrids were grown in conventional-till (CT), Minimum-till (MT), Reduced-till (RT) and zero-till (ZT) with graded fertilization. Averaged across fertilizer rates, cultivars, and years, sunflower seed yields were greater with CT (1477 kg/ha) than with MT, RT and ZT. Graded fertilizers at 150% RDF (1424 kg/ha) increased grain yield over RDF and reduced level at 75% RDF but varied over years. Economic returns also higher in CT along with graded fertilizers for RSFH-1887. Results indicate sunflower can be grown successfully in paddy fallows with CT and MT and graded fertilization in the Vertisols.

Keywords: Conventional tillage, Minimum tillage, Sunflower, Zero tillage

Despite several challenges in rice fallows, there is an extensive scope to grow a second crop through appropriate soil moisture conservation. Characteristics of sunflower such as deep root system, ability to utilize the moisture from deeper soil layers of the rice fallows make it a choice crop in the fallows. However, its performance in rice-fallow is still uncertain and related information is lacking. Adoption of soil moisture conservation practice and advancement of sowing time may improve winter crop productivity. Given the context, field experiment was conducted to assess the performance of sunflower in rice fallows under four crop establishment techniques CT, MT, RT and ZT to develop the agro-techniques for sustainable cropping intensification of rice fallows.

Field experiments were conducted in *rabi* 2017-18 and 2018-19 in paddy fallows of deep Vertisols at UAS, Raichur, Karnataka. Experiment was laid out in split plot design with factorial arrangement replicated thrice. Tillage managements were main plots and sunflower hybrids and fertilizer levels were arranged in factorial as subplots. Tillage treatments were MT, RT and ZT

compared with CT. Wherein primary tillage was with two time tractor drawn MB ploughing and cultivator twice followed by harrowing. Non selective herbicide paraquat was applied to zero tillage treatment before sowing, whereas pre-emergent herbicide pendimethalin 38.7 CS was applied for other treatments. Sunflower hybrids DRSH-1, KBSH-44 and RSFH-1887 (Local check) sown at 60 x 30 cm spacing with fertilizer levels at 100%, 125% and 150% recommended dose of fertilizers (90:90:60 N:P₂O₅:K₂O kg/ha) applied at basal and 45 DAS. Hybrids were sown last week of December after paddy harvest. Other practices were followed as per recommended production packages for the region.

Sunflower seed yield was significantly influence by conventional tillage (1477 kg/ha) and it was 9%, 18% and 50% higher over RT, MT and ZT respectively (Table 1). Whereas, seed yield of hybrid RSFH-1887 was better over DRSH-1 (21%) and KBSH-44 (26%). While, application of fertilizers 50% more than RDF resulted in 13 and 27% higher grain yield over RDF and 50% RDF respectively. Oil yield was

significantly higher in CT and RT over MT and ZT and RSFH-1887 gave greater oil yield over other hybrids. Yield differences between hybrids varied from year to year and with tillage and fertilizer level. Higher monetary return was realized when RSFH-1887 was grown in conventional or reduced tillage with 150% RDF (Table 1). This way, the findings of the study could

be implicated for intensifying the rice fallows with sunflower following either conventional or reduced tillage. Besides this, an improved understanding of rice-fallow ecology may further enable us to design the appropriate crop rotations and moisture conservation practice to upscale the farmers' income in rice-fallows of Northern Karnataka.

Table 1 Influence of tillage, hybrids and fertilizer levels on yield and economics of sunflower grown in paddy fallows (Pooled data of two years)

Treatment	Oil content (%)	Seed yield (kg/ha)	Oil yield (kg/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net Returns (₹/ha)	B:C ratio
Tillage Management (M)							
Conventional- till	39.6	1477	585	23344	55179	31835	2.36
Reduced -till	40.2	1355	545	22844	50618	28274	2.22
Minimum-till	38.6	1251	483	21844	46408	24564	2.12
Zero-till	39.5	984	389	19694	35975	16281	1.83
CD (P=0.05)	0.36	65.2	71	-	-	-	-
Sunflower hybrids(G)							
DRSH-1	40.0	1113	445	21807	40968	19161	1.88
KBSH-44	38.9	1276	496	21807	47413	25606	2.17
RSFH-1887	39.6	1411	559	21807	52754	30948	2.42
CD (P=0.05)	0.38	39.4	32	-	-	-	-
Fertilizer levels (N:P₂O₅:K₂O kg/ha) (F)							
45:45:30	39.6	1119	443	15803	41217	25414	2.61
90:90:60 (RDF)	39.4	1257	495	21807	46753	24946	2.14
135:135:90	39.5	1424	562	27811	53165	25355	1.91
CD (P=0.05)	NS	30.2	36				
Interaction (M x G x F)							
CD (P=0.05)	1.1	NS	NS				

Effect of herbicides on weed dynamics, efficiency and yield of linseed (*Linum usitatissimum* L.)

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ABSTRACT

The lowest weed density and weed dry matter was observed with hand weeding twice [(21 and 45 days after sowing (DAS)]. Among herbicidal treatments, the lowest value was observed with isoproturon + metsulfuron-methyl (1 kg + 4 g/ha) as post-emergence application. The dry matter accumulation at 30 and 60 DAS was recorded significantly higher under hand weeding twice which was at par with the post-emergence application of isoproturon + metsulfuron-methyl (1 kg + 4 g/ha), metsulfuron-methyl (4 g/ha) post-emergence, isoproturon 1 kg/ha post-emergence and pendimethalin (1 kg/ha) pre-emergence followed by post-emergence application of metsulfuron-methyl (4 g/ha). The seed yield was recorded significantly higher under treatment of hand weeding twice (at 21 and 45 DAS) which was statistically comparable to the post-emergence isoproturon + metsulfuron-methyl (1 kg + 4 g/ha), metsulfuron-methyl (4 g/ha), pendimethalin (1 kg/ha) pre-emergence followed by metsulfuron-methyl (4 g/ha) post-emergence and isoproturon (1 kg/ha) post-emergence. Among the herbicides applications, weed control efficiency at 90 DAS and at harvest was recorded maximum with the application of isoproturon + metsulfuron-methyl (1 kg + 4 g/ha) and minimum was noted with the application of imazethapyr (75 g/ha).

Keywords: Herbicides, Seed yield of linseed, Weed control efficiency

The slow initial growth with lower canopy spread leads to dominance of weeds over the crop. An initial growth period of 5-45 days is very critical and season long weed competition has been found to reduce linseed yield to the extent of 30-40 per cent (Mahere *et al.*,

2000) depending on the type and intensity of weed flora. Hand weeding, which is usually preferred, adds to the cost of cultivation due to higher labour wages. Moreover, no availability of labour during peak period is also a major constraint in realizing higher yields of

linseed. Hence, chemical weed control has become an effective and cheaper alternative to manage weeds in linseed production.

A field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *rabi* season of 2017 and 2018. The experiment was laid out in a randomized block design with ten treatments, replicated three times, the treatment details were metribuzin + oxyflurofen (250 + 125 g/ha) pre-emergence (PE), oxyflurofen (125 g/ha) PE, oxadiargyl (80 g/ha) PE, imazethapyr (75 g/ha) post-emergence (PoE), metsulfuron-methyl (4 g/ha) PoE, isoproturon (1 kg/ha) PoE, isoproturon + metsulfuron-methyl (1 kg + 4 g/ha) PoE, pendimethalin (1 kg/ha) PE fb metsulfuron-methyl (4 g/ha) PoE, hand weeding twice at 21 and 45 days after seeding (DAS) and weedy check. Weed density and dry weight data were subjected to square root transformation ($\sqrt{x+0.5}$) prior to statistical analysis.

The weed density and weed dry matter were significantly influenced by different weed management treatments. At 90 DAS and at harvest, minimum weed density was observed under the treatment of hand weeding twice, while at 90 DAS, application of isoproturon + metsulfuron-methyl (1 kg + 4 g/ha) PoE was found minimum weed density of *Medicago*

denticulate and *Parthenium hysterophorus* weed species. *Convolvulus arvensis* and others weeds were found maximum with oxyflurofen (125 g/ha) PE and imazethapyr (75 g/ha) PoE, respectively at 90 DAS. Similar trend was noticed with respect to weed dry matter and weed control efficiency.

Hand weeding twice at 21 and 45 DAS registered significantly higher seed yield (1940 kg/ha), however, it was statistically at par with the application of isoproturon + metsulfuron-methyl (1 kg + 4 g/ha) PoE (1921 kg/ha), metsulfuron-methyl (4 g/ha) PoE (1871 kg/ha), pendimethalin (1 kg/ha) PE + metsulfuron-methyl (4 g/ha) PoE (1826 kg/ha) and isoproturon (1 kg/ha) PoE (1813 kg/ha). Similar findings have been reported by Dange *et al.* (2007).

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Bio-efficacy of growth regulator stance 110 SC on soybean (*Glycine max* L.)

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ABSTRACT

Plant height, no. of branches/plant, no. of pods/plant, seed yield and haulm yield were significantly greater with the application of growth regulators compared to control. Seed yield (1455 kg/ha) with the spray of stance 110 SC @ 150 ml/ha was on par with that of highest yielded treatment Chlormequat chloride 50% SL @ 500 ml/ha (1656 kg/ha).

Keywords: Growth regulator, Seed yield, Soybean, Stance

Soybean is primarily grown in kharif season. Under excessive and continuous rainfall conditions soybean produces excessive vegetative growth but it does not reflect in increased seed yield due to poor source-sink relationship. To improve source-sink relation, plant growth regulators are used in soybean.

Field experiment was conducted in the *kharif* season of 2016 and 2017 to quantify the effect of growth regulator, stance 110 SC on soybean yield and yield parameters. Four growth regulators with different doses along with control were tested on soybean (Var. DSb 21). This experiment was conducted with eight treatments in RBD. Growth regulators were sprayed two times at 45 and 60 days after sowing (DAS). The crop was grown as per the recommended package of practices.

Plant height, no. of branches/plant, no. of pods/plant, seed yield and haulm yield were significantly

greater with the application of growth regulators compared to control. Plant height was significantly the highest with stance @ 400 ml/ha; no. of branches/plant were significantly the highest with Chlormequat chloride 50% SL @ 500 ml/ha; no. of pods/plant were highest with Chlormequat chloride 50% SL @ 500 ml/ha which was on par with stance @ 150 ml/ha, mepiquat chloride 5% AS @ 355 ml/ha and Cyclanilide 2.8% SC @ 160 ml/ha. Seed yield was highest (1656 kg/ha) with Chlormequat chloride 50% SL @ 500 ml/ha which was on par with Mepiquat chloride 5% AS @ 355 ml/ha (1478 kg/ha) and stance 110 SC @ 150 ml/ha (1455 kg/ha).

Therefore, growth regulator stance @ 150 ml/ha can be sprayed as seed yield was on par with the other highest yielding treatments involving growth regulators (Chlormequat chloride @ 500 ml/ha and mepiquat

chloride @ 355 ml/ha). Similar response was also observed by Manu *et al.* (2018) in soybean.

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Table 1 Effect of growth regulators on soybean (mean of two years)

Treatment	Plant height (cm) at 75 DAS	No. of branches/ plant at 75 DAS	No. of pods/ plant	Seed yield (kg/ha)	Haulm yield (kg/ha)
Control	43.2	4.4	23.0	987	1067
Stance @ 100 ml/ha	45.7	5.9	27.9	1201	1293
Stance @ 150 ml/ha	45.7	5.4	33.8	1455	1558
Stance @ 200 ml/ha	46.1	5.2	28.8	1289	1380
Cyclanilide 2.8% SC @ 160 ml/ha	43.5	5.8	32.1	1397	1478
Mepiquat chloride 5% AS @ 355 ml/ha	48.5	5.8	33.0	1478	1695
Chlormequat chloride 50% SL @ 500 ml/ha	48.5	6.8	35.7	1656	1793
Stance @ 400 ml/ha	43.5	5.8	29.4	1315	1452
Cyclanilide 22 + Mepiquat chloride 88 SC*	48.5	6.8	29.4	1315	1452
SEm±	0.31	0.24	1.43	72	80
CD(P=0.05)	0.9	0.8	4.4	220	246

Stance* - cyclanilide 22 + mepiquat chloride 88 SC

Productivity potential of sesame in *rabi*-summer season under rice-fallow and turmeric-fallow

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ABSTRACT

The productivity potential of *rabi*-summer sesame was demonstrated in six districts of three states with adoption of improved technologies. The productivity increase with adoption of improved technologies under rice fallow situation was 22, 25 and 27% in Andhra Pradesh, Telangana and West Bengal respectively, whereas under turmeric fallow situation, the increase was 25% in West Bengal over farmer's practice.

Keywords: Productivity potential, Rice fallow, Sesame, Turmeric fallow

Rabi-summer sesame has tremendous potential in doubling the yield than the traditional kharif crop because of low incidence of insect pests and diseases (IIOR, 2016) and crop can fit well as catch crops between two regular crops (Hegde, 2012).

To show the potential of *rabi*-summer sesame under rice-fallows and turmeric-fallows, demonstrations were conducted in large contiguous areas. It was implemented in six potential districts from three states (Prakasam and Kadapa in Andhra Pradesh, Khammam and Nizamabad in Telangana, West Medinapur and Bankura districts in West Bengal) representing high spread-low productivity and low spread-high productivity. Key technologies *viz.*, improved variety, optimum seed rate, spacing, soil test based fertilizer application, seed treatment with bio-inoculants and management of pests and diseases were demonstrated (IT) in 402 farmers' fields for two years during *rabi*-summer (2015-16 and 2016-17) in contiguous clusters of four ha each.

In Andhra Pradesh, under rice-fallow situations of Kadapa and Prakasam 70% and 53% improvement in seed yield was observed as compared to the state average yield. In Telangana, under rice-fallow situation of Khammam the seed yield improvement was one and half times the state average yield. In West Bengal, where high productivity was observed, still there is scope for further enhancing the productivity by adoption of improved technologies as evidenced from the demonstrations (1575 kg/ha) compared to state average yield (930 kg/ha). In Telangana, high potential was observed in turmeric-fallow areas of Nizamabad, where the seed yield was two times that of the state average yield (Table 1).

The demonstrations have clearly indicated the potential of enhancing the productivity of sesame with adoption of improved technologies. In order to scale-up the demonstrations and speed up the dissemination of improved technologies there is a need to forge

partnerships involving extension agencies, state department of agriculture and input agencies.

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Table.1. Productivity potential of sesame during *rabi*-summer under rice-fallow and turmeric fallow

State	District	No.	Yield (kg/ha)		Increase over FP (%)	DAY (kg/ha)	% increase over DAY	SAY (kg/ha)	% increase over SAY
			IT	FP					
Rice-fallow									
Andhra Pradesh	Kadapa	24	543	450	21	430	26.2	320	70
	Prakasam	77	490	403	22	350	40.0	320	53
Telangana	Khammam	40	900	750	20	400	125.0	350	157
West Bengal	Bankura	90	1572	1214	30	825	29.5	930	69
	West Medinipur	121	1575	1275	24	795	23.5	930	69
Turmeric-fallow									
Telangana	Nizamabad	50	1050	842	25	900	16.7	350	200

IT = Improved Technology; FP = Farmer's practice; DAY = District Average Yield; SAY = State Average Yield

Effect of sowing dates on confectionery traits of groundnut cultivars

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ABSTRACT

Groundnut being a rich source of quality oil, protein and minerals, is considered as a potential crop to overcome protein-energy malnutrition. Its demand for use in confectionery is fast increasing. A field experiment was conducted with 4 sowing dates and 4 spanish bunch cultivars in 2018. Sowing period of 25th February to 10th March offered better environment for test cultivars. Cultivars J-87 and SG-99 produced bolder size kernels with higher protein content whereas, J-87 and TG-37A had higher reducing sugar content in kernels. TG-37A also had lower fat and total solids in milk than other cultivars.

Keywords: Confectionery, Groundnut, Traits for confectionery type

In India, almost half of the groundnut is used in confectionery. There is a need to increase production of confectionery type groundnut traits to meet its growing demands for both export and domestic consumption. However information on suitable cultivars and optimum sowing time with desirable quality traits under north India conditions is lacking.

Field experiment was conducted on loamy sand soil at Punjab Agricultural University, Ludhiana, during spring-summer season of 2018. Experiment was laid out in split plot design with 4 sowing dates (25th February, 10th March, 25th March and 10th April) in main plots and 4 spanish bunch type cultivars (SG-99, TG-37A, TAG 24 and J-87) in subplots in 3 replications.

Kernels produced from 25th February sown crop were bold in size with higher 100 kernel weight (67.9 g), had higher protein content and lower total carbohydrate content as compared to later sowings (Table 1). The differences in oil content, total soluble sugars, reducing

sugars and kernel hardness due to different sowing dates were non-significant. Crop sown on 25th February registered highest protein content in milk and lowest protein content in milk residue. Crop sown on 25th March produced significantly higher total solids and protein content in milk residue than the crop sown on other sowing dates. Cultivar J-87 produced bold size kernels with higher 100 kernel weight (90.6 g) and hard kernels and higher total carbohydrates as compared to other cultivars. TG-37A had lowest 100 kernel weight (50.7 g) with higher reducing sugars and oil content whereas, SG-99 had higher kernel protein content than other cultivars. Cultivar SG-99 registered significantly higher protein content in milk and milk residues whereas, J-87 had higher total solids content in groundnut milk residue than other cultivars. This analysis also showed that total soluble sugars and reducing sugars did not change across dates as well as genotypes.

Table 1. Effect of sowing dates and cultivars on confectionery attributes of groundnut

Treatments	100 kernel weight (g)	Hardiness (N)	Colour (L)	Oil (%)	Protein (%)	Total carbohydrates (%)	Total soluble sugars (micro g/ g kernel)	Reducing sugars (micro g/ g kernel)
Sowing dates								
25th February	67.9	66.1	44.0	49.8	24.4	18.6	6.21	0.369
10th March	65.2	65.2	44.5	49.6	24.3	19.0	6.22	0.371
25th March	64.6	61.4	45.4	49.4	24.2	19.2	6.23	0.373
10th April	62.1	60.9	48.7	49.2	24.1	19.4	6.25	0.375
SEm ±	1.36	-	0.76	-	0.07	0.16	-	-
CD (P=0.05)	3.33	NS	1.85	NS	0.17	0.39	NS	NS
Cultivars								
SG-99	63.0	56.3	44.2	49.5	25.2	18.1	4.68	0.345
TG-37A	50.7	51.4	46.4	50.0	24.4	19.1	6.86	0.383
TAG-24	55.4	49.3	44.7	49.4	24.0	19.4	6.90	0.365
J-87	90.6	96.7	47.3	49.0	23.3	19.5	6.47	0.393
SEm ±	1.62	2.33	0.95	0.27	0.15	0.22	0.07	0.005
CD (P=0.05)	3.33	4.81	1.96	0.56	0.31	0.45	0.15	0.01
Sowing dates × cultivars	NS	NS	NS	NS	NS	NS	NS	NS

Effect of hydro-priming on imbibition rates in oilseed crops

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ABSTRACT

Laboratory experiment was conducted to study the rate of imbibition in major oilseed crops (groundnut, sunflower and soybean) which would be useful in seed hardening process. Imbibition of 30 to 35% would be ideal for normal seed germination and this was achieved by 3 to 4 h (groundnut), 2 h (sunflower) and 1 to 2 h (soybean) after soaking.

Keywords: Imbibition, Oilseed, Priming, Seed hardening

The studies on imbibition would be relevant for attaining good plant stand in the field. Further, higher imbibition is also not useful as the solutes will be leaked out from the tissue and results in poor germination. The imbibition of 30-35% would be ideal for proper seed germination. Hence, the present study was conducted to identify the time required for 30-40% imbibition in major oilseed crops.

The laboratory experiment was conducted at University of Agricultural Sciences, Dharwad. The experiment included three crops (groundnut, sunflower and soybean) with six soaking periods (0, 1, 2, 3, 4, 24 h) in four replications. Nearly 5 g of seeds were weighed, soaked in 50 ml of water for different time periods in beakers. At each time, seeds were taken out from the beaker, water adhering to seed surface was removed using a tissue paper and weighed. After recording the seed weights upon imbibition, the data was analysed CRD for statistical significance in each crop separately.

The imbibition weight of seed increased significantly with time of soaking in groundnut, sunflower and soybean. The rate of imbibition was lower in case groundnut compared to the sunflower and soybean (Table 1). The differences in imbibition could be due to seed coat, seed size, the surface area to volume ratio and seed composition. Although groundnut and

sunflower are similar for oil, protein and fat composition, the surface area to volume is low in groundnut and hence lower seed germination. Further, the higher imbibition in sunflower could be due to space available between kernel and seed coat to hold more water as compared to tight seed coat in groundnut. Soybean recorded highest imbibition per cent, as soybean is less in fat content and rich in protein compared to groundnut and sunflower.

The appropriate time for imbibition in groundnut, sunflower and soybean was 4h, 2h and 1h respectively (Table 1). Harris *et al.* (1999) have proposed overnight soaking to 24h for seed hardening, however, overnight soaking may lead to leakage of solutes from the seeds; seed may rotten and reduce the germination. Hence, this study was useful in identification of appropriate seed hardening time for each crop that would help in mitigating the moisture stress at seed germination stage in rainfed situations.

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Table 1 Effect of soaking period on water imbibition in oilseeds

Treatment	Groundnut		Sunflower		Soybean	
	Seed weight (g)	Imbibition (%)	Seed weight (g)	Imbibition (%)	Seed weight (g)	Imbibition (%)
0	5.067		5.003		5.063	
1h	5.988	18.2	6.218	24.3	6.662	31.6
2h	6.395	26.2	6.869	37.3	7.659	51.3
3h	6.662	31.5	7.464	49.2	8.546	68.8
4h	6.787	33.9	7.827	56.4	9.444	86.5
24h	7.078	39.7	9.079	81.5	12.656	149.9
SEm±	0.028		0.071		0.140	
CD (P=0.05)	0.083		0.213		0.421	
CV(%)	0.880		2.011		3.370	

Evaluation of sunflower (*Helianthus annuus* L.) based cropping systems for enhanced productivity and efficiency

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ABSTRACT

A field experiment was conducted to study the performance of sunflower in emerging cropping system during 2017-18. The experiment was laid out in split plot design. Cropping systems (Cotton-sunflower, Maize-sunflower, Soybean-sunflower and Sunflower-groundnut) were raised in main plots and fertilizer levels (RDF, STCR and 50% STCR) were implemented in subplots. Among the cropping systems, maize – sunflower cropping system gave the highest BCR (1.53) followed by sunflower-groundnut (1.49). Among the fertilizer levels, STCR based fertilizer application recorded significantly greater yield increase than RDF.

Keywords: Economics, Seed yield, STCR, Sunflower

Adoption of suitable cropping systems enables the farming community to use natural resources efficiently. Practicing of improper cropping systems to suit sunflower production was identified as one of the major production constraints. To overcome the above constraint the possibility of cropping systems with sunflower were studied during 2017-18.

The field experiments were conducted at the Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore during 2017-18. The experiment was laid out in split plot design and the treatments were replicated thrice. The main plot consisted of cropping systems (Cotton-sunflower, Maize-sunflower, Soybean-sunflower and Sunflower-groundnut) and subplot consisted the fertilizer levels (RDF, STCR and 50% STCR).

Among the kharif crops, maize registered higher net income and benefit cost ratio followed by cotton when compared to soybean and sunflower. Higher sunflower seed equivalent yield was maximum in sunflower-groundnut cropping sequences which may be attributed to higher yields and better price. This finding is in confirmation with the findings of Sesha *et al.* (2006). Among the different cropping systems, maize-sunflower

cropping system gave the highest BCR (1.53) followed by sunflower-groundnut cropping system which gave second best BCR (1.49) (Table 1). Among the fertilizer levels STCR based fertilizer application recorded significant yield increase as compared to RDF. The increase in yield may be due to increased availability of nutrients to plants, since in STCR based fertilizer application, 30 to 50% higher dose of fertilizers was applied than the RDF. Similar results were reported in pearl millet crop by Sharma *et al.* (2016).

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Table 1 Yield and economics of sunflower based cropping systems

Cropping system	Sunflower equivalent yield (kg/ha)		Sunflower yield in system (kg/ha)	System economics			BCR
	<i>Kharif</i>	<i>Rabi</i>		Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	
Cotton - sunflower	3314	1708	5022	109000	160696	51696	1.47
Maize - sunflower	2412	1851	4263	89000	136416	47416	1.53
Soybean - sunflower	1256	1897	3153	74000	100884	26884	1.36
Sunflower - groundnut	1935	3971	5906	127000	188995	61995	1.49

Nitrogen and sulphur requirements of shattering tolerant canola oilseed rape (*Brassica napus* L.) under varied plant population

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ABSTRACT

The study was conducted during *rabi* 2018-19 to study about the row spacing, nitrogen and sulphur requirements of shattering tolerant oilseed rape. Row spacing of 30 cm resulted in 12.7 and 12.6 % higher seed (2819 kg/ha) and oil (1066 kg/ha) yield than 45 cm row spacing. Application of 100 kg/ha of N significantly increased the seed yield by 11.8% and oil yield by 11.9% over 75 kg/ha of N. Application of 40 kg/ha of S increased the seed and oil yield by 3.8% and 4.5%, respectively over 20 kg/ha of applied S. Interactions between different treatments for different traits were non-significant.

Keywords: Canola, Nitrogen, Plant population, Sulphur

Oilseed rape introduced in Punjab in early eighties has become the most important oilseed crop in Punjab and Himachal Pradesh particularly in the colder regions due to its high yield potential, cold tolerance and resistance to white rust. Development of canola quality cultivars owing to their better oil and meal quality has further increased its scope in the region. However, oilseed rape is highly prone to seed shattering which results in substantial seed losses at harvest. Concerted breeding efforts in PAU have led to development of shattering tolerant genotypes.

A field study was carried out during *rabi* 2018-19 with two row spacings (30 cm and 45 cm), three doses of nitrogen (75, 100 and 125 kg/ha) and two doses of sulphur (20 and 40 kg/ha). Row spacing comprised the

main plot and combinations of doses of nitrogen (N) and sulphur (S) comprised the subplot treatments which were arranged in split plot design with three replications.

Closer row spacing resulted in 12.7 and 12.6 % higher seed (2819 kg/ha) and oil (1066 kg/ha) yield than wider row spacing due mainly to higher plant population per unit area. Increase (13.7%) in stover yield with 30 cm row spacing over 45 cm row spacing was significant. Seed, stover and oil yields increased with increase of N 125 kg/ha though significantly up to 100 kg/ha of N. Application of 100 kg/ha of N, thus, significantly increased the seed yield by 11.8% and oil yield by 11.9% over 75 kg/ha. S did not influence the yield and yield parameters of crop. Interactions between different treatments for different traits were non-significant.

Table 1 Effect of row spacing, nitrogen and sulphur levels on shattering tolerant canola oilseed rape

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)	Plant height at harvest (cm)	Primary branches/plant	Secondary branches/plant	Siliquae/plant	Seeds/siliqua
Row spacing (cm)										
30	2819	9757	22.4	41.3	1166	192.2	8.0	2.8	298.5	22.8
45	2501	8577	22.6	41.4	1035	191.8	8.2	3.2	299.3	22.9
CD (P=0.05)	NS	855	NS	NS	NS	NS	NS	0.3	NS	NS
N (kg/ha)										
75	2422	8725	21.7	41.4	1002	191.5	8.0	2.7	292.3	21.4
100	2708	9190	22.8	41.4	1121	192.7	8.0	2.8	295.6	23.6
125	2850	9585	23.0	41.3	1178	191.9	8.3	3.4	308.8	23.5
CD (P=0.05)	199	619	NS	NS	83	NS	NS	NS	NS	1.3
S (kg/ha)										
20	2610	9147	22.2	41.3	1076	191.1	8.0	2.7	289.1	22.8
40	2710	9187	22.8	41.5	1124	192.9	8.2	3.2	308.7	22.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Integration of pre and post-emergence herbicides for weed management in irrigated groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Field experiment was conducted during *kharif* 2018 to evaluate suitable integrated weed management practices for effective weed control in groundnut. Pre-emergence application of pendimethalin 30EC+imazethapyr 2EC (1.0 kg/ha) followed by one manual weeding at 25-30 days after sowing recorded higher weed control efficiency and pod yield than other treatments.

Keywords: Groundnut, Herbicide, Hand Weeding, Weed Control

Groundnut is highly susceptible to weed infestation because of its slow growth at initial stages upto 40 days after sowing (DAS). Therefore, weeding has to be completed before pegging. Therefore, an experiment was carried out to identify the most effective and cheaper weed control methods for yield improvement in groundnut.

A field experiment was conducted during *kharif* 2018 at Regional Research Station, Tamil Nadu Agricultural University, Vridhachalam in red sandy loam soil. Nine treatments were laid out in randomized block design with three replications. Treatment details are given in Table 1. The groundnut variety VRI 8 was sown at 30x10 cm. Total weed density and weed biomass were recorded using 0.25 m² quadrant. The experimental data were subjected to statistical analysis using standard procedures.

Application of pendimethalin 30EC+imazethapyr 2EC @ 1.0 kg/ha (ready mix) as pre-emergence herbicide followed by one manual weeding at 25-30 DAS recorded lower weed density (33.3/m²) and higher weed control efficiency (67.4%). Significantly higher

pod yield of 2400 kg/ha was recorded by pre-emergence application of pendimethalin 30EC+imazethapyr 2EC @ 1.0 kg/ha (ready mix) followed by one manual weeding at 25-30 DAS. The results are in close agreement with the findings of Jadhav *et al.* (2015) and Shwetha *et al.* (2016).

From the present investigation, it was concluded that PE application of pendimethalin 30 EC+imazethapyr 2EC @ 1.0 kg a.i//ha (ready mix) followed by one manual weeding at 25-30 DAS proved best weed management practice for groundnut.

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Table 1 Influence of weed management practices on groundnut

Treatments	Weed density (/m ²)	Weed control efficiency (%)	Dry pod yield (kg/ha)
T1 Pendimethalin 30EC @ 1.0 kg/ha PE	186.7	29.9	950
T2 T1+ Imazethapyr 2EC @ 1.0 kg/ha PE (ready mix)	96.0	41.4	1300
T3 T1+ Quizalofop-p-ethyl @ 50 g/ha at 15-20DAS	157.3	34.1	1267
T4 T2 + Quizalofop-p-ethyl @ 50 g/ha at 15-20 DAS	93.3	41.0	1400
T5 T1 + Imazethapyr @ 75 g/ha at 15-20 DAS	72.7	52.4	1600
T6 T1 + Manual weeding at 25-30 DAS	71.3	60.3	2067
T7 T2 + Manual weeding at 25-30 DAS	33.3	67.4	2400
T8 Two manual weeding at 20 and 40 DAS	53.3	61.4	1967
T9 Weedy check.	356	0	383
S.Ed	13.2	-	130.8
CD(P=0.05)	28	-	277

Genetic association studies for oil yield in F₃ generation of sunflower (*Helianthus annuus* L.) for the cross COSF7B x 302 B

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ABSTRACT

Eleven progenies of F₃ generation of sunflower were selected for the character association study to assess the relationship among oil yield and its components. Observations were recorded on fourteen traits viz., days to first flowering, days to maturity, plant height, head diameter, powdery mildew percentage disease index, 100 seed weight, volume weight, seed yield, seed shape, seed colour, stripes on the margin, stripes between the margin, seed yield/plant, oil content and oil yield. Character association analysis revealed strong positive association of oil yield/plant with head diameter, 100-seed weight, seed yield and oil content. Hence, synchronized selection of these characters would contribute for the improvement of the oil yield/plant.

Keywords: Correlation, Oil yield, Sunflower

Information of genetic system controlling yield and its components is useful in understanding the prepotency of the parents and thus benefit to select parents possessing in-built genetic potential. For efficient selection with improved oil yield interrelationship between oil yield and its components is inevitable and mutual association of plant characters which is determined by correlation coefficient is used to find out the degree (strength), mutual relationship between various plant characters and the component character on which selection can be relied upon the genetic improvement of yield.

The experimental material comprised of eleven progenies of F₃ generation of single cross COSF7B x 302 B and their parents. These progenies and the parents were raised at the Department of Oilseeds, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during *kharif* 2018. The characters studied were days to first flowering, days to maturity, plant height, head diameter, powdery mildew percentage disease index, 100 seed weight, volume weight, seed yield, seed shape, seed colour, stripes on the margin, stripes between the margin, seed yield/plant, oil content and oil yield/plant. Genotypic (rg) correlation coefficient was calculated using the formulae given by Al-Jibouri *et al.* (1958).

Oil yield was highly significant and positively correlated with seed yield/plant (0.984). Other researchers Singh *et al.* (2018) indicated a positive relationship of different intensity between seed and oil yield. Head diameter (0.603), 100-seed weight (0.572), oil content (0.921) were significantly correlated with oil yield. Similar results were reported by Sivamurugan (2011). The trait volume weight recorded a significant negative correlation with oil yield. The characters viz., days to first flowering, days to maturity, plant height, seed shape and seed colour had non-significant and positive association with oil yield whereas characters such as percentage disease index, seed stripes on the margin and seed stripes between the margin had non-significant negative association with oil yield (Table 1).

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Table 1 Estimates of correlation coefficient between oil yield and yield contributing traits in F₃ population of sunflower (*Helianthus annuus* L.) for the cross COSF7B x 302 B

	Days to flowering	Days to maturity	Plant height	Head diameter	PDI	Seed yield	Hundred Seed weight	Volume weight	Seed shape	Seed colour	Stripes on the margin	Stripes between the margin	Oil content
Oil yield	0.253	0.254	0.347	0.603**	-0.258	0.984**	0.572*	-0.456*	0.273	0.145	-0.077	-0.077	0.921**

**Significance at 0.01 probability level *Significance at 0.05 probability level

Influence of weed management practices on growth parameters and seed yield of sunflower (*Helianthus annuus* L.)

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ABSTRACT

Pre-emergence application of pendimethalin 38.7CS @ 750 g/ha followed by inter-cultivation recorded significantly higher growth parameters viz., plant height (202.5 cm), total dry matter production (170.4 g/plant), leaf area (144.6 dm²/plant), leaf area index (0.81) and seed yield (20.7 q/ha) of sunflower than all other treatments. This was on par with farmers' practice. Net returns and benefit cost (B: C) ratio followed the similar trend.

Keywords: Economics, Seed yield, Sunflower, Weed control

Sunflower yield loss due to weeds is estimated to be about 81 per cent (Jayakumar *et al.*, 1988). So, it is necessary to control weeds timely to optimize the sunflower yield and there is need to identify the best weed management practice.

The field experiment was conducted at University of Agricultural Sciences, Dharwad during late *kharif*, 2018. Fifteen treatments were replicated thrice in RCBD on Vertisols against weeds in sunflower (DSFH-3). All recommended package of practices were adopted.

Substantially higher growth parameters viz., plant height (202.5 cm), drymatter (170.4 g/plant), leaf area (144.6 dm²/plant), leaf area index (0.81), seed yield (20.7 q/ha), net returns (43074/ha) and B:C ratio (2.46)

of sunflower crop were recorded with pre-emergence application of pendimethalin 38.7CS @ 750 g/ha followed by inter cultivation at 35 days after sowing (DAS). Similar findings were reported by Hansraj *et al.* (2018). This was attributed to better control of weeds during initial crop stage by herbicide as well as at later stage of the crop by inter cultivation (Table 1).

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Hansraj H, Vikram B, Vipin K, Vijay K and Vinay K 2018. Influence of weed management practices on economics and nutrient uptake in sunflower. *International Journal of Pure and Applied Biosciences*, **6**: 777.

Table 1 Influence of weed management practices on growth parameters, seed yield, net returns and B: C ratio of sunflower

Treatment	Plant height (cm)	Dry matter (g/plant)	Leaf area (dm ² /plant)	LAI	Seed yield (q/ha)	Net returns (₹/ha)	B: C ratio
T1: Pendimethalin 30 EC @ 1000 g/ha	182.1	141.6	68.9	0.38	16.6	30,280	2.09
T2: Pendimethalin 38.7 CS@ 750 g/ha	181.6	144.2	73.4	0.41	16.4	29,559	2.06
T3: Sulfentrazone 48 SC @ 192 g/ha	179.3	138.1	62.0	0.35	14.7	23,877	1.87
T4: Propaquizafop 10 EC@ 75 g/ha	176.4	127.3	51.5	0.29	13.2	18,167	1.65
T5: Quizalofop-p-ethyl 5 EC @ 75 g/ha	179.1	128.8	56.4	0.32	13.1	16,820	1.58
T6: Fenoxaprop-p-ethyl 9.3 EC@ 50 g/ha	174.7	126.7	54.0	0.30	12.9	17,854	1.65
T7: Pendimethalin 30 EC @ 1000 g/ha fb IC	198.0	166.0	134.9	0.75	20.2	41,415	2.42
T8: Pendimethalin 38.7 CS@ 750 g/ha fb IC	202.5	170.4	144.6	0.81	20.7	43,074	2.46
T9: Sulfentrazone 48 SC @ 192 g/ha fb IC	197.1	161.9	128.9	0.72	18.2	35,665	2.23
T10: Propaquizafop 10 EC @ 75 g/ha fb IC	192.9	151.7	117.1	0.65	17.8	33,082	2.13
T11: Quizalofop-p-ethyl 5 EC @ 75 g/ha fb IC	193.4	154.3	125.3	0.69	18.5	33,147	2.09
T12: Fenoxaprop-p-ethyl 9.3 EC @ 50 g/ha fb IC	189.3	151.8	121.0	0.067	17.8	33,434	2.16
T13: Farmers practice (2 HW + 1 IC at 40 DAS)	197.0	164.4	134.1	0.75	19.5	34,193	2.01
T14: Weed free check	204.6	180.4	165.2	0.92	22.1	33,835	1.78
T15: Weedy check	167.1	110.2	45.5	0.25	8.6	4,020	1.15
SEm ±	6.6	4.9	7.4	0.04	1.1	3,810	0.12
CD (P=0.05)	19.2	14.2	21.3	0.12	3.2	11,036	0.35

Note: fb: followed by, IC: inter-cultivation at 35 days after sowing (DAS), HW: hand weeding (at 15 and 30 DAS)

Effect of different levels of fertilizer doses on growth, nutrient uptake and yield of sunflower cultivars

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ABSTRACT

Application of 100% RDF improved all growth parameters, yield contributing characters, uptake of nutrients, oil content, protein content, oil yield and available soil nutrient status at harvest of sunflower. Among the different cultivars DRSH-1 was found superior in growth parameters, yield contributing characters, nutrient uptake, oil content, protein content and oil yield followed by Jwalamukhi, DRSF-108, LSF-08 and LSFH-35.

Keywords: Cultivars, Seed yield, Sunflower

Generally sunflower is grown in marginal soil with poor crop husbandry under mostly rainfed or partial irrigated conditions. To enhance the productivity of the crop, proper nutrient management of major nutrients along with sulphur is necessary. Therefore, for wide spread adoption and exploitation of high yield potential of the sunflower hybrids, it is important to work out requirement of graded levels of fertilizer under rainfed condition of Marathwada. Keeping these in view the present investigation was carried out to study the effect of different levels of fertilizer doses on growth, uptake and yield of sunflower cultivars.

The experiment was conducted in *kharif* at Oilseed Research Station, Latur. The soil was deep black with clay in texture, moderately calcareous in nature and slightly alkaline in reaction, low in available N (155.41 kg/ha), high in available P (22.44 kg/ha), high in available K (243.15 kg/ha) and high in available S (18.7 kg/ha) content. The field experiment consisting of 4 fertilizers levels (0, 50, 100, 150% RDF) and 5 cultivars (DRSF-108, LSF-08, DRSH-1, LSFH-35, Jwalamukhi). It was laid out in split plot design with three replications. The recommended dose of fertilizer was 60: 30: 30 N:P₂O₅:K₂O kg/ha.

Application of 100% RDF and hybrid DRSH-1 recorded significantly greater growth parameters over rest of the fertilizer doses and cultivars. However, it was at par with the treatment 150% RDF. DRSH-1 was followed by Jwalamukhi, DRSF-108, LSFH-35, and LSF-08. Significant increase in no. of filled seeds (705), seed yield/plant (35.2 g), test weight (54.3 g) was

observed due to 100% RDF followed by 150% RDF and DRSH-1 produced maximum number of unfilled seeds/plant followed by Jwalamukhi DRSF-108, LSFH-35, and LSF-08. While no. of unfilled seeds/plant was highest in LSF-08 and lowest was in DRSH-1.

RDF recorded significantly higher seed yield (1404 kg/ha), stalk yield (4165 kg/ha), dry weight of capitulum (1538 kg/ha) and harvest index (19.7%) than the rest of the treatments. The increase in seed yield of sunflower might be due to adequate supply of nutrients to different parts of sunflower plant which resulted in proper development of seeds. Similar findings were also recorded by Mandal and Giri (2002). DRSH-1 recorded maximum seed yield (1480 kg/ha), stalk yield (4226 kg/ha), dry weight of capitulum (1538 kg/ha) and harvest index (20.37%) followed by Jwalamukhi, DRSF-108, LSFH-35, LSF-08. Lower yield characters were recorded by LSF-08. The combination of hybrid DRSH-01 and 150% RDF recorded highest seed yield (1698 kg/ha). Significantly, the higher nutrient concentration and uptake of N, P, K and S was recorded with 100% RDF than rest of the treatments but it was at par with 150% RDF. Concentration and uptake of nutrients were significantly higher with cultivars DRSH-01 than rest of the cultivars.

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Response of safflower (*Carthamus tinctorius* L.) to integrated nutrient management practices

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ABSTRACT

Application of RDF + 2 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha (T10) recorded significantly higher seed yield (989 kg/ha) compared with other treatments. Lowest seed yield (773 kg/ha) was

recorded with RDF (40:40:12 kg/ha) (T2). Growth and other yield parameters also followed similar trend. However, application of 50% RDF + 1 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ 10 kg/ha (T7) recorded significantly higher net returns (₹ 9853/ha) and B:C ratio (1.61) than other treatments.

Keywords: *Azospirillum*, Net returns, Safflower, Seed yield, Vermicompost,

Inadequate and imbalanced fertilizer use and emergence of multiple nutrient deficiencies are the major factors responsible for low productivity of the crops (Tiwari, 2002). Therefore, in order to achieve sustainable yield, there is a need to work out proper nutrient management technique for safflower through combined application of organic manures, chemical fertilizers and biofertilizers.

A field experiment was conducted at the Agricultural Research Station, Annigeri (UAS-D) during *rabi* season of 2015-16. The experiment comprised of 10 treatments namely, T1- RDF (40:40:12 kg/ha N:P₂O₅:K₂O + FYM (5 t/ha); T2 - RDF, T3 - 50% RDF + 1 t/ha vermicompost + *Azospirillum* + PSB; T4 - RDF + 1 t/ha vermicompost + *Azospirillum* + PSB, T5 - 50% RDF + 2 t/ha vermicompost + *Azospirillum* + PSB; T6 - RDF + 2 t/ha vermicompost + *Azospirillum* + PSB; T7 - 50 % RDF + 1 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha; T8 - RDF + 1 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha; T9 - 50% RDF + 2 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha and T10 - RDF + 2 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha. The treatments were replicated thrice and experiment was laid out in a randomized complete block design (RCBD). The soil of the experimental field was clayey in texture and soil in low and high rating for available N (224 N kg/ha), available phosphorus (20.86 kg/ha) and available potassium (342 kg/ha). The seed of Annigeri-1 variety was sown on 8th October, 2015 at a spacing 60 x 30 cm. The fertilizer was applied as per treatments. The crop was grown with recommended package of practices.

Yield and yield components of safflower varied significantly among various integrated nutrient levels. T10 recorded significantly higher number of capitula/plant (28.27), no. of seeds/capitula (28.53), seed weight (21.45 g/plant), 100 seed weight (6.11 g), seed yield (989 kg/ha) and stalk yield (2628 kg/ha) than all the other treatments. But T6 to T9 were statistically at par with T10. Increased seed yield and yield components perhaps are due to the balanced and continuous supply of macro and micro nutrients throughout the crop growth period. These results are in confirmation with that of Jalilian *et al.* (2012).

Treatment T7 recorded significantly higher net returns (₹9977/ha) and B:C ratio (1.61) than other treatments. This is mainly because of reduction in input cost on chemical fertilizer and vermicompost. Based on the results of the field experimentation, it is concluded that profitable and potential production of safflower can be achieved by application of 50% RDF + 1 t/ha vermicompost + *Azospirillum* + PSB + ZnSO₄ @ 10 kg/ha.

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Management strategies to mitigate drought stress in Indian mustard (*Brassica juncea* L.) through microbes

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ABSTRACT

One irrigation schedule produced statistically similar seed yield of mustard as produced with two irrigations. One irrigation could be saved by using these cultures. Among the cultures, MRD17 and MKS6 gave 29.7% and 24.7% higher productivity over no inoculation. The other parameters such as relative water content, membrane stability index and chlorophyll content were also higher in these treatments.

Keywords: Drought stress, Microbes, Mustard

After soybean and palm oil, rapeseed mustard is ranked third most essential source of plant oil in the world. Among all abiotic stresses, drought stress is the major cause of low crop yield. About 40% to 60% of total crop yield losses in the world is due to drought stress. The water deficit stress has deleterious effects during both vegetative and reproductive growth stages of the crop. The biggest task in the future will be growing crops with less water availability, especially in areas which have inadequate good quality water resources. So, there is a need to cope with this problem by adopting strategies which result in more economical and more efficient use of water. Many strategies such as foliar applied nutrients, growth regulators, compatible solutes, mulching and different sowing methods have already been developed to cope with water deficit conditions. The soil microbes isolated from the same region could play a significant role in alleviation of drought stress in plants.

An experiment was conducted at Directorate of Rapeseed-Mustard Research, Bharatpur, (770 27' E, 270 11' N), Rajasthan, during 2017-18. The climate of the experimental area is dry with hot summer, a cold winter and a short monsoon. More precisely, the area is semiarid dry accounting moisture index (-53.1). The rainfall is variable with greater distribution during onset of south-west monsoon. The experimental field was

sandy loamy Inceptisol (Typic Ustochrepts). A split-split plot design with three replications was used for the study. The main plot was irrigation levels (one irrigation, two irrigation, no irrigation) and four microbial cultures treatments (NAD7, MRD17, MKS 6, without inoculation) constituted the subplots. The sources of N and P were urea (46% N) and di-ammonium phosphate (18% N & 46 % P₂O₅), respectively. All the P and half of the N were applied basally before planting; the other half of N was top-dressed at 30 days after sowing. Recommended fertility level means 80 kg N and 17.5 kg P/ha, but without potassium application. Other package of practices, including insect, pests including weed control were followed according to local agronomic practices unless otherwise indicated.

The irrigation scheduling and microbial cultures had shown significant effect on mustard seed yield. However, interaction had no significant influence on the seed yield. Significantly highest seed yield (2396 kg/ha) was recorded with two irrigations but was at par with one irrigation (2363 kg/ha).

Among the microbial cultures seed dressing with MRD 17 and MKS 6 recorded significantly higher seed yield of mustard over NAD 7 and without inoculation. The mustard productivity increased by 27.1% by the use of these two cultures over no inoculation.

Response of soybean (*Glycine max* L.) genotypes to different spacings

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ABSTRACT

MAUS-612 variety recorded significantly highest seed yield over MAUS-158, JS-93-05 and MAUS-162. The spacing of 45 x 7.5 cm recorded significantly highest seed yield. This combination recorded significantly the highest seed yield.

Keywords: Seed yield, Soybean, Spacing, Varieties

Optimum plant population is the key factor affecting growth and yield of soybean and limited information is available on the performance of soybean genotypes under different spacing. In view of above considerations, the present investigation was carried out to assess the response of soybean varieties to different spacings.

A field experiment was conducted during *kharif* 2018 at Department of Agronomy College of Agriculture, Latur. The soil was clayey in texture, low in available N, medium in available P, high in available K. The experiment was laid out in factorial randomized block design with three replications. The treatments were consisting of twelve combinations with two factors i.e. four varieties (MAUS-158, JS-93-05, MAUS-162, MAUS-612 and three spacings (45 x 5 cm, 45 x 7.5 cm, 45 x 10 cm). The data recorded were statistically analyzed by using technique of analysis of variance.

45 x 10 cm. The data recorded were statistically analyzed by using technique of analysis of variance.

Soybean variety MAUS-612 produced significantly highest values of growth and yield attributes over all the varieties except MAUS-162. This apparent variation might be attributed to the differences in the genotype which decide the biometric parameters that vary in each variety. These results are in agreement with the previous finding reported by Kausale (2000).

The spacing of 45x 5 cm recorded highest plant height of soybean over 45 x 10 cm and found at par with 45 x 7.5 cm. The increased plant height under 45x 5 cm might be due to higher competition for space and light resulting in taller plants. The number of functional leaves and number of pods/plant were significantly

higher with 45 x 10 cm over 45 x 5 cm and found at par with the 45 x 7.5 cm. The significantly highest values of branches/plant, leaf area/plant, dry matter/plant and seed yields were recorded with 45 x 7.5 cm. Interaction effects were not significant. This might be because of the accumulating effect of the growth contributing characters. Similar results were also reported by Pandey *et al.* (2005).

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Table 1 Effect of different genotype and spacing on growth attributes, yield attributes, yield and economics of soybean

Treatments	Plant height	Branches/plant	Functional leaves/plant	Leaf area (dm ² /ha)	No. of pods / plant	Drymatter (g/plant)	Seed yield (kg/ha)
MAUS-158	22.6	6.9	15.0	13.58	66.7	23.29	1639
JS-93-05	27.5	7.5	14.7	13.10	69.0	23.64	1688
MAUS-162	32.1	7.7	14.7	13.15	70.3	23.72	1856
MAUS-612	33.0	8.3	16.8	14.12	70.5	24.13	2306
SE±	0.67	0.25	0.36	0.15	0.34	0.17	38
CD (P=0.05)	1.9	0.7	1.0	0.44	1.0	0.48	110
45 x 5cm	30.2	7.3	14.6	13.26	68.5	23.77	1806
45 x 7.5 cm	28.5	7.4	15.6	13.31	69.2	23.40	2155
45 x 10 cm	27.7	8.1	15.7	13.89	69.7	23.93	1656
SE±	0.58	0.22	0.31	0.13	0.29	0.14	33
CD (P=0.05)	1.6	0.6	0.9	0.38	0.8	0.42	95
SE±	1.15	0.43	0.62	0.26	0.59	0.29	65
CD (P=0.05)	NS	NS	NS	NS	NS	NS	191

The agro-morphological characterization of castor (*Ricinus communis* L.) inbred lines

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ABSTRACT

Thirty six castor inbred lines were studied for agro-morphological characterization, the entire group of inbred lines showed wide range of genetic variation for qualitative traits like anthocyanin pigmentation on hypocotyl and younger leaves, bloom/waxiness, stem colour, types of internodes on main stem, leaf shape, petiole surface, types of flowers on primary spike, spike shape, spike compactness, spines on capsules, location of branches, branching pattern, seed shape, seed coat colour, seed mottling and seed caruncle and quantitative traits like days to 50% flowering, plant height, primary spike length, no. of nodes to primary raceme, 100 seed weight. The hypocotyl anthocyanin pigmentation showed close association with presence of anthocyanin pigmentation on young leaves. About 97% of inbred lines exhibited double bloom nature which is an important trait for drought tolerance in castor.

Keywords: Castor inbreds, Qualitative traits, Quantitative traits, Variability

For the effective selection of superior genotype to use in hybridization programmes aimed at developing superior varieties, proper study of genetic variability due to genetic and non-genetic causes and other genetic parameters is necessary (Prasad *et al.*, 2012). Large variability in the initial breeding material ensures better chances of producing new desired forms of a crop (Raturi *et al.*, 2014). The present investigation was undertaken to study the essential characters of castor

genotypes for grouping them and to study the distinctness in each genetic stock under investigation.

The experimental material comprised of 36 castor inbred lines and was sown in augmented block design at AICRP on Castor ZARS, GKVK, Bengaluru. Each entry was raised in single row of 6 m length with a spacing of 90 x 60 cm. The recommended package of practices was followed. The varieties were characterized for 25 characters as per DUS test guidelines (Anonymous, 2006).

Qualitative characters are considered as the diagnostic markers traits for identification and distinguishing castor genotypes. These traits are less influenced by environment (Raut, 2003). Traits like anthocyanin pigmentation on hypocotyl and younger leaves, presence of bloom, stem colour, type of internodes, leaf shape, petiole surface, types of flowers on primary spike, spike shape, spike compactness, spininess on capsules, location of branches, branching pattern, seed shape, seed coat colour, seed mottling and seed caruncle. The hypocotyl anthocyanin pigmentation on young leaves showed close association with presence of anthocyanin pigmentation on young leaves. About 97% of inbred lines were exhibited double bloom nature which is an important trait for drought tolerance in castor. About 10 genotypes found early which were flowered in less than 45 days after sowing. Further, 13 castor inbred lines shown high 100 seed weight (>30 gm). All the inbreds had dense spines on capsules except MI-84, oval seed shape observed in 34 inbreds and the

results are in accordance with findings of Chaudhari *et al.* (2019)

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Performance of castor (*Ricinus communis* L) hybrids and varieties under rainfed conditions in Alfisols

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ABSTRACT

An experiment was conducted to study the performance of seven hybrids/varieties of castor for their adaptability and yield potentiality. GCH-8 recorded significantly higher seed yield of castor (2369 kg/ha) and was statistically superior over rest of the cultivars. Seed yield of GCH-8 in each harvest was 961, 698 and 710 kg/ha at primary, secondary and tertiary spikes respectively.

Keywords: Castor, Hybrids, Performance, Varieties

The assessment of stability and adaptability of the genotypes is an important component of natural recourse management, because in the eve of elevated agro inputs prices and depleting natural resource, the venture of crop production must explore the resources judiciously. Hence, genotype used in crop production process must have higher resource use efficiency. Therefore, an experiment was conducted to study the performance of castor hybrids and varieties under rainfed conditions in Alfisols.

Experiment comprises of seven castor hybrids/varieties and was tested for their adoptability and yield potentiality. The experiment was conducted under randomized complete block design with three replications. The growth and yield observations are made as per the standard methodology.

Among the genotypes under investigation for their adaptability and yielding ability, GCH-8 recorded significantly higher seed yield of castor (2369 kg/ha) and was statistically superior over rest of the genotypes *J. Oilseeds Res.*, **37** (Special Issue), Feb., 2020

under evaluation. However, castor genotype 48-1 (1681 kg/ha), DCS-107 (1646 kg/ha), GCH-4 (1549 kg/ha) and DCH-177 (1529 kg/ha) were next in the order of merit. Again with respect to oil yield per hectare, GCH-8 recorded significantly higher oil yield (1152 kg/ha) an account of higher seed yield (2369 kg/ha) and oil content (48.64 %) and was closely followed by 48-1 (793 kg/ha) and GCS-107 (765 kg/ha). Further, because of higher yield, higher gross returns (₹ 128386/ha), net returns (₹99809/ha) and benefit cost ratio (3.95) was also recorded with castor hybrid GCH-8, these results were in accordance with Sowmya *et al.* (2016).

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Table 1 Yield and oil content of various castor genotypes

Genotypes	Yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
GCH-8	2369	48.64	1152	128386	99809	3.95
DCH-177	1529	45.32	693	79235	50658	2.55
DCH-519	1373	45.86	630	65544	36967	2.29
48-1	1681	47.16	793	81214	52637	2.80
GCH-7	1518	47.72	724	81562	52985	2.53
DCS-107	1646	46.49	765	83514	54937	2.74
GCH-4	1615	47.07	729	86482	57905	2.58
S Em±	133	0.40	62			
CD (P=0.05)	408	1.22	192			
CV (%)	14	1.46	14			

Cropping systems approach in oil palm for higher productivity and profitability

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ABSTRACT

Existing situation of oil palm gardens created the need for intercropping in mature oil palm for improving the productivity and profitability. Crops like red ginger, heliconia, cocoa, bush pepper and banana have been identified as suitable ones for oil palm. Improved physico-chemical and biological properties of soil, root density and fresh fruit bunch (FFB) yield of oil palm were the added benefits from inter cropping.

Keywords: Cocoa, Heliconia, Intercropping, Oil palm, Red ginger

Oil palm is perennial in nature with productive life for 25-30 years. Intercropping is not a priority in major oil palm producing countries because land is not a limiting factor. Large canopy size and equilateral triangular method of planting (9 x 9 x 9 m) highly restricts choice of intercrops in mature oil palm gardens due to prevalence of more shade (75-80%). Considering the small size holdings, high density of shade and need for intercropping, experiment was conducted for identifying suitable intercrops in mature oil palm gardens.

The study was carried out during 2007-2017 at ICAR-Indian Institute of Oil Palm Research, Pedavegi. Evaluated the performance of crops (cocoa, heliconia, red ginger, bush pepper and banana) in RBD under mature oil palm (12-22 yrs). Intercrops were planted in inter space of oil palm and followed the recommended practices of listed crops. Yield observations of oil palm and intercrops were recorded by employing standard methods. Light infiltration in the system was recorded at monthly intervals.

Higher fresh fruit bunch (FFB) yield in oil palm was recorded in intercropped plots as compared with monocropped one. Among the crop combinations, highest FFB yield was observed in oil palm-cocoa combination. Similar results in oil palm were reported by Jessy Kutty (2005) and Sunitha and Varghese (2009). Higher root density and microbial population were

noticed in intercropped area as compared with oil palm alone. Oil palm draws water and nutrients (applied to intercrops) from inter space and this may be the reason for increased oil palm yield. Among the intercrops, there was a tremendous improvement in microbial population in cocoa plot. Significant improvement in OC, P, K and Ca in soil was observed in inter space of oil palm-cocoa. Higher nutrient levels and microbial population in cocoa plot must be attributed to presence of more biomass.

Of all the inter crops, red ginger and heliconia were emerged as the most promising while performance of cocoa, bush pepper and banana was found satisfactorily under the microclimate of oil palm. Among the crop combinations, highest net returns and cost benefit ratio were observed under oil palm-bush pepper followed by oil palm-cocoa. Among the intercrops, maximum net returns and cost benefit ratio were recorded with heliconia and red ginger.

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Effect of source of nitrogen, organic manure and PSB application on groundnut (*Arachis hypogaea* L.) yield, P uptake in calcareous soil of southern Saurashtra

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ABSTRACT

Twelve treatments consisting of two different nitrogen sources in combination with farm yard manure (FYM) and phosphate solubilizing bacteria (DGRC1) were used to quantify the effect on groundnut yield, enzymatic activities, P uptake and phosphorus use efficiency (PUE). Significantly high pod yield (2651 kg/ha) was obtained with the application of ammonium sulphate in addition to FYM and DGRC1. DGRC1 alone improved pod yield by over 200 kg/ha compared to control. Application of Urea+DGRC1 gave significantly higher pod yield (2444 kg/ha) than Ammonium sulphate + DGRC 1 (2216 kg/ha). Alkaline phosphatase activity, PUE, P uptake were significantly high with Ammonium sulphate+FYM+DGRC 1. Dehydrogenase activity was significantly high (5.8 µg TPF/g soil/h) when DGRC1 was applied alone. It was concluded that PSB (DGRC1) application enhances groundnut pod yield, improves PUE and other fertility parameters.

Keywords: Groundnut, Phosphate solubilizing bacteria (PSB), Phosphorus use efficiency, P uptake

The requirement of P in nodulating legumes like groundnut is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen. P supply below its critical level of 10 mg P/kg soil reduces groundnut pod yield by as much as 50% (Veeramani and Subrahmaniyan, 2011). 49% of soils of India are deficient in P. Phosphorus deficiency is generally addressed by application of phosphorus fertilizers. However, majority of applied P is fixed in soil and is unavailable to plant, leading to low phosphorus use efficiency (PUE). The holistic P management in calcareous soils is possible by the use of proper nitrogen (N) fertilizer along with phosphorus solubilizing bacteria (PSB). The present investigation attempted to improve PUE by use of organic manure, acidic N source and PSB application

The experiment was conducted in Summer-2019 at ICAR-DGR farm, Junagadh. The experiment consisted 12 treatments (T1-control; T2-DGRC 1; T3-FYM @ 10 t/ha; T4-FYM+DGRC1; T5-Urea; T6-Urea+DGRC1; T7-Urea+FYM; T8-Urea+FYM+DGRC1; T9-Ammonium sulphate; T10 - Ammonium sulphate + DGRC1; T11-Ammonium sulphate + FYM; T12-Ammonium sulphate + DGRC1 + FYM) and three replications in randomized block design (RBD), with initial soil available P of 4.8 kg/ha. RDF (25:50:30 N:P2O5:K2O kg/ha) was used. FYM @ 10 t/ha was applied at the time of sowing. DGRC1 (5 g/kg seed) culture was applied.

Groundnut pod yield was found to be significantly high ($P < 0.05$) in T12 (2651 kg/ha) followed by T8 (2540 kg/ha). The difference in observed yield may be due to

the differences in the acidity produced by the two nitrogenous fertilizers. This difference was observed only when the N fertilizer was applied along with FYM. Ammonium sulphate has equivalent acidity of 110, compared to urea which has 80. DGRC1 alone had a yield advantage of over 300 kg compared to control (No P applied). When N fertilizers were applied with DGRC 1 without FYM, urea had a clear advantage in yield (>200 kg/ha) over ammonium sulphate. The other parameters like haulm yield (range 5.0-5.5 t/ha), shelling % (range 70-75 %), shoot height, root length, nodule weight, HKW, and mature pod weight were found to be non-significant. Alkaline phosphatase activity (ALP) was significantly high in T12 (158 µg of p-nitrophenol/g soil/h) followed by T2. Acid phosphatase activity was significantly more in T9 (153 µg p-nitrophenol/g soil/h) followed by T7. Dehydrogenase activity was significantly high in T2 (5.8 µg TPF/g soil/h) followed by T12 (4.7 µg TPF/g soil/h). Available P at harvest was significantly high in T6 (14.9 kg /ha) followed by T12 (14.1 kg/ha). Total P uptake was significantly high in T12 (20.2 kg/ha) followed by T11 (18.7 kg/ha) and PUE (%) was significantly high in T12 (40.4 %) compared to other treatments. PSB (DGRC1) increased the PUE by 8-10% in different treatments.

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Effect of potassium on growth, yield and economics of safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Field experiment was conducted for ascertaining the response of safflower to different levels of potassium for three years in post rainy season from 2016-17 to 2018-19. The experiment consisted of five treatments viz., 0, 20, 30, 40 and 50 kg/ha K₂O with four replications in RBD. Potassium application @ 50 kg/ha recorded significantly higher seed yield than 40 kg/ha. Plant height and 100- seed weight were also significantly influenced due to potassium.

Keywords: Nutrition, Potassium, Safflower, Seed yield

Large amounts of potassium are required by high-yielding genotypes of safflower and although total K content of most soils is high, availability is usually low due to fixation of K in silicates and strong adsorption by K-specific binding sites. Thus, applying potassium fertilizer represents an effective measure to ensure adequate K supply.

The field experiment was conducted during post rainy seasons from 2016-17 to 2018-19 at Solapur. The experimental soil was low in available N and medium in available phosphorus and high in available potassium. The experiment was laid out in a randomized block design (RBD) with four replications having five treatments (0, 20, 30, 40 and 50 kg/ha K₂O). The recommended cultural practices were adopted for growing safflower. Nitrogen (50 kg/ha) and phosphorus (25 kg/ha) were applied as per recommended dose.

Data presented in Table 1, revealed that the significantly highest seed yield of safflower (651 kg/ha) was recorded by the T5 over all the levels of potassium. However, it was at par with all the treatments except treatment T1. The significant increase in seed yield of safflower was recorded with the increased supply of potassium. Dry matter production was significantly influenced in safflower crop fertilized with treatment T5

(76.32 g/plant) in bud initiation stage was at par with T4 (72.88 g/ plant). The same treatments gave significantly highest dry matter at 50% flowering stage (83.18 g/plant) and plant height (46.2 cm). However, it was found at par with the treatment T3 and T4. Similar results were reported by Abasiyeh *et al.* (2012). The significant increase in 100 seed weight of safflower was recorded with T5 (6.13 g) over all other levels. However, it was found to be at par with all the treatments except T1. Similar findings were reported by Singh *et al.* (2013) and Salve *et al.* (2018).

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Table 1. Dry matter production, growth, yield and economics of safflower as influenced by K (K₂O kg/ha) application

Treatments	Plant height (cm)	100- seed weight (g)	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T1: 0	38.53	4.96	480	2561	18.76
T2: 20	41.13	5.67	526	2888	18.23
T3: 30	42.10	5.94	587	2958	19.87
T4: 40	43.27	6.07	618	3124	19.78
T5: 50	46.20	6.13	651	3160	20.60
SEm ±	1.41	0.19	47	384	2.74
CD (P=0.05)	4.33	0.58	142	NS	NS

Enhancing the productivity of wheat + mustard intercropping system with different row proportions and nutrient management practices

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ABSTRACT

The effect of row ratios and nutrient management practices in wheat-mustard intercropping system was studied to optimize row ratio and nutrient management practice. Intercropping system wheat + mustard in 5:1 row proportion with 125% recommended dose of fertilizer (RDF) recorded significantly higher seed yield, land equivalent ratio, area time equivalent ratio and net returns.

Keywords: Mustard, Nutrient management, Row ratio, Wheat

Wheat + mustard is the popular intercropping system during rabi season in Karnataka. Productivity of the intercropping system need to be enhanced with agronomic management practices.

A field experiment was carried out during *rabi* season of 2016-17 to study the effect of row ratios and nutrient management practices in wheat + mustard intercropping system at Main Agricultural Research Station, UAS, Dharwad, Karnataka. The experiment was laid out in a Randomized complete block design (RCBD) having 10 treatments and replicated thrice. Wheat grain yield (2942 kg/ha) was significantly higher with wheat-mustard 5:1 row proportion. Higher mustard seed yield (1997 kg/ha) was recorded in wheat + mustard 4:2 row proportion. Application of 125 per cent RDF recorded significantly higher wheat grain yield (2724

kg/ha) and mustard seed yield (1075 kg/ha). Wheat + mustard (5:1) with 125% RDF recorded significantly higher wheat equivalent yield (4746 kg/ha), land equivalent ratio (1.35) and area time equivalent ratio (2.36) over other treatments and found on par with Wheat-mustard (5:1) with 100% RDF. Similarly higher protein content (12.6%) and sedimentation value (36.8 ml) and oil content (38%) was recorded with wheat-mustard in 5:1 row proportion with 125% RDF. Higher gross returns, net returns and B:C ratio was recorded in wheat + mustard (5:1) row proportion with 125% RDF. Wheat-mustard in 5:1 row proportion with 125% RDF recorded significantly higher seed yield, land equivalent ratio (LER), area time equivalent ratio (ATER) and net returns in the Northern Transition Zone of Karnataka.

Seed yield of sunflower (*Helianthus annuus* L.) in rice fallow system

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ABSTRACT

A field study was conducted during 2017-18 in *rabi* season in *kharif* paddy fallow to study the effect of varying tillage practices, fertilizer levels and hybrids on sunflower yield. Higher seed yield (1005 kg/ha) was recorded with zero tillage, which was comparable with minimum tillage (858 kg/ha). Lower seed yield was recorded with reduced tillage (707 kg/ha), which was on par with conventional tillage (711 kg/ha). Sunflower crop responded up to 150% RDF (904 kg/ha) and harvested greater seed yield than 100% RDF (815 kg/ha) and 50% RDF (736 kg/ha). Seed yield of KBSH-44 and NDSH-1012 were on par with each other and significantly greater than DRSH-1.

Keywords: Bulk density, Hybrids, Sunflower, Tillage practices

Rice fallow is a potential area for expansion of oilseeds. In Andhra Pradesh, there is a vast paddy area that can be brought under this programme. It is essential to adopt appropriate tillage practice to conserve the moisture for the crop succeeding paddy. In the present investigation, efforts were made to identify suitable
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tillage practices along with the fertilizer requirement for sunflower crop in rice fallows of Andhra Pradesh. Also, the adaptability of three promising hybrids of sunflower was tested.

The soil was medium deep black cotton soil with low in OC, high in available P₂O₅ and available K₂O.

The main plot consists of conventional tillage, reduced tillage, minimum tillage, zero tillage. Fertilizer levels [50% RDF, 100% RDF (60:30:30 N, P₂O₅ and K₂O kg/ha) and 150% RDF] were in subplot. Genotypes (DRSH-1, KBSH-44, NDSH-1012) were sub-sub-plot.

Significantly higher seed yield was recorded with zero tillage. Lower values were recorded with reduced tillage (Table 1). The yield advantage in zero tillage sowing may be due to advantage of early sowing and effective utilization of initial soil moisture and soil fertility. The findings were in accordance with Kalita *et al.* (2005). Among the fertilizer levels tried, 150% RDF recorded significantly higher values of seed yield. The results indicated that sunflower crop in paddy fallows response up to 150% RDF, recorded seed yield and which was on par with 100% RDF. The lower seed yield was recorded with 50% RDF. Sunflower hybrids KBSH-

44 and NDSH-1012 recorded greater seed yield than DRSH-1.

At harvest significantly the soil moisture percentage was lower with zero tillage and may be the reason the crop utilized the soil moisture efficiently and contributed to higher seed yield when compare to other 3 tillage practices. Similarly 150% RDF treatment recorded lower moisture percentage. Initial bulk density was higher with zero tillage, but at harvest stage the bulk density of zero tillage was also similar effect with other tillage practices. This may be due to soil condition changes occurred during crop growth period.

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Table 1 Seed yield of sunflower as influenced by tillage practices, fertilizer levels and hybrids

Treatments	Seed yield (kg/ha)	Soil moisture (%)		Bulk density (g/cc)	
		Initial	At harvest	Initial	At harvest
Tillage practices					
Conventional tillage	711	39.8	30.2	1.24	1.32
Reduced tillage	707	39.9	32.5	1.21	1.31
Minimum tillage	858	38.4	30.4	1.35	1.32
Zero tillage	1005	37.9	24.6	1.45	1.27
SEm±	45	2.2	1.3	0.03	0.05
CD (P= 0.05)	201	NS	3.6	0.09	NS
Fertilizer levels					
50% RDF	736	39.3	31.2	1.38	1.21
100% RDF	815	37.0	30.2	1.32	1.23
150% RDF	904	39.7	24.7	1.35	1.22
SEm±	25	2.5	1.4	0.07	0.09
CD (P= 0.05)	86	NS	3.5	NS	NS
Hybrids					
DRSH-1	720	38.7	31.1	1.31	1.21
KBSH-44	824	37.0	30.7	1.31	1.18
NDSH-1012	916	38.0	31.4	1.34	1.20
SEm±	13	2.1	1.6	0.53	0.52
CD (P= 0.05)	39	NS	NS	NS	NS

Yield maximization through INM in sunflower (*Helianthus annuus* L.)

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ABSTRACT

The experiment was conducted for two years in RBD with seven treatments of INM. The experiment was replicated four times. Sunflower was grown during summer after rice. Application of FYM @ 12.5 t/ha coupled with RDF increased the seed yield of sunflower.

Keywords: Integrated nutrient management, Seed yield, Sunflower

Reducing the green-house gas (GHGs) emission and enhancing the C sequestration in soil and biomass has

become a challenging task. Among the various strategies, manure management contributes a

considerable share in sustaining soil fertility and reducing GHGs emission. Hence, the study was conducted to find out the effect of appropriate combinations of inorganic fertilizers with organic manures on yield potential in rice-sunflower production system.

The rice was grown during September to January of 2015 and 2016, followed by sunflower as irrigated crop from February to May. The experiment was conducted in RBD replicated four times. The treatments followed for rice and sunflower were, control (T1), 100% recommended dose of fertilizer (RDF) (T2), 100% RDF + FYM @ 12.5 t/ha (T3), RDF + vermicompost @ 5 t/ha (T4), RDF + press mud @ 5 t/ha (T5), RDF + poultry

manure @ 5 t/ha (T6) and RDF + coir pith compost @ 5 t/ha (T7) to examine the CO₂ and CH₄ fluxes in rice. Single super phosphate (40 kg/ha) was added for all the treatments (except T2 and T1) to sunflower.

T3 recorded an increased growth, yield attributes, yield and nutrient uptake. Increased seed yield of sunflower was observed in the treatments of integrated nutrient management (INM) treatments. The highest seed yield of sunflower 2218 and 2295 kg/ha was recorded in T3 in both the crops. INM treatments significantly influenced the CO₂ fluxes in all treatments compared to T2 and T1. INM through FYM @ 12.5 t/ha coupled with RDF increased the seed yield of sunflower.

Table 1. Effect of INM on yield and CO₂ emission in sunflower

Treatments	Seed yield (kg/ha)	
	First year	Second year
T1 Control	976	991
T2 100% recommended dose of fertilizer (RDF)	1815	1822
T3 100% RDF + FYM @ 12.5 t/ha	2218	2295
T4 RDF + vermicompost @ 5 t/ha	2120	2212
T5 RDF + press mud @ 5 t/ha	1911	1981
T6 RDF + poultry manure @ 5 t/ha	1996	2092
T7 RDF + coir pith compost @ 5 t/ha	1836	1895
S.Ed	29.4	30.59
CD (P=0.05)	61.73	64.24

Effect of sulphur application on seed yield of sesame (*Sesamum indicum* L.) in north coastal Andhra Pradesh

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ABSTRACT

A field study was conducted at the Agricultural Research Station, Yellamanchili during *rabi* season of 2015-16 and 2016-17 to study the effect of various sources (gypsum and sulphur Bentonite) and levels (15, 30 and 45 kg S/ha) of sulphur on seed yield of sesame. Application of sulphur at 45 kg/ha through gypsum produced significantly higher seed yield (587 kg/ha) than at 15 kg S/ha through gypsum, sulphur bentonite and recommended NPK alone.

Keywords: Seed yield, Sesamum, Sulphur

Sesamum is an important oil seed crop in Andhra Pradesh. Even with the application of recommended doses of NPK fertilizers, the full potential yield could not be achieved due to inadequacy of secondary and micronutrients. In oilseeds, sulphur plays a prominent role in the synthesis of essential oils, chlorophyll formation and gives pungency in oil. Sulphur is an important constituent of three amino acids *viz.*, cystine, cysteine and methionine which are essential components of proteins. Since there is no adequate information on the Sulphur nutrition for sesame, a study was undertaken

to suggest optimum level of sulphur for sesame grown in North coastal Andhra Pradesh.

The treatment details are given in Table 1. The seven treatments were replicated thrice in a randomized block design. Sesame variety YLM-66 was used as a test variety. Sulphur was applied through different sources at the time of sowing as per the treatments. All recommended package of practices were followed.

Irrespective of sources of sulphur, seed yield increased progressively with increase in sulphur dose from 15 to 45 kg/ha and the increase was significant at 45 kg/ha over 15 kg/ha. Thus, treatments T3, T4, T6 and

T7 did not differ indicating that 30 kg/ha Sulphur in any form is beneficial for increasing the seed yield in sesame. Seed yield (587 kg/ha) was significantly higher at 45 kg/ha through gypsum (T7) than at 15 kg S/ha through gypsum (485 kg/ha) and sulphur bentonite (481 kg/ha). Similar results were also reported by Kundu *et al.* (2010) and Nagavani *et al.* (2010).

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Table 1. Effect of sulphur application on seed yield of sesame

Treatments	Seed yield (kg/ha)	% increase over control
T1 – Recommended N:P ₂ O ₅ :K ₂ O (40:20:20 kg/ha) - (0 sulphur, Control)	405	-
T2 - T1+ 15 kg S/ha through Sulphur Bentonite	481	18.7
T3 - T1+ 30 kg S/ha through Sulphur Bentonite	561	38.3
T4 - T1+ 45 kg S/ha through Sulphur Bentonite	578	42.6
T5 - T1+ 15 kg S/ha through gypsum	485	19.5
T6 - T1+ 30 kg S/ha through gypsum	567	40.0
T7 - T1+ 45 kgS/ha through gypsum	587	44.7
SEm ±	24.3	
CD(P=0.05)	75	
CV%	8.2	

Optimization of seed rate and spacing in soybean (*Glycine max* L.)

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ABSTRACT

To optimize seed rate and plant spacing in soybean an experiment was conducted with four plant spacings and three treatments of number of seeds dibbled. Sowing of soybean at 45 x 5 cm plant spacing with single seed dibbling (50 kg seed/ha) was beneficial for higher yields and economic returns in soybean.

Keywords: Seed rate, Seed yield, Soybean, Spacing

Optimum plant population is an important factor in determining the yield in any crop. In soybean, with the test weight of seed being very high, larger volumes of seed are required per unit area basis. Therefore, the present investigation was carried out to determine the ideal plant spacing and the required seed rate in soybean in Kolhapur regions of Maharashtra.

A field experiment was conducted during *kharif* season at Rajarshree Chhatrapati Shahu Maharaj (RCSM) College of Agriculture, Kolhapur to optimize seed rate and plant spacing. The field experiment was laid out in split plot design with three replications and 12 treatment combinations consisting of four plant spacings (30 x 5, 30 x 10, 45 x 5, 45 x 10 cm) and number of seeds dibbled (one, two, three seeds/hill). The soil of the experimental plot was clayey in texture, low in available N (208 kg/ha), medium in available phosphorus (28.7 kg/ha) and high in available potassium (287 kg/ha). The soil was slightly alkaline in reaction (pH 7.75).

The plant spacing of 30 x 5 cm produced maximum plant height than other plant spacings. The plant

spacings of 45 x 10 cm and 45 x 5 cm produced maximum plant spread, number of branches, leaf area, number of functional leaves and plant dry matter than rest of the plant spacings. The number of pods/plant, weight of pods/plant, number of seeds/pods, seed weight/plant, number of root nodules/plant, weight of wet root nodules/plant, 100 seed weight and it was on par with spacing 45 x 5 cm. As a result, the plant spacing 45 x 5 cm recorded the highest seed yield (26.46 q/ha) and stover yield (39.20 q/ha). The uptake of N, P and K in soybean was highest in plant spacing 30 x 5 cm. The plant spacing 45 x 5 cm recorded maximum gross monetary returns (₹ 83986/ha), net returns (₹ 46988/ha) and B: C ratio (2.27) than rest of the plant spacings. The plant height was increased with the increase in number of seeds dibbled and found maximum in three seeds dibbled treatment. One seed dibbling recorded maximum number of branches/plant, plant spread/plant, leaf area/plant, number of functional leaves/plant and dry matter/plant followed by two seed dibbling. The number of root nodules/plant and weight of wet root

nodules/plant were higher in single seed dibbling. The highest seed yield and straw yield of 26.90 q/ha and 40.46 q/ha was recorded in two seeds dibbling and single seed dibbling respectively. The uptake of N, P and K was highest three seeds dibbling. In single seed dibbling, maximum gross monetary returns (₹ 85,413/ha), net returns (₹ 47,777/ha) and B:C ratio (2.26) was found than rest of the plant spacings.

The interaction effect due to different plant spacing and sowing of different number of seeds dibbled soybean was non-significant for all the characters. Thus, considering net monetary returns, sowing of soybean at 45 x 5 cm plant spacing with using 50 kg seed/ha (single seed dibbling) was beneficial for higher yields and economic returns in soybean.

Effect of time of sowing and spacing on seed yield and quality of hybrid seed production in castor (*Ricinus communis* L.)

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ABSTRACT

The parental lines, DPC-9 (female) and TMV-5 (male) of castor hybrid (YRCH-1) were sown in 3:1 ratio with six sowing dates and four different spacings. The highest seed yield was recorded from first fortnight of November or second fortnight of November adopting either 120 cm x 120 cm or 150 cm x 120 cm. The genetic contamination in terms of interspersed male flowers present in the female lines was minimum during the November sowing.

Keywords: Castor, Hybrid seed production, Spacing, Sowing

Castor is unique crop having different types of inflorescence i.e., monoecious, pistillate and the expression of male and pistillate flowers depends mostly on environmental and soil factors and hence the genetic purity of F₁ hybrid seed prescribed was 85% as per the certification standards. Hence, a study was undertaken to standardize the dates of sowing, spacing requirement and planting male female ratio of castor for quality hybrid seed production.

The trial was conducted as on-farm trial for two years during *rabi* (2014-16) in split plot design with three replications. Six dates of sowing (M1: first fortnight of September, M2: second fortnight of September, M3: first fortnight of October, M4: second fortnight of October, M5: first fortnight of November, M6: second fortnight of November and four different spacings (S1: 90x60 cm, S2: 90x90 cm, S3: 120x120 cm, S4: 150x120 cm). Parental lines of castor hybrid

YRCH-1, DPC-9 (female) and TMV-5 (male) were sown in 3:1 ratio on the six dates with four different spacings.

Sowing in the first fortnight of September recorded the more number of interspersed male flowers and second fortnight of November sowing recorded lesser number. Spacing at 90 x 90 cm recorded greater number of interspersed male flowers/spike and lower in 150 x 120 cm.

The hybrid seed yield recorded was the highest in November second fortnight sowing and the lower in September first fortnight of sowing. Among the spacing, 90 x 90 cm recorded the higher hybrid seed yield and it was on par with 120 x 120 cm, 90 x 60 cm recorded lower seed yield. Sowing of male and female lines at 1:3 ratio in first or second fortnight of November with 120 x 120 cm or 150 x 120 cm can be followed for hybrid seed production in castor YRCH-1.

Table 1 Effect of time of sowing and spacing on number of interspersed male flowers/spike and seed yield of female parent (DPC-9)

Spacing/ time of sowing	M1	M2	M3	M4	M5	M6	Mean	M1	M2	M3	M4	M5	M6	Mean
S1	10.3	7	5.8	4	3.1	1.7	5.3	218	398	406	399	504	539	410
S2	9.8	6	7.5	5	3.3	1.3	5.5	235	454	472	469	519	552	450
S3	8.6	7	8.1	3.2	1.6	1.1	4.9	220	434	438	459	526	528	434
S4	10.8	6	5.9	4.1	2.3	1.5	5.1	220	420	432	437	518	527	122
Mean	9.9	6.5	6.8	4.0	2.6	1.4	5.2	223	427	437	441	517	536	354
	M	S	M x S	S x M				M	S	M x S	S x M			
SEd	0.52	0.24	0.73	0.6				19.8	43.1	19.8	43.1			
CD(P=0.05)	1.1	0.4	1.5	1.2				20	42	20	42			

Energy use efficiency in mechanized cultivation of castor (*Ricinus communis* L.)

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ABSTRACT

The highest seed yield (1765 kg/ha) was recorded under normal practices than mechanized practices (1640 kg/ha). A total of 63 man days/ha were employed with a time consumption of 442 hr/ha against normal practices (153 man days/ha with 1244 hr/ha). Thus, higher gross return of ₹ 67,240/ha, return above variable cost of ₹ 46,740/ha with a benefit cost ratio of 3.28 was realized under mechanized cultivation.

Keywords: Castor, Drudgery, Energy use efficiency, Mechanization

Mechanization in castor cultivation is gaining momentum, due to acute labour shortage, unavailability of skilled labour, steep increase in wages and other expenses. Considering the facts, the experimental trial was conducted to study the effect of different mechanization practices on castor productivity, economics and energy use efficiency.

Large plot non replicated experimental trial was conducted during *kharif* 2016-18 at tapioca and castor research station farm, Yethapur, to study the effect of different mechanization practices in castor hybrid cultivation (tractor drawn seed drill sowing, intercultural operation with power weeding, spraying with boom sprayer and harvesting, threshing & shelling by castor thresher). Tractor drawn seed drill was used for sowing with a inter row spacing of 120 and intra row spacing of 70 cm. Energy use efficiency were worked out and analyzed by using the procedure suggested by Siqueira *et al.* (1999).

The highest growth and yield attributing characters viz., No. of primary branches/plant (5.4), length of primary spike (63.4 cm), No. of capsules/primary spike (59.8) and seed yield of 1765 kg/ha were recorded under normal practices (Srinivas, 2009). Yield attributing characters and seed yield were numerically lower under mechanized treatment which might be due to closer intra row spacing of 70 cm. While, significantly higher net

returns and benefit cost ratio were realized in mechanized treatment due to low cost of cultivation coupled with higher plant load per unit area which compensated the seed yield/unit area.

Under mechanized treatment, a total of 63 man days/ha were employed with a time consumption of 442 h/ha against normal method of cultivation (153 man days/ha; 1244 h/ha). Thus, higher gross return of ₹ 67240/ha, return above variable cost of ₹ 46740/ha with a benefit cost ratio of 3.28 was realized under mechanized cultivation. Total energy input of 10360 MJ/ha was acquired under mechanized practices against normal method (11568 MJ/ha). The reason for generating higher output energy of 36006 MJ/ha under normal practices was mainly due to higher seed yield of 1765 kg/ha.

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Table 1. Comparative performance of seed yield, labor use, time consumption and energy use as influenced by the mechanization practices in castor

Particulars	Total no. of man days/ha	
	Mechanized	Normal
Seed yield (kg/ha)	1640	1765
Cost of cultivation (Rs/ha)	20500	28750
Gross returns (Rs/ha)	67240	72365
Net returns (Rs/ha)	46740	43615
Benefit cost Ratio	3.28	2.51
Total no. of man days/ha	63	153
Total time period (hr/ha)	442	1224
Total energy Input (MJ/ha)	10360	11568
Energy output (MJ/ha)	33456	36006
Net energy returns (MJ/ha)	23096	24438
Energy use efficiency	3.22	3.11
Specific energy (MJ/ha)	6.3	6.55
Energy productivity (kg/MJ)	0.16	0.15

*Working hour/day is 8 hr/day

Effect of micronutrient on growth attributes, yield and economics of linseed under limited irrigation

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ABSTRACT

Plant height, number of branches and number of capsules/plant were significantly greater with soil application of ZnSO₄ (25 kg/ha) and borax (1.5 kg/ha) at the time of sowing. Seed yield, gross returns and net returns followed the similar trend. Seed yield was at par with foliar application of ZnSO₄ and boron.

Keywords: Economics, Growth attributes, Linseed, Micronutrient, Yield

The deficiency of micronutrients has been very pronounced under multiple cropping systems due to excess removal of the nutrients by high yielding varieties and hence their exogenous application is urgently required (Rashid and Ryan, 2004). Zinc is required in protein synthesis and for ensuring seed quality and uniform maturity. Boron is required for cell division and extension and essential for pollen tube growth which affects seed/fruit set and hence yields.

An experiment was conducted in *rabi* season of 2018-19 at AICRP on Linseed, College of Agriculture, Nagpur on variety PKV NL-260 with two limited irrigations in randomized block design with three replication. The nine treatment details are given in Table 1.

The plant height, number of branches/plant, number of capsules/plant were greater in T9 (Soil application of ZnSO₄@ 25 kg/ha + borax @1.5 kg/ha). These results are in conformity with the findings of Anuja Kumari *et al.* (2013). Similar trend was noticed with respect to seed yield, however it was on par with T8 (Soil application of borax @1.5 kg/ha + foliar application of borax @ 0.3% at 45 DAS), T7 (Soil application of borax @1.5 kg/ha +

foliar application of borax @ 0.3% at 45 DAS) and T4 (Soil application of ZnSO₄@ 25 kg/ha + foliar application of ZnSO₄@ 0.5% at 45 DAS). Similar results have also been reported by Dandoti *et al.* (2017), Babaeian *et al.* (2013) and Anuja Kumari *et al.* (2013).

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Table 1 Effect of micronutrients on linseed

Treatments	Plant height (cm)	No. of branches/plant	No. of capsules/plant	Test weight (g)	Seed yield (kg/ha)
Control	61.1	2.6	52.3	7.8	1257
Soil application of ZnSO ₄ @ 25 kg/ha	65.0	3.0	53.9	7.9	1293
Foliar application of ZnSO ₄ @ 0.5 % at 45 DAS	63.7	2.7	52.9	7.9	1287
Soil application of ZnSO ₄ @ 25 kg/ha+foliar application of ZnSO ₄ @ 0.5 % at 45 DAS	68.7	3.2	63.1	8.3	1378
Soil application of borax @1.5 kg/ha	64.3	2.8	52.9	7.9	1293
Foliar application of borax @ 0.3% at 45 DAS	63.7	2.7	51.8	7.9	1285
Soil application of borax @1.5 kg/ha + foliar application of borax @ 0.3% at 45 DAS	65.2	3.1	62.1	8.0	1374
Foliar application of ZnSO ₄ @ 0.5% + borax @ 0.3% at 45 DAS	70.9	3.4	64.1	8.3	1391
Soil application of ZnSO ₄ @ 25 kg/ha + borax @1.5 kg/ha	71.7	3.4	65.1	8.4	1439
SEm±	1.91	0.19	2.99	-	0.39
CD(P=0.05)	5.76	0.56	9.00	-	1.17

Standardization of fertigation schedule for *rabi* castor (*Ricinus communis* L.) under drip irrigation

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ABSTRACT

Fertigation @ 30 kg N during 10-55 days after sowing (DAS); 40-50 kg N during 56-85 DAS; 20-30 kg N during 86-115 DAS and 20 kg N/ha during 116-145 DAS resulted in significantly higher seed yield of castor (3351 to 3356 kg/ha), higher water use efficiency (8.79-8.82 kg/ha/mm) and nitrogen use efficiency (27.9 kg/ha).

Keywords: Castor, Fertigation, Nitrogen use efficiency, Water use efficiency

Scheduling of irrigation @ 0.6 PE and fertigation @ 120 kg N/ha was advocated for *rabi* castor in Andhra Pradesh for higher productivity, water use efficiency and economic returns (Ramanjaneyulu *et al.*, 2012). However, stage wise fertigation schedule was not worked out so far. Hence, an experiment was conducted to work out optimum fertigation schedule, estimate the yield gain, water and nutrient use efficiency.

An experiment was conducted during *rabi* under drip irrigation, for two years (2014-15 to 2016-17) at

RARS, Palem on Alfisols. The site was low in N, medium in available phosphorus and high in potassium. The drip laterals with 60 cm dripper distance and 4 l/h discharge are spread at 120 cm apart. The castor hybrid DCH-519 (5 kg/ha) seed treated with carbendazim 3 g/kg was sown at a spacing of 120 cm x 60 cm. The drip irrigation was scheduled @ 0.6 Epan uniformly. There were seven fertigation treatments details are furnished below:

Treatment	kg N/ha			
	10-55 DAS	56-85 DAS	86-115 DAS	116-145 DAS
T1	30	30	30	30
T2	30	50	20	20
T3	30	40	30	20
T4	20	40	30	30
T5	Drip irrigation @ 0.6 PE+pocketing method of N application (120 kg/ha)			
T6	Check basin irrigation 75 mm CPE+pocketing method of N application (80 kg/ha)			
T7	Check basin irrigation 75 mm CPE+ pocketing method of N (120 kg/ha)			

A common dose of 40 kg P₂O₅ and 30 kg K₂O/ha was applied basal. The irrigation through drip was given at three days interval (T1 to T5) while fertigation at six days interval (T1 to T4). In case of T5 to T7 treatments, half of the N was applied as basal and remaining half in three split doses at 30, 60 and 90 DAS. The data were analysed statistically in a randomised block design (RBD) using OPSTAT.

Significantly higher seed yield of castor (3356 and 3351 kg/ha) was obtained due to fertigation @ 120 kg N/ha due to adoption of stage specific differential fertigation schedule of 30:50:20:20 (T2) and 30:40:30:20 kg N/ha (T3). Further, higher WUE was observed with T3 (8.82) and T2 (8.79 kg/ha/mm) against 4.47 and 4.74 kg/ha/mm in T6 and T7. The nitrogen use efficiency was also higher with T2 (27.9 kg/ha) as compared to that T1 (24.8 kg/ha) and T7 (21.7 kg/ha).

Adoption of crop growth stage specific and differential N application schedule i.e., 30 kg during 10-55 DAS; 40-50 kg N/ha during 56-85 DAS; 20-30 kg N/ha during 86-115 DAS and 20 kg N/ha during 116-145 DAS through fertigation to *rabi* castor under drip irrigation was better.

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Effect of conservation tillage practices on rice fallow sunflower (*Helianthus annuus* L.) at Odisha

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ABSTRACT

Sunflower is an emerging profitable rice fallow crop at Odisha. An experiment at College of Agriculture (OUAT) Bhubaneswar on rice fallow sunflower conducted to standardize tillage, fertilizer dose and suitable hybrid has shown that sunflower hybrid KBSH 44 performed better than other hybrids under zero tillage at 150% RDF and registered the maximum nutrient uptake.

Keywords: Conservation tillage, Rice fallow, Seed yield

Sunflower, one of the important oilseed crop whose oil is considered as premium oil due to quality, cultivated in 27.3 m ha worldwide occupies 25,000 ha in different districts of Odisha as a catch crop during the period when land is left fallow after harvest of the *kharif* rice. The present experiment was conducted to standardise tillage practices and fertility levels for higher productivity and nutrient uptake of rice fallow sunflower hybrids.

A field experiment was conducted under AICRP Sunflower at OUAT, Bhubaneswar during rice fallow season 2019 in a sandy loam soil. Four tillage management (Conventional, Reduced, Minimum and Zero), were evaluated for three genotypes DRS-1, KBSH-44 and MSFH-17 under three fertility levels 50% RDF, 100% RDF (60 :80 :60 N: P₂O₅: K₂O kg/ha) and 150% RDF was imposed in a split-split plot design, replicated thrice with standard package of practices and as per the treatments .

Zero tillage recorded significantly highest seed yield (1.91 t/ha) and stover yield (4.36 t/ha) while conventional tillage gave the least seed and stover yield of 1.63 t/ha and 3.95 t/ha respectively. Among the genotypes, KBSH-44 recorded significantly highest seed (1.81 t/ha) and stover yield (4.22 t/ha) which was at par with the genotype DRS-1 (1.73 and 4.16 t/ha respectively). 150% RDF produced significantly higher seed and stover yield of 2.09 and 5 t/ha respectively followed by 100% RDF (1.75 and 4.16 t/ha). Balanced fertilisation with multinutrient approach is a viable technology for sustaining the productivity of several

cropping systems (Ramesh *et al.*, 2017). Zero tillage recorded significantly higher uptake of NPK (52.65, 21.87 and 76.03 kg/ha respectively). This corroborates the findings of Sridhar *et al.* (2012) probably due to enhanced soil moisture which facilitated better nutrient uptake by increasing biomass. Among the cultivars, KBSH-44 resulted in the highest nitrogen and potassium uptake followed by DRS-1.

Zero tillage during rice fallow/summer was found to be the optimum tillage practice for getting higher productivity of sunflower on sandy loam soils under the agroclimatic conditions of Bhubaneswar. Among the genotypes, the hybrid KBSH-44 performed better than other hybrids. Application of 150% recommended dose of fertilizer gave highest seed and oil yield in sunflower. Growing of sunflower hybrid under zero tillage fertilized with 90:120:90 N: P₂O₅: K₂O kg/ha could maximize the productivity under rice fallow at Odisha.

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Mechanized cultivation in safflower (*Carthamus tinctorius* L.)

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ABSTRACT

The un-replicated field experiment was conducted with two sets of treatments (mechanization and farmer's practice) in safflower. Mechanized cultivation in safflower recorded significantly higher yield of safflower than

farmer practice. The seed yield increase was 24% under mechanized condition than farmer's practice. Energy productivity (kg/MJ) was higher (0.49) under mechanized cultivation compared to farmer's practice (0.28).

Keywords: Cultivation, Energy use efficiency, Mechanization, Safflower

Agricultural mechanization is an important input to agriculture for performing timely farm operations, reducing the cost of operation, maximizing the utilization efficiency of costly inputs.

Field experiment was conducted at AICRP on safflower, Parbhani during 2018-19 in Vertisols in safflower after soybean. It is un-replicated trial with two sets of treatments viz., mechanized cultivation and farmer's practice. Each plot size was 1000 m².

Safflower seed yield (1350 kg/ha) was higher with mechanized cultivation than farmer's practice (1087 kg/ha). Energy productivity (kg/MJ) was higher under

mechanized cultivation (0.49) than farmer's practice (0.28). Total Energy input (MJ/ha) recorded higher in case farmer's practice (3921) over mechanization (2769). Higher number of labour and time consumption was found in farmer's practice than mechanized cultivation. Specialized mechanization practice having less time and labour consuming (Singh, 1968). Mechanization in safflower is found profitable over farmer practice.

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Table 1 Mechanized cultivation in safflower

Treatment	Seed yield (kg/ha)	Biological yield (kg/ha)	100 seed weight (g)
Mechanized cultivation	1350	7825	6.0
Farmer's practice	1087	6514	5.3
t-test (P=0.05)	9.2	10.9	16.1

Table 2 Energy budgeting in mechanized cultivation and farmer's practice

Particulars	Energy input (MJ/ha)	
	SMP	FP
Seed, sowing, manure and fertilizer	2310	2609
Weed management	99	229
Irrigation	80	81
Need based plant protection	34	162
Harvesting and threshing	293	840
Total energy input (MJ/ha)	2769	3921
Energy output (MJ/ha)	33750	27175
Net energy returns (MJ/ha)	30981	23254
Energy ratio	12.2	6.9
Energy productivity (kg/MJ)	0.49	0.28

Response of sunflower (*Helianthus annuus* L.) based cropping systems to fertilizer levels

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ABSTRACT

Field experiment was conducted during 2018-19 to study the effect of different preceeding crops and fertilizer levels on yield and economics of rabi sunflower. Significantly higher sunflower equivalent yield was obtained in maize-sunflower cropping system (2071 kg/ha) which is on par with greengram-sunflower cropping system (2060 kg/ha). Application of 100% RDF recorded significantly higher sunflower equivalent yield (1785 kg/ha) than 50% STCR (1428 kg/ha) but on par with that of 100% STCR (1650 kg/ha). The highest system gross returns, net returns and B: C ratio were obtained with greengram-sunflower and 100% RDF fertilizer.

Keywords: Cropping system, Sunflower, System productivity

In Telangana, most of the sunflower area is confined to rabi season and most of the research work has been mainly confined to the nutrient requirement of an individual crop. But the information regarding to the preceding crop to be cultivated before sunflower is unavailable. Besides, cereal-cereal cropping sequences are more exhaustive and put heavy demand on soil resources as compared to cereal-legume and cereal-oilseed sequences (Reddy and Suresh, 2009). Hence, crop diversification has been identified as an important and essential strategy to improve farm income and soil and environmental health consistently. Hence, the present study is taken to assess sunflower crop as component under crop diversification with emerging/new cropping systems in terms of productivity and profitability in Telangana.

The field trial was conducted at Agriculture Research Station, Tornala, during *kharif* and *rabi*, 2018-19. The experimental trial was laid out in a split plot design in which *kharif* crops (Greengram, Maize, Redgram and Cotton) were sown on 14th July, 2018 and immediately after the harvest of the *kharif* crop, sowing of *rabi* sunflower (DRSH-1) was taken up with three different fertilizer treatments i.e., 100% RDF (75:90:30 N: P₂O₅: K₂O kg/ha), 100% STCR (132: 16: 41 N: P₂O₅: K₂O kg/ha) and 50% STCR (66:8:20.5 N:P₂O₅:K₂O kg/ha) respectively and replicated thrice. The main plot size is 15m x 6m and sub plot size is 6m x 4.2 m and spacing followed 60 cm x 30 cm. All the agronomic

practices were followed as per the recommendation of PJTSAU.

In the present study, maize-sunflower cropping system resulted in significantly higher sunflower equivalent yield (2071kg/ha) which was at par with greengram-sunflower cropping system (2060 kg/ha) whereas significantly lower equivalent yield was obtained in cotton-sunflower cropping system (1445 kg/ha) and 100% RDF treatment resulted in significantly higher sunflower equivalent yield (1785 kg/ha) on par with that of 100% STCR (1650 kg/ha) when compared with 50% STCR (1428 kg/ha) treatment among different fertilizer treatments.

Further, greengram-sunflower cropping system accrued maximum system gross returns (₹81,181/ha), net returns (₹ 29,491/ha) and B: C ratio (1.57) when compared with other cropping systems. And application of 100% RDF treatment to sunflower has observed highest system gross returns (₹70,477/ha), net returns (₹9,310/ha) and B:C ratio (1.15) and lowest was recorded in 50% STCR gross returns (₹62,247/ha, ₹3,838/ ha and 1.07) respectively.

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Influence of component technology on growth, yield and economics of safflower (*Carthamus tinctorius* L.)

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ABSTRACT

A field experiment was conducted to quantify the contribution of component technologies to the yield of safflower for two consecutive years in post rainy season from 2017-18 to 2018-19 at Solapur (MS). The experiment composed of eight treatments with three replications in RBD. The treatment T8 (T7 + Cycocel application @ 1000 ppm at bud initiation) obtained significantly higher seed yield (725.3 kg ha⁻¹) than rest of the treatments. The magnitude of yield increase over control was 4 to 80 per cent and 25 to 43 per cent over farmers' practice. The treatment showed significant changes in plant height, number of capitula/plant and 100 seed weight than rest of the treatments. In terms of economics, treatment T4 was found numerically superior in net returns and B: C ratio.

Keywords: Moisture conservation, PSB, Seed treatment, *Trichoderma*

In Maharashtra, the total area and production of safflower was 256 thousand hectares and 101 thousand tonnes production with average productivity of 397 kg/ha (Patil *et al.*, 2018). Bio fertilizers are the newest and most technically advanced way of supplying mineral nutrients to crops. Compared to chemical fertilizers alone, when bio-fertilizers are used along with fertilizers,

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fertilizer use efficiency improves (Kumar *et al.*, 2017). Therefore, a suitable ratio of organic, inorganic and bio fertilizers are necessary for higher crop yield. There is a need to maximize productivity with minimum deterioration of soil. Keeping these considerations in view, present investigation was carried out for sustained safflower production.

The field experiment was conducted during post rainy seasons from 2017-18 to 2018-19 at Solapur. The experimental soil was low in available nitrogen and medium in available phosphorus and high in available potassium. The experiment was laid out in a Randomized Block Design (RBD) with three replications having eight treatment combinations, T1 : Control (Sowing only), T2 : farmers' practice (No moisture conservation, seed treatment, thinning followed by one hoeing only, inadequate plant protection measures), T3 : T1+ moisture conservation (flat beds, 6 x 6 m), T4 : T3+ Seed treatment of azotobacter, PSB and *Trichoderma* + RDF (50: 25: 00 kg N P₂O₅ K/ha), T5 : T3+Seed treatment of *Azotobacter*, PSB and *Trichoderma* + GRDF (50: 25: 00 kg N P₂O₅ K/ha+ FYM @ 2.5 t ha⁻¹), T6 : T5+ Thinning+ Inter culture (2 hoeing and 1 weeding), T7 : T6 + Need based plant protection and T8 : T7+ Cycocel application @ 1000 ppm at bud initiation.

The data regarding growth, yield and economics of safflower as influenced due to different treatments is presented in Table 1. The treatment T8 gave significantly higher seed yield (725.3 kg/ha) than rest of the treatments. However, it was at par with treatment T7 (710.3 kg/ha), T6 (688.9 kg/ha), T5 (661.4 kg/ha) and T4 (634.9 kg/ha). Perusal of the data, indicated that treatment T4, T5, T6, T7 and T8 had produced

significantly higher seed yield over control. The results of this study showed that combined application of N and P biofertilizers had a synergistic effect seed yield of safflower and increased that compared to control. Treatment T8 showed significant differences with respect to plant height (60.37 cm), number of capitula/plant (20.89) and 100 seed weight (6.63 g) than rest of treatments but it was at par with T4, T5, T6 and T7. In terms of economics, the treatment T4 was found numerically superior in net returns and B:C ratio. Whereas, the components like seed treatment, application of RDF + FYM, thinning and intercultural along with need based plant protection measures had pronounced effect on seed yield of safflower grown in rainfed areas.

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Table 1 Yield and economics of safflower as influenced due to different treatments

Treatments	Plant Height (cm)	No of capitula/ plant	100 seed weight (g)	Seed yield (kg/ha)	Bio. Yield (kg/ha)	Harvest Index (%)	Economics (Rs/ha)			
							Gross Ret.	Cost of Cult.	Net Ret.	B: C Ratio
T1	39.77	14.99	4.87	401.2	2695	15.08	17628	13060	4568	1.35
T2	47.73	17.05	5.30	507.1	3065	16.96	20260	13350	6910	1.52
T3	39.47	15.14	4.72	416.7	3075	13.84	19662	15150	4512	1.30
T4	53.97	19.19	6.01	634.9	3106	20.67	25958	16176	9782	1.60
T5	54.40	19.43	6.28	661.4	3218	21.32	27945	21176	6769	1.32
T6	56.70	20.25	6.30	688.9	3524	19.93	29103	24676	4427	1.18
T7	57.77	20.63	6.42	710.3	3531	20.10	32755	26236	6519	1.25
T8	58.37	20.89	6.63	725.3	3554	21.15	33347	27186	6161	1.23
SEm±	1.89	0.58	0.22	40.6	294	1.94				
CD±0.005%	5.61	1.72	0.65	122	NS	5.90				

NOTE : T1 : Control (Sowing only), T2 : Farmers practice (No moisture conservation, seed treatment, thinning followed by one hoeing only, inadequate plant protection measures), T3: T1+ moisture conservation (flat beds, 6 x 6 m), T4: T3+ Seed treatment of *Azotobacter*, PSB and *Trichoderma* + RDF (50: 25: 00 kg NPK/ha), T5: T3+ Seed treatment of *Azotobacter*, PSB and *Trichoderma* + GRDF (50: 25: 00 kg NPK/ha+ FYM @ 2.5 t/ha), T6 : T5+ Thinning+ Interculture (2 hoeing and 1 weeding), T7: T6+ Need based plant protection and T8: T7+ Cycocel application @ 1000 ppm at bud initiation.

Efficacy of pre and post-emergence herbicide on growth, yield and economics of sunflower (*Helianthus annuus* L.) under modified spacing

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ABSTRACT

Application of pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray along with propaquizafop @ 62 g a.i./ha at 15-20 DAS as post emergent spray recorded significantly lower weed dry weight (53.5 g/m² area), weed index

(5.31) and higher weed control efficiency (89.1 %), seed yield (1728 kg/ha), head diameter (16.06 cm), test weight (6.06 g), gross returns (₹ 65,266), net returns (₹ 26,248) and B:C ratio (2.48).

Keywords: Pendimethalin, Weed control, Weed control efficiency

Sunflower is poor competitor with weeds on account of its slow growth in the initial stage. Therefore, newly introduced pre-emergence and post emergence herbicides including cultural and mechanical practices for their effective weed management and their influence on productivity of sunflower is investigated in this study. A field experiment was carried out during Kharif season of 2018 to study the efficacy of pre and post-emergence herbicide on sunflower under modified spacing at ZARS, GKVK, University of Agricultural Sciences, Bangalore. The experiment was laid out with randomised complete block design with three replications. Details of treatments are given in Table 1. The spacing followed was 75 cm between the rows and 25 cm between the plants. The soil of the experimental field was red sandy loam in texture and medium in available soil N, P and K. The sunflower hybrid KBSH-78 was used as a test crop. The recommended fertilizer dose of 90:90:60 N:P₂O₅:K₂O kg/ha was applied.

Application of pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray along with propaquizafop @ 62 g

a.i./ha at 15-20 DAS as post emergent spray recorded significantly lower weed density, weeds dry weight and weed index; and higher weed control efficiency than all other treatment. Similar trend was noticed with respect to seed yield (1728 kg/ha), head diameter (16.06 cm), 100 seed weight (6.06 g), gross returns (₹ 65,266/ha), net returns (₹39,018/ha) and B:C ratio (2.48). Similar results have also been observed by Triveni *et al.* (2017) and Nagre *et al.* (2017).

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Table 1 Integrated weed management in sunflower under modified spacing

Treatment	Weed dry weight at harvest (g/m ²)	Weed control efficiency (%)	Weed Index (%)	Plant height at harvest (cm)	Head diameter (cm)	100 seed weight (g)	Oil content (%)	Seed yield (kg/ha)	Oil yield (kg/ha)
Pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray + one weeding by power weeder or intercultivation at 35 DAS	64.2	86.9	12.7	149	16.2	4.76	38.6	1592	616
One weeding by power weeder or intercultivation at 35 DAS	94.5	80.7	44.7	165	12.1	4.13	37.4	1009	378
Pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray + propaquizafop @ 62 g a.i./ha at 15-20 DAS as directed post-emergence spray on weeds	53.5	89.1	5.3	183	16.0	6.06	37.6	1728	651
Farmers practice (two IC at 20 & 40 DAS + one hand weeding at 30 DAS)	36.2	92.6	38.0	162	14.6	5.26	37.9	1130	428
One intercultivation at 20 DAS + one hand weeding at 30-35 DAS	56.2	88.5	18.5	172	11.4	5.50	37.3	1487	555
Weed free (3 hand weeding at 15, 30 & 45 DAS)	-	100	0.0	181	17.7	5.10	37.8	1825	691
Unweeded control	491.5	-	45.5	148	9.3	4.66	38.6	993	383
SEm±				9.0	0.45	0.16	1.3	72.8	31.9
CD (P=0.05)				28	1.5	0.52	NS	227	99

Yield response of soybean [*Glycine max* (L.) Merrill] to liming and manuring in acidic soil of Manipur

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ABSTRACT

Field experiment was conducted in acidic soil. Application of farm yard manure @ 2.5 t/ha significantly enhanced the soybean yield and yield attributes. Soybean yield and yield attributes linearly increased as the levels of lime increased up to 600 kg/ha and then declined. Application of FYM @ 2.5 t/ha along with 600kg/ha of lime recorded maximum seed yield and yield components of soybean.

Keywords: Liming, Organic manure, Soybean

The north eastern region of India which receives high rainfall is being affected by soil acidity. This is one of the limiting factors for soybean production in this region. Liming is widely practiced to correct soil pH as it is economically feasible method to maintain a suitable soil pH for crop growth (Suryantini, 2007). Besides, application of organic matter was reported to fix the soil pH in some acid soils. The harmful effects of soil acidity on chemical properties and plant productivity are well known fact. However, studies on the rate of liming on soybean are very limited in this region. So, an attempt has been made with the objective to reclaim the acidic soil of Manipur for better production of soybean.

The experimental trial was conducted at Agricultural Research Farm, Andro, Central Agricultural University, Imphal, Manipur during the *kharif* 2017. The soil was clay loam in texture containing 313 kg/ha available nitrogen, 22.0 kg/ha available phosphorus and 236 kg/ha available potassium with an organic carbon content of 1.00%. The experiment was laid out in factorial randomized block design and the treatment consist of application of organic manure (farm yard manure @ 2.5 t/ha and control) and rate of lime (200, 400, 600, 800 kg/ha and control) having ten treatment combination which were replicated thrice. Application of

farm yard manure (FYM) and liming was done 15 days and 30 days respectively prior to sowing as per the treatment. The recommended dose of fertilizers was applied as basal @ 20:60:40 kg/ha of N, P₂O₅ and K₂O in the form of urea, single super phosphate and muriate of potash, respectively. The genotype used in the experiment was RKS 18 with a spacing of 45 cm x 10 cm. No irrigation was applied and the total rainfall received was 1210 mm during cropping period.

It was found that application of farm yard manure @ 2.5 t/ha significantly enhanced the soybean yield by 12.3%. Similarly yield attributes also increased due to application of FYM @ 2.5 t/ha as comparison with control. Soybean yield linearly increased as the levels of lime increased up to 600 kg/ha and then declined. Same trend was also observed in yield attributes. Application of FYM @ 2.5 t/ha along with 600 kg/ha of lime recorded maximum seed yield and yield components of soybean. The soil pH increased from 5.0-5.3 to 6.1-6.2.

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Table 1 Effect of liming and manuring on yield, yield attributes and economics of soybean

Treatment	Seed yield (kg/ha)	Haulm yield (kg/ha)	Branches/ plant	Pods/ plant	pH	
					Initial	After
Organic manure						
FYM @ 2.5 t/ha	1336	2046	3.78	45	5.73	6.17
Control	1190	1793	3.49	39	5.69	6.16
SEm±	46.3	82.2	0.14	1.8	0.02	0.03
CD (P=0.05)	137	244	NS	6	NS	NS
Lime (kg/ha)						
200	1182	1994	3.72	41	5.72	6.20
400	1344	1917	3.35	42	5.68	6.22
600	1524	2035	4.07	48	5.68	6.10
800	1320	2048	3.67	45	5.73	6.10
Control	945	1606	3.38	34	5.72	6.20
SEm±	73.1	130	0.23	2.9	0.03	0.05
CD (P=0.05)	217	NS	NS	9	NS	NS

Role of seed age in screening for salt tolerance of sunflower at germination

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ABSTRACT

Three sunflower hybrid seeds of known age (3, 2 and 1 month old) seeds of DRSH-1, KBSH-44, CO-2 respectively were tested for salt tolerance by conducting germination studies in 200, 250, 300, 350 mM NaCl at monthly intervals. Results differed when seeds of same age were compared with seeds of mixed age. Therefore, for valid comparisons, the seeds should essentially be of same age.

Keywords: Salt tolerance, Seed age, Sowings, Sunflower

Majority of the times when large numbers of entries are to be evaluated or when seed lots are to be tested for salt tolerance, the seeds are usually of mixed age. This experiment was conceived as the sunflower hybrid CO-2 which showed tolerance to salt consistently failed to show tolerance one year which was suspected to be due to old age of seed. Though many reports on sunflower salt tolerance at germination are available (Islam *et al.*, 2008), none of them mention age of seeds at the time of study. The objective of the present study was to know whether the seeds should essentially be of similar age for comparison for salt tolerance under lab conditions or even otherwise whether the comparison holds good.

The present experiment started with 3, 2 and 1 month old seeds of DRSH-1, KBSH-44, CO-2 respectively. The seeds were stored at ambient conditions. These hybrids were selected as they were found tolerant in the previous experiments. Seeds were germinated in 4 different salt concentrations (200, 250, 300, 350 mM) along with control at monthly intervals.

Thirteen sowings were taken up for DRSH-1, 12 sowings for KBSH-44 and CO-2. About 70% germination was noticed up to 11 months in KBSH-44 and DRSH-1 and in CO-2 up to 10 months (Table 1) and declined later. This could be due to increased solute leakage from seeds with advancing seed age. Germination in highest concentration of salt (350 mM

NaCl) was observed till 6, 7, 8 months in DRSH-1, KBSH-44 and CO-2, respectively.

By comparing performance of 4-month age seed of all the three hybrids for salt tolerance, CO-2 was found to be more tolerant with higher germination (20%) at high salt stress and with least percent reduction followed by DRSH-1 and KBSH-44 (Table 1). By comparing seeds of mixed ages, 12-month old CO-2, 6-month old KBSH-44 and 2-month old DRSH-1 in an experiment, KBSH-44 emerged as more tolerant followed by DRSH-1 and CO-2 with no germination at highest salt stress (Table 1). In alfalfa it was reported that salt tolerance at germination of different aged seed lots from the same germplasm source was shown to differ significantly compared to control (nonsaline) of each lot (Smith and Dobrenz, 1987).

Inference drawn from experiments involving seeds of mixed age leads to erroneous conclusions as different age seeds respond differently to salt stress. Therefore, it is essential to conduct the lab experiments with seeds of similar age for stress tolerance.

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Table 1 Effect of salt stress on germination of hybrid seed of same and mixed age

Hybrid	Seed age	Germination (%)					Seedling length (cm)				
		1	2	3	4	5	1	2	3	4	5
Seeds of same age											
DRSH-1	4	78	60	44	29	12	12.6	2.6	1.9	1.4	1.2
KBSH-44	4	94	50	45	38	10	13.2	2.3	1.7	1.6	1.1
CO-2	4	75	56	53	27	20	9.4	2.5	2.0	1.7	1.3
Seeds of mixed age											
DRSH-1	2	90	32	10	5	0	10.9	2.5	1.8	1.1	0.0
KBSH-44	6	82	42	20	10	5	12.7	3.6	2.0	1.2	1.1
CO-2	12	44	32	16	10	0	2.2	1.3	0.9	1.0	0.0

Treatments: 1) control; 2) 200 mM NaCl, 3) 250 mM NaCl, 4) 300 mM NaCl, 5) 350 mM NaCl

Establishment of suitable date of sowing and nutrient management for niger [*Guizotia abyssinica* (L.f.) Cass.]

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ABSTRACT

The experiment was conducted during the *kharif* 2018 at JNKVV, Jabalpur, Madhya Pradesh to find out the suitable date of sowing and nutrient management practice for niger. Sowing of niger in last week of September with application of 100% P & K and 50% N as basal and 50% N in equal splits (at 20 and 40 DAS) was the most suitable time of sowing and fertilizer management practice to get better seed yield and returns.

Keywords: Date of sowing, Fertilizer, Niger

Optimum sowing time plays an important role to exploit the full genetic potential of niger varieties (Eberhort and Russel, 1966). Besides, it affects the plant height, number of branches, flowering and capitula bearing habits. Thus, the time of sowing has a prominent influence on both vegetative and reproductive growth of niger which has a diverse effect on the production. Keeping in view above facts the present study was conducted to develop suitable date of sowing and nutrient management for niger under aberrant weather conditions of central India.

The experiment was conducted during the *kharif* 2018 at Project Coordinating Unit (Sesame and Niger), JNKVV, Jabalpur (M.P.). The treatments were 3 dates of sowing *viz.*, last week of September, I week of October and III week of October and 3 nutrient management practices *viz.*, 100% P & K and 50% N as basal and 50% N in two equal splits (at 20 and 40 DAS), 100% RDF (40:20:10 NPK) as basal and control (no fertilizer). The experiment was conducted in split-plot design with three replications. Dates of sowing were taken as main plot treatments and nutrient management as sub-plot treatments.

The tallest plant (88.62 cm) was observed when crop was sown during last week of September and it gradually decreased with successive delay in sowing by

10 days i.e., on I week of October (83.86 cm) and III week of October (81.74 cm) at maturity stage. Application of 100% P & K and 50% N as basal and 50% N in split (25% N at 20 DAS, 25% at 40 DAS) recorded significantly higher plant height (101.29 cm) than application of 100% RDF as basal (96.07 cm) and control (61.57 cm). Similar trend was noticed with respect to no. of branches, no. of capitula/plant and seeds/capitula.

Sowing of niger during the last week of Sept with application of 100% P & K and 50% N as basal and 50% N in split (25% N at 20 DAS, 25% at 40 DAS) gave significantly higher seed yield of 561 kg/ha than delay in sowing with other nutrient management practices. Similar trend was noticed with respect to returns.

Therefore, it could be concluded that sowing of niger in last week of September with application of 100% P & K and 50% N as basal and 50% N in split (25% N at 20 DAS, 25% at 40 DAS) was the most suitable time of sowing and fertilizer management practice to get the greater seed yield and returns.

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Response of linseed (*Linum usitatissimum*) to sulphur, zinc and iron under irrigated conditions

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ABSTRACT

An experiment was conducted at College of Agriculture, Latur during *rabi* 2018-19 to study the response of linseed to macro and micro nutrients. Application of RDF + ZnSO₄ @ 20 kg/ha + FeSO₄ @ 20 kg/ha was found most effective for increasing growth and productivity of linseed. Application of RDF in combination with ZnSO₄ @ 20 kg/ha and FeSO₄ @ 20 kg/ha recorded significantly higher growth and yield attributing characters and seed yield (1998 kg/ha), straw yield (2204 kg/ha), oil yield (476 kg/ha), gross monetary return (₹71,880/ha), net monetary return (₹36,426/ha) and B:C ratio (2.03) of linseed than RDF alone or in combination with ZnSO₄, FeSO₄ or sulphur alone respectively.

Keywords: Iron, Nutrition, Potassium, Sulphur, Zinc

The crops require sulphur to make specific amino acids and various metabolites containing S and for protein synthesis. Today, zinc is considered as the most limiting factor in producing crop in different parts of the world. Zinc deficiency not only reduces crop yield and production but also results in reduction of their nutritional value. Iron (Fe) is one of the important nutrients involved in the formation of chlorophyll and light reaction of electron transport chain and thus can enhance the growth and yield of crops (Kakar *et al.*,

2000). In view of this consideration, the present investigation was carried out to study the response of linseed to macro and micro nutrients.

An experiment was conducted at College of Agriculture, Latur during *rabi* 2018-19. The experimental plot was clayey in texture, low in available nitrogen (125.3 kg/ha), medium in available phosphorus (18.20 kg/ha) and high in available potassium (498 kg/ha). The experiment was laid out in a randomized block design with 7 treatments replicated thrice. The

treatments were T1- 100% RDN, T2- RDF, T3- RDF + sulphur @ 20 kg/ha, T4- RDF + ZnSO₄ @ 20 kg/ha, T5- RDF + FeSO₄ @ 20 kg/ha, T6- RDF + ZnSO₄ @ 20 kg/ha + FeSO₄ @ 20 kg/ha and T7- Control. The recommended cultural practices and plant protection measures were adopted during experimentation.

The yield of linseed was influenced significantly due to application of RDF in combination with zinc sulphate @ 20 kg/ha and ferrous sulphate @ 20 kg/ha which recorded significantly higher seed yield (1198 kg/ha) followed by application of RDF + zinc sulphate @ 20 kg/ha (1045 kg/ha) and application of RDF + ferrous sulphate @ 20 kg/ha (1024 kg/ha). The increase in yield could be attributed to the increase in all growth and yield related traits *viz.*, plant height, number of branches, plant spread, dry matter, number of capsules/plant, weight of capsule/plant, number of seeds/plant and seed yield/plant. The application of RDF in combination with zinc sulphate @ 20 kg/ha and ferrous sulphate @ 20 kg/ha recorded significantly higher seed yield (1198 kg/ha). The better portioning of

assimilates from source to sink might have led to higher yield attributes, which finally resulted in higher seed yield of linseed. The result of present investigation is in line with those of Yaduwanshi *et al.* (2018). The oil content (%) in linseed was not influenced significantly due to different treatments. Application of RDF in combination with zinc sulphate @ 20 kg/ha and ferrous sulphate @ 20 kg/ha recorded significantly highest oil yield (476 kg/ha), gross monetary returns (₹ 71880/ha) and net returns (₹ 36426/ha) with higher B:C ratio (2.03).

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Performance of soybean (*Glycine max L.*) genotypes under delayed monsoon conditions in transitional tract of Dharwad

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ABSTARCT

The experimental results indicated that genotype DSb-32 recorded significantly higher seed yield (25.04 q/ha) and B:C ratio (2.75) concluding that the genotype DSb-32 proved superior under delayed onset monsoon conditions for realizing optimal yield and returns.

Keywords: Delayed monsoon, Performance, Seed yield, Soybean

Selection of right genotypes has been found to boost crop productivity by 20-25 per cent (Singh *et al.*, 2011). With the release of new improved soybean varieties, knowledge on their potential and performance under different cultural practices are required. Thus, there is a need for farmers to know specific varieties to achieve optimum yield. Hence it is essential to identify suitable genotypes and their production technologies to attain sustained production under varied environmental conditions.

The field experiment was replicated thrice in split plot design at MARS, Dharwad during *khariif* 2017 to study the performance of soybean genotypes (DSb-31, DSb-32, DSb-21 and JS 93-05) at late sowing date of 26 July 2017 under delayed monsoon conditions. The recommended sowing dates for soybean under Dharwad conditions is first week of June to first fortnight of July.

The genotype DSb-32 was superior in terms of seed yield (25.04 q/ha), number of pods/plant (51.76) and 100

seed weight (17.05 g) than rest of the genotypes. Number of root nodules/plant (31.83 & 27.83) at 60 DAS and dehydrogenase activity at 45 DAS (16.48 & 16.29 μ g of TPF formed/g/24hr) were significantly higher for DSb-21 and DSb-32, respectively. The experimental results indicated that genotype DSb-32 recorded significantly higher seed yield (25.04 q/ha) and B:C ratio (2.75) concluding that the genotype DSb-32 proved superior under delayed onset monsoon conditions for realizing optimal yield and returns (Table 1). The experimental results indicated that genotype DSb-32 recorded significantly higher seed yield (25.04 q/ha) and B:C ratio (2.75) concluding that the genotype DSb-32 proved superior under delayed onset monsoon conditions for realizing optimal yield and returns. The varietal differences in growth and yield characteristics with different genotypes are also established by Raghuwanshi *et al.* (2017).

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Table 1 Soybean seed yield, yield parameters, dehydrogenase activity, nodule number per plant and B:C ratio as influenced by genotypes

Genotypes	Seed yield (q/ha)	Number of pods/plant	100 seed weight (g)	DHA at 45 DAS (μg of TPF formed/g/24 hr)	Number of root nodules/plant	B:C ratio
DSb-31	19.36	46.05	15.06	15.84	24.25	2.41
DSb-32	25.04	51.76	17.05	16.29	27.83	2.75
DSb-21	17.37	47.09	12.56	16.48	31.83	2.06
JS 93-05	15.76	28.30	15.84	13.79	20.58	1.79
S Em. \pm	0.83	1.23	0.54	0.10	0.85	0.12
CD(P=0.05)	2.87	4.25	1.87	0.34	2.93	0.42

Raising micropot nursery and crop establishment in main field for improving oilseed productivity

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ABSTRACT

Micropot method involving raising of nursery seedlings and their subsequent establishment in main field has been emerged as an innovative package of growing these crops under changing climate situation. The method offers multifarious advantages including climate-resilience, timely or even early sowing, reduced seed rate, easy crop establishment, hands-down weed management, shortened crop duration in main field, less incidence of diseases etc.

Keywords: Climate-resilient method, Higher productivity, Micropot nursery

Delayed sowing, short winter spell, marginalized/sub-optimal cultivation etc. are the bottlenecks in achieving higher productivity, profitability and quality of mustard and sunflower in West Bengal. Micropot method has emerged as an innovative package of growing these crops under changing climate situation.

A model micropot nursery has been developed, using 10,000 nos. of Sampad Micropots (SMPs made of PVC with 25 mm top diameter, 23 mm bottom diameter, 30 mm pot height and 12 cc inner volume). A raised bed (6.00 m length x 1.50 m width x 0.15 m height) needs to be prepared in a sunny area and surrounded by bricks along with the placement of good quality polythene sheet in inner space (5.50 m x 1.00 m). A layer of sand (about 3 cm) is to be spread inside the box. Then, SMPs (10,000 nos.) are placed inside in a compact fashion (honey comb structure). Growing medium is prepared by mixing compost and top field soil in 3:1 proportion. Single super phosphate (SSP), boric powder and Zn-EDTA are mixed at 1.4 kg, 7.5 g and 1.0 g per CFT of growing medium, respectively. Ready pot mixture (5

CFT) is loosely poured inside the pots, followed by watering. Germinated/nutri-primed seeds are sown singly in each pot, and then covered with pot mixture. Irrigation is given in sandy layer as and when required. Water will move to the SMPs through capillary action. Watering should not be done directly over the pots. Nursery is sprayed with the solution (dissolving 1.0 g ZnSO₄.7H₂O, 10.0 g urea and 1.0 g boric acid in 1.0 L of water) at 2 days before transplanting. Healthy seedlings of oilseed crops (mustard and sunflower) could be raised within 12-15 days after sowing (4-leaf stage).

Seedlings can be transplanted in main field under normal tillage or zero tillage condition. Tillage involves land preparation, basal fertilization (P₂O₅, K₂O and B), planting of seedlings at recommended spacing, application of 0.5% urea solution just after transplanting, top dressing of urea at 5-7 and 20 days after transplanting (DAT), foliar spray of Zn and B along with 1% urea solution and need-based management practices. Under zero tillage condition, it is to dig out the holes only where the seedlings are planted at recommended spacing. Pot mixture [preparing growing medium with

one to two part (s) compost and one part top soil, mixing the same with 850 g SSP and 2 g boric powder per CFT of growing medium] is placed in each hole before transplanting whilst 0.5% urea solution needs to be added just after transplanting, followed by top dressing of N and K₂O at 15 and 20-40 DAT. No other special cultural practices are needed.

Several experiments were conducted on micropot method of oilseed cultivation at different research stations in West Bengal. These were validated through on-farm experiments at farmers' fields. There was an early harvest of sunflower (by at least three weeks) with seed yield of more than 2.5 t/ha in the district of South 24 Parganas during rabi season. In case of mustard (Divya 55), a high seed yield of 3 t/ha was recorded. Such yield advantages were due to timely or sometimes early sowing, production of healthier seedlings and

better crop establishment with reduced pest and disease incidence in both the crops (Patra and Bhowmick, 2019). The method offers multifarious advantages including timely or even early sowing, reduced seed rate, easy crop establishment, hands-down weed management, shortened crop duration in main field, scope of increasing cropping intensity. Use of secondary and micronutrients would also have a crucial role in improving the oil quality.

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Seed and petal yield of non-spiny cultivars of safflower (*Carthamus tinctorius* L.) under rainfed conditions

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ABSTRACT

Eight non-spiny cultivars were evaluated under rainfed conditions during the post rainy season of 2012-13 for their seed and petal yield in comparison to two spiny cultivars. Spiny cultivars gave significantly greater yields (1515 kg/ha) compared to non-spiny cultivars (911 kg/ha). Among the non-spiny cultivars NARI-NH-1 and NARI-6 (1175 kg/ha) were significantly superior over other non-spiny cultivars (823 kg/ha).

Keywords: Hybrids, Non-spiny varieties, Petal yield, Seed yield

Non-spiny cultivars of safflower were released at different centres of AICRP (Safflower) to ease harvesting of crop and also to harness petals value as petals contain medicinal properties. Therefore the study was carried out to compare the productivity (seed and petals) of non-spiny cultivars in comparison to spiny cultivars of safflower under rainfed conditions.

A field experiment was conducted at ICAR-Indian Institute of Oilseeds Research in Vertisols during post-rainy season of 2012-13. Total of 9 cultivars of safflower (seven non-spiny and two spiny) were evaluated in RBD with three replications. Seeds were sown in the third week of October. An amount of 755 mm of rainfall was received during the growth period. Eight rows of 5 m length was harvested by excluding two border rows on either side of plot (6 x 4.5 m²) at the time of physiological maturity. Petals were harvested 15 days before harvest of seed in each plot in non-spiny cultivars.

Seed and petal yield of spiny and non-spiny varieties and hybrids differed significantly (Table 1). Seed yield of both spiny cultivars, NARI-H-15 (spiny

hybrid) and Annigeri-1 (spiny variety) were statistically on par (1580; 1450 kg/ha) and was significantly greater than non-spiny cultivars

Table 1 Seed and petal yield of safflower cultivars

Cultivar	Seed yield (kg/ha)	Petal yield (kg/ha)
Annigeri-1	1450	-
NARI-H-15	1580	-
NARI-6	1150	140
NARI-NH-1	1200	160
PBNS-40	680	90
JSF-97	800	110
JSF-99	940	120
JSI-7	870	100
JSI-73	850	95
SSF-658	800	100
SEm±	70	9.2
CD (P=0.05)	210	28

Seed yield of NARI-NH-1 (non-spiny hybrid) and NARI-6 (non-spiny variety) was on par to each other (1200; 1150 kg/ha) and significantly higher than other non-spiny cultivars. Highest petal yield was recorded with NARI-NH-1 (160 kg/ha) which was on par with NARI-6 (140 kg/ha). The genetic differences with respect of seed yield were also reported by Mohankumar *et al.* (2005) and Koutroubas (2004). Therefore, it was concluded that, among non-spiny cultivars NARI-6 and NARI-NH-1 were better yields both in terms of seed and petal yield compared to other non-spiny cultivars.

Traits conferring intermittent drought tolerance across seasons in sesame (*Sesamum indicum* L.)

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ABSTRACT

Intermittent drought, seasonal temperature variations affect yield of sesame (*Sesamum indicum* L.) under rainfed conditions. Sesame germplasm were assessed for intermittent drought tolerance across season under field conditions. Seed yield was significantly and positively associated with leaf traits, leaf tissue moisture and CT across seasons. The identified trait specific germplasm will be used further in crop improvement programme.

Keywords: Drought, Genotypes, Intermittent, Sesame, Tolerance

Sesame cultivation is reported in tropical as well as subtropical regions of the world. The arid and semi-arid regions where sesame is grown are known to experience high temperatures, high values of solar radiation, high evaporation demand and occurrence of unpredictable drought. Although India is one of the top sesame producers of the world, severe drought threatens its production under rainfed cultivation. It is of great importance to explore the traits that contribute tolerance to drought in sesame. Therefore, the effects of intermittent drought on yield of sesame across seasons have an important challenge in sesame research. Improvement of drought tolerance genotypes of sesame is one of the major objectives of sesame breeding programs for recommendation to marginal and arid regions of its cultivation. With this backdrop, Indian core set of sesame consisting 314 accessions (Bisht *et al.*, 1998) were evaluated for their drought tolerance.

The core set consists of indigenous land races from different agro-ecological zones of India along with 5 accessions of wild sesame (*S. mulayanum*). Intermittent drought was imposed by reducing 4 to 4.5 Mpa of soil metric potential using soil moisture sensors. Different traits including: the number of primary branches/plant, plant height, number of capsules/plant, number of

seeds/capsule, seed weight and harvest index were recorded under both conditions under stressed and irrigated conditions in *kharif* and *rabhi* seasons of 2017. Seed and biological yield were determined by harvesting plants of each plot.

The leaf weight, total biomass, the number of capsules/plant, the capsule weight, the seed weight/capsule and the seed weight were found to reduce under drought conditions as compared to irrigated condition. The average seed yield reduced up to 20%, indicating that the reproductive process has vulnerability to intermittent drought reflecting on seed yield. Total oil content varied from 36 to 48% among core set analyzed. Further, 83 accessions were selected from core set based on cluster analysis and their seed yield responses under intermittent drought, under both drought and irrigated conditions across seasons for identification of source material with traits associated with intermittent drought tolerance.

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Climate change mitigation strategies by altering crop canopy for enhancing heat unit efficiency and sustainable productivity of sesame (*Sesamum indicum* L.)

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ABSTRACT

Field experiments on climate mitigation strategies for enhancing heat unit efficiency and productivity of sesame was conducted during summer 2016 at Regional Research Station, Vridhachalam. The treatment involved terminal nipping and 100 ppm salicylic acid spray at 30 and 45 DAS alone and in combination. The results of the experiments revealed that altering the crop canopy architecture by terminal nipping and foliar spray of 100 ppm salicylic acid at 30 DAS increased the heat unit efficiency and sesame seed yield.

Keywords: Heat use efficiency, Sesame, Terminal nipping

Sesame is very responsive to environmental and abiotic factors such as temperature and humidity which can affect its yield (Kenan *et al.*, 2017). Due to climate change there is a poor source-sink partitioning resulting in poor yield of sesame. Appropriate crop growth regulation technologies are required to combat the climate change and to sustain the productivity of sesame. Field experiment was conducted at Regional Research Station, Vridhachalam to study the effect of nipping and spray of growth regulator on yield of sesame during Summer 2016. The treatments included T1-control, T2-terminal nipping at 30 DAS, T3-terminal nipping at 45 DAS, T4-foliar spray of 100 ppm salicylic acid (SA) at 45 DAS, T5- T2 + 100 ppm salicylic acid spray at 30 DAS, T6- T2 + T4, T7- T3 + T4. The experiment was conducted in randomized block design with three replications. Sesame variety VRI 2 of 80 days duration was used for the study. Growth attributes and yield parameters were recorded and analyzed statistically.

Altering crop canopy of sesame by terminal nipping and foliar spray of 100 ppm salicylic acid at 30 DAS

significantly harnessed the solar radiation and increased the heat unit efficiency (312) and recorded high seed of 930 kg/ha (Harisudan and Vincent, 2019). Nipping practices efficiently alters the crop architecture which in turn increases the lateral branches that lead to greater chances for development of source to sink features in sesame (Siddagamma *et al.*, 2018).

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Table 1 Effect of nipping and plant growth hormone on HUE and yield of sesame

Treatments	No. of branches/plant	No. of flowers/plant	No. of capsules/plant	No. of seeds/capsules	Seed yield (kg/ha)	HUE
T1 - Control	5.3	101	83.1	30.1	525	234
T2 -Nipping at 30 DAS	8.3	116	95.6	47.6	685	290
T3 -Nipping at 45 DAS	6.8	107	88.6	40.6	647	282
T4-100 ppm salicylic acid spray at 45 DAS	6.1	103	84.9	34.9	601	236
T5 - T2 + SA 100 ppm at 30 DAS	9.7	132	109.5	69.5	930	312
T6 - T2 + T4	8.7	119	98.3	57.3	875	304
T7 - T3 + T4	8.5	118	97.3	51.3	801	297
SEd	0.56	6.6	7.5	2.9	46	25.6
CD (P=0.05)	1.3	14.0	16.2	6.4	100	56.8

Sustainability of castor based intercropping systems under varied planting geometry

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ABSTRACT

The field experiment was conducted with the objective to assess the performance of castor based intercropping system. The experiment was laid out in randomized block design and replicated thrice with 8 treatment combinations. The results indicated that 180 cm row spaced castor intercropped with methi resulted in higher seed yield. The 240 cm row spaced castor intercropped with methi resulted in higher gross return and net return whereas 240 cm row spaced castor intercropped with mung bean gave highest B: C ratio.

Keywords: Castor, Intercropping, Spacing, Yield and Economics

Castor (*Ricinus communis* L.) is one of the most suitable oilseed crops for arid and semi-arid parts of country, which can be used to fulfil the ever increasing demand of industrial oil. Castor, due to its low input and water requirement, low cost of production and higher economic returns, is getting popular among the farmers in the country.

Yield of a crop is a function of yield/plant and number of plants/unit area. Proper spacing provides sufficient interception of sunlight and satisfactory absorption of nutrients and water from the soil resulting in higher crop yield. Growing castor at wider row spacing reduces the plant population on acreage basis but castor can compensate the yield loss by increasing growth and yield of individual plant (Dhimmer *et al.*, 2009). To take the advantages of different rooting depths, duration, nutrient and water requirement of the crops and better utilization of all the resources, the concept of intercropping has been introduced in primitive agriculture.

A field experiment was conducted at Regional Research Station, Bawal during *kharif* 2017 under irrigated condition. The experiment was laid out in randomized block design and replicated thrice with 8 treatment combinations. Combination of row spacing 180cm x 60cm and 240cm x 60cm, two intercrops such as mung and methi in 1:4 and 1:6 row ratio and other two popular sequential cropping systems of region *viz.*, mung- mustard and methi-wheat.

With respect to the productivity, castor sown in 180 cm row spacing and intercropped with methi produced higher yield (3573 kg/ha) followed by sole castor sown with same row spacing (3482 kg/ha) and lowest yield was obtained from castor grown in 240 cm row spacing when intercropped with mung bean with 1:6 row proportion (3191 kg/ha). But contradictory report was made by Rani (2008) and Singh (2009), who found that sole castor was producing maximum yield followed by

same crop intercropped with mung bean compared to intercropping with other field crops.

With respect to economics, higher gross income was reported when methi was grown as intercrop in 240 cm row spaced castor (₹184264/ha) and net income (₹118644/ha) also from same treatment. Even though marginal reduction in castor over sole crop was noticed, it was compensated by higher yield of methi. Higher B:C ratio was found in 240 cm row spaced castor intercropped with mung bean (3.04), it is because of lesser cost of cultivation incurred in production of mung bean compared to methi. Kumar (2002) reported that intercropped castor found higher B:C ratio over sole castor. Treatments S2, S5 and S7 are found on par with each other with respect to B:C ratio.

It could be concluded that, intercropping system in castor was profitable even though there was marginal reduction of main crop as the loss was compensated by additional income generated by intercrops apart from their ecological benefits.

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Table 1 Yield and economics of different treatments

Treatments	Yield (kg/ha)		Gross income (₹/ha)	Net income (₹/ha)	B:C ratio
	Main crop	Component crop			
S1 : Sole castor (180 cm)	3482	-	132316	80226	2.54
S2 :Castor (180cm) + Mung bean (1:4)	3348	703.5	166409	108159	2.86
S3 :Castor (180cm) + Methi (1:4)	3573	2200	179774	109698	2.57
S4 :Sole castor (240 cm)	3453	-	131214	81434	2.64
S5 :Castor (240cm) + Mung bean (1:6)	3191	865	169439	113637	3.04
S6 :Castor (240cm) + Methi (1:6)	3393	2766.5	184264	118644	2.81
S7 : Mung bean - Mustard	-	1158-2544	165440	106583	2.81
S8 : Methi – wheat	-	3892-4434	153218	82668	2.17

C.D. (P = 0.05) value for yield of castor is 235 kg

Standardization of seed viability testing through tetrazolium in oil palm (*Elaeis guineensis* L.)

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ABSTRACT

To evaluate the seed viability in the zygotic embryo of oil palm through quick test, different tetrazolium (TZ) concentrations, staining temperatures, staining timings and staining pattern were evaluated in the Dura x Pisifera (D x P) crossed seeds. The best staining was obtained with 1 % TZ solution under 30°C for 5 hours kept under complete dark. The staining pattern on the embryo indicated that the top portion towards the operculum had given proper growth in vitro. Hence, TZ staining was found suitable indicator for seed viability in oil palm seed.

Keywords: Oil palm, Seed viability, Tetrazolium

Oil palm seeds are difficult to germinate due to mechanical dormancy categorized under intermediate between recalcitrant and orthodox (Grout *et al.*, 1983). Weakening the dormancy and achieving germination takes 3-4 months. Germination or growing zygotic embryos in a wet tissue in a petri dish are the widely used testing methods (Eddy S Kelanaputra *et al.*, 2018). Hence, attempt was made with TZ test (quick test) to standardize the procedure and the staining pattern to understand the overall viability of hybridized bunch having 2000-3000 seeds.

The fruits of D x P crosses were obtained after full maturity. Fruits were processed to get the fresh seed (nut). Zygotic embryos were excised and exposed to 0.5, 0.75, 1.00, 1.25, 1.5, 1.75 and 2% concentration of Tetrazolium salt (2, 3, 5 triphenyl tetrazolium chloride: Hi media company) solution. Four replications with 25

embryos each in 8 crosses were included in the experimentation. Five incubation periods (3, 4, 5 and 6 hours) and three temperature regimes (30, 35 and 40°C) were tested. To understand the staining pattern, freshly excised zygotic embryos under laminar flow were exposed to silica gel for 5 hrs for desiccation. These embryos were cut in to 4 pieces in longitudinal and cross (top and bottom) and cultured in vitro in the modified MS medium. The result on the growth was recorded after 7 days.

Among the 7 concentrations of TZ solutions tried, proper staining started from 1% concentration onwards. Required TZ solution concentration varies with crop and species (Lamarca *et al.*, 2014). The incubation temperature of 25°C did not give any staining, however above that incubation temperature did give staining. Hence, 30°C was finalized as the required incubation

temperature for better staining. The incubation period of 5 hours gave proper staining. In the staining pattern on the embryo, though all portions responded in the media, the portion towards the operculum had given proper growth of radicle and plumule. Hence, it could be concluded that for oil palm zygotic embryo viability test, TZ solution can be used at the concentration of 1% at 0°C for 5 hours under dark condition. The embryo should have a staining pattern in the top portion facing the operculum.

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Evaluation of mutants for bold seed and high yield in niger (*Guizotia abyssinica* L.)

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ABSTRACT

Two varieties RCR 18 and DNS 17 of niger were irradiated with different doses of gamma rays viz., 150Gy, 175 Gy, 200 Gy, 225 Gy, 250 Gy and 275 Gy. The M1 generation along with control was evaluated during *rabi* 2016. The LD 50 dose was found to be 250 Gy for DNS 17 and 275 Gy for RCR 18. Mutants showed variations for plant height, number of branches/plant, number of capitula/plant in both the varieties. Control showed maximum seed weight/plant (1.7360 g) in DNS 17. But in RCR 18, mutants irradiated with 150 Gy showed maximum seed weight/plant (3.92280 g) followed by 250 Gy (3.1334 g).

Keywords: Mutants, Niger, Radiations, Seed yield

Mutants were isolated for high oleic acid and high oil yield (Aftab *et al.*, 2011) and improved oil content and early flowering (Naik and Murthy, 2009) in niger. Improvement in other characters was also reported in niger (Patil, 2006). An effort was made to study the gamma irradiated M1 generations.

The two varieties DNS 17 and RCR 18 were irradiated with different doses of gamma rays viz., 150 Gy, 175 Gy, 200 Gy, 225 Gy, 250 Gy and 275 Gy at ARS, Kalaburgi and evaluated at College of Agriculture, Raichur during *rabi* 2016 along with control. The number of plants germinated was counted and LD₅₀ dose was worked out. The observations were taken in each individual plant on plant height, number of primary branches, and number of capitula at harvest and seed weight. The individual plants were harvested separately.

The variation among the mutants was observed for all the characters studied (Table 1). The LD₅₀ dose was found to be 250 Gy for DNS 17 and 275 Gy for RCR 18. Maximum seed weight/plant was found in the control (1.7360 g) followed by 150 Gy irradiated mutants in

DNS 17, but in RCR 18 maximum seed weight/plant was found in mutants irradiated with 150 Gy (3.92280 g) followed by 250 Gy (3.1334 g). Improvement in the characters studied was observed in RCR 18 mutants. So isolation of mutants for high seed weight/plant helps in increasing the yield of niger and also contribute to more productivity.

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Table 1 Performance of mutants of DNS 17 and RCR 18 for yield and yield attributing characters in M1 generation

Treatments	No. of plants harvested	Range			Maximum seed weight (g) among mutants
		No. of capitula	Plant height (cm)	No. of branches	
Variety: DNS 17					
Control	140	3-42	17-45	2-8	1.7360
150 Gy	108	2-31	16-41	2-11	1.6794
175 Gy	91	1-27	16-42	2-7	0.6294
200 Gy	86	3-23	17-47	2-9	1.0272
225 Gy	65	2-26	18-41	2-8	0.9770
250 Gy	72	1-28	18-40	1-8	1.1256
275 Gy	46	2-28	18-41	2-9	1.3302
Variety: RCR 18					
Control	130	3-14	15-40	2-5	2.5726
150 Gy	86	3-95	16-58	2-12	3.9228
175 Gy	15	3-36	25-42	2-6	0.6579
200 Gy	109	2-49	11-60	2-11	3.1334
225 Gy	113	3-58	16-59	2-10	2.7685
250 Gy	13	2-9	17-37	2-9	2.9096
275 Gy	52	3-35	15-47	1-10	1.5724

Screening of sesame (*Sesamum indicum* L.) genotypes for leaf potassium accumulation under drought stress environments

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ABSTRACT

Sesame (*Sesamum indicum* L.) an orphaned, neglected, multipurpose oilseed crop, which is least explored for systematic research and tolerance to abiotic stresses, such as drought. Leaf K in maintaining the plant water status, stomatal regulation and plant survival when exposed to various abiotic stresses is well known. An experiment was carried out to screen 71 available genotypes for leaf K accumulation pattern. The results revealed that under water stress conditions irrespective of the genotype, leaf K content was found to increase and was highly correlated with seed yield and RWC content although there were variations among the genotypes. This suggested the possible role of K in conferring stress tolerance in sesame.

Keywords: Drought stress, K accumulation, Relative water content, Sesame

Sesame (*Sesamum indicum* L.) is one of the oldest and important oil seed crops, usually cultivated in arid and semi-arid regions of the world for its quality edible oil (Eskandari *et al.*, 2009). In India, the crop is majorly grown under rainfed conditions and there is significant impact of vagaries of monsoon on the overall productivity of crop in the sesame growing regions of the country. Among the major nutrients, potassium (K) is considered as an essential mineral element required in large quantities for optimal plant growth after nitrogen and phosphorus. Moreover, potassium is a “plant-preferred” ion for maintaining plant water status (Reddy *et al.*, 2003) and it has beneficial effect in overcoming the soil moisture stress also. Therefore, an experiment was conducted to investigate and screen the available genotypes for K accumulation pattern under water stress conditions.

An experiment was carried out with 71 genotypes (GT-10 and TKG-22 as national checks) during late rabi/summer season for two years (2018 and 2019). The genotypes were arranged in a strip plot design with three replications at ICAR-IIOR. The seed of each accession was planted in two rows (each row 4 m²) at spacing of 45 x 15 cm and standard package of practices including recommended fertilizer dose were followed to raise a healthy crop. Water stress was imposed by withholding irrigation at flowering stage (45 DAS) and moisture content of the soil was monitored with the help of soil moisture sensors (Proximal Soil Sen S; Make: IIT Bombay) on hourly basis. Data was recorded 15 days after imposing the water stress (60-65 DAS) on morphological traits (plant dry weight, leaf area and leaf dry weight), physiological traits (canopy temperature, SPAD readings and RWC content), leaf K content, yield and yield contributing parameters.

All the morphological, physiological, yield and yield attributing traits were significantly reduced in all the genotypes except SPAD and canopy temperature during both the seasons under water stress conditions. All the 71 genotypes were found to accumulate more potassium in their leaf as a stress tolerance mechanism although there were variations among the genotypes. Correlation studies showed that K content was highly correlated with most of the characters including seed yield ($p < 0.01$) during both the seasons.

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Influence of different levels of pressmud compost and fertilizer grades on growth, yield and quality of soybean (*Glycine max*)

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ABSTRACT

Pressmud, a by-product of sugar industry and is left behind as a by-product. In the present investigation, the effect of pressmud, supplemented at three different levels of fertilizers, on soybean crop was taken up through a field experiment. The results indicated that the growth, yield and quality attributes of soybean were significantly influenced by different levels of pressmud compost and fertilizer grades.

Keywords: Compost, Fertilizers, Pressmud, Soybean

Pressmud, a by-product of sugar industry and is left behind as a by-product. This byproduct when composted, it is converted into a very nutritive organic manure. Composting is the most promising technology of waste disposal, enabling recycling and solid treatment of waste organic matter (Sunil Kumar *et al.*, 2017). In the present study, the effect of pressmud on the growth parameters of soybean was studied under three fertilizer regimes.

A field experiment was conducted during *kharif* season of 2018 at the Experimental Farm, Department of Agronomy College of Agriculture, Latur to study the influence of different levels of pressmud compost and fertilizer grades on growth, yield and quality of soybean (*Glycine max*). The soil of the experimental site was medium, black in colour with good drainage. The soil was clayey in texture, low in available nitrogen, medium in available phosphorus, high in available potassium and alkaline in reaction. The experiment was laid out in Factorial Randomized Block Design with three replications and the treatments consisted of nine combinations with two factors i.e. levels of pressmud compost and fertilizer grades each tried at three levels. The levels of pressmud P1-2 t/ha, P2-3 t/ha, P3-4 t/ha and fertilizer grades F1-20:40:20 kg NPK/ha, F2-30:60:30 kg NPK/ha, F3- 40:80:40 kg NPK/ha.

The results of the field experiment indicated that the growth, yield and quality attributes of soybean were

significantly influenced by different levels of pressmud compost and fertilizer grades. The significantly higher plant height (54.58 cm), number of functional leaves/plant (18.99), number of branches/plant (7.55) were found significantly superior with pressmud @ 2 t/ha and it was at par with 3 t pressmud/ha. Whereas leaf area/plant (15.47 dm²), dry matter/plant (26.32 g), number of nodules/plant (71.20), number of pods/plant (35.62), were significantly superior than lower levels of pressmud compost. Number of seeds/plant (62.67), seed yield/plant (9.98 g), seed yield/ha (2610 kg), straw yield/ha (3439 kg), biological yield/ha (6049 kg) were significantly superior over lower levels pressmud compost. Higher protein content (40.16 %) and oil content (19.92 %) was obtained with the application of 4t pressmud/ha.

The higher values of growth yield and quality attributes of soybean were observed with the application of 40:80:40 kg NPK/ha. The significantly higher plant height (53.84 cm), number of functional leaves/plant (18.97) and number of branches/plant (7.50) than 20:40:20 kg NPK/ha and on par with 30:60:30 kg NPK/ha. However leaf area/plant (13.90 dm²), dry matter/plant (24.19 g) and number of pods/plant (35.04) were significantly superior over lower grades of fertilizer. Number of seeds/plant (60.11), seed yield/plant (9.04 g), pod yield/plant (10.37 g), seed yield/ha (2111 kg), straw yield/ha (3110 kg) and

biological yield/ha (5221 kg) were found significantly superior over lower levels of fertilizer grades. Maximum protein content (39.86 %) and oil content (19.82%) observed with the application of 40:80:40 kg NPK/ha.

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Selective mechanization-A way forward in augmenting the productivity and profitability of safflower (*Carthamus tinctorius* L.)

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ABSTRACT

An experiment was taken up to study the influence of mechanization of critical tasks like sowing, inter cultivation harvesting and shelling on throughput and economics of safflower cultivation under medium black soil and under both conservative and mechanized methods. Results indicated that the performance of Safflower in selective mechanization plot registered significantly higher growth and yield attributing characters resulting in significantly higher seed yield (1333 kg/ha), net returns (₹33539/ha) and B:C ratio (4.01). Selective mechanization produced nearly 14.7% higher seed yield over traditional cultivation (normal plot). Higher energy output (20764 MJ/ha), net energy returns (15423 MJ/ha) and energy use efficiency (3.89) as compared to traditional normal pot (17713 MJ/h; 10220; 2.36). Selective mechanization helped to save 121.25 hrs time period and 80 labour and thus reduced the cost of cultivation by ₹ 4417/ha and increased the net returns by ₹14355/ha as compared to normal (traditional) plot.

Keywords: Augmenting, Increased profitability, Labour saving, Mechanization, Safflower

Effective use of agriculture machinery helps to increase productivity and production of output, undertake timely farm operations. This judicious use of time, labour and resources facilitates sustainable intensification and timely planting of crops, leading to an increase in productivity. Hence, mechanical power has become more economical and indispensable to meet targets of timeliness and efficient utilization of natural resources and inputs (Srinivasarao *et al.*, 2013). To study the influence of selective mechanization on productivity and economics of safflower production, AICRP on Safflower, an experiment was carried out at ARS, Tandur.

Field experiments were carried out during *rabi* 2018-19 Various farm implements used are shown in Table 1. Safflower variety PBNS-12 was sown at spacing of 45 cm (between rows) x 20 cm (between plants) and common fertilizer dose of 40 kg N, 25 kg P₂O₅/ha was applied. The data on growth and yield parameters were analysed with paired 't' test and cost of cultivation, net returns, B:C ratio were worked out. Data on time period for each operation, labour used (number) for each operation, energy used, were converted into suitable energy units and expressed in MJ/ha. Energy equivalents of inputs and outputs were computed based on values suggested by Gopalan *et al.* (1978). The calculation of energy input and output equivalents, the indices of energy ratio (energy use efficiency), energy

productivity and net energy were calculated (Rafiee *et al.*, 2010) as follows:

$$\text{Energy ratio} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

$$\text{Energy productivity} = \frac{\text{Safflower yield (kg/ha)}}{\text{Energy input (MJ/ha)}}$$

$$\text{Net energy} = \text{Energy output (MJ/ha)} - \text{Energy input (MJ/ha)}$$

The analysis of the data showed that performance of safflower in selective mechanization treatment recorded significantly higher growth and yield attributes, and resulted in 14.7% increased seed yield (1333 kg/ha), compared to normal plot (1037 kg/ha) (Table 2). The higher yield parameters in selective mechanized plot might be due to better aeration provided to the root zone by pulverizing and fine tilling of soil by weeder that favoured new root growth, which might have favoured better root proliferation leading to better nutrient utilization, leading to the higher growth parameters that favoured increased light interception by the canopy. Further, the cost of cultivation incurred for normal method of cultivation was higher (₹ 15,551) compared to mechanized safflower cultivation (₹ 11,134) leading to higher net returns (₹ 33,539) and B:C ratio (4.01) in

mechanized plot (Table 3). Comparing the yield and economics of cultivation methods, mechanized plot reduced the labour requirement, time of operation and cultivation cost in turn resulted higher benefits. Similarly, in Palem also higher net returns (₹ 67710) and B:C ratio (3.6) were observed in mechanized plot. The energy use efficiency in mechanized plot (0.26 kg/MJ) was higher than normal plot (0.16 kg/MJ). This lead to saving of 80 labour / ha and saved 121.25 hrs time period/ha through selective mechanization of important operations. The results were in agreement with the findings of Saeed Firouzi and Hashem Aminpanah (2012) who reported that Energyoutput-input ratio, specific energy, energy productivity, and net energy gain computed were 3.93, 4.74 MJ/kg, in semi-mechanized groundnut production.

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Table 1 Various farm implements used in safflower

Operation	Selective Mechanized Plot	Normal plot
Land preparation	Mould board plough, rotovator	Bullock drawn implements
Sowing	Broad bed maker cum seeder	Behind the bullock drawn plough
Inter culturing	manual weeder	Normal intercultivation
Need based plant protection	Motorized/power sprayers	Knapsack sprayer
Harvesting	Paddy combined Harvester	Manual
Post-harvest	--	Manual

Table 2 Performance of safflower in terms of growth and yield as influenced by selective mechanization *vis-à-vis* traditional method

Treatment	Plant height (cm)	Number of primary branches/plant	Number of capitula/plant	Number of filled seeds/Capitula	100 seed weight	Seed yield (kg/ha)	Biological yield (kg/ha)
SMP	118.9	8.7	19.9	23.6	6.38	1333	4926
TP	97.00	7.0	16.6	16.8	5.31	1037	4352
SEd	1.344	0.181	0.315	0.443	0.016	21.146	45.39
t-test	12.48	6.98	7.28	11.58	36.30	10.69	10.21

SMP: Selective mechanization plot TP: Traditional plot

Table 3 Performance of safflower as influenced by selective mechanization *vis-à-vis* traditional method

Treatment	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
SMP	44673	33539	4.01
TP	34735	19184	2.23
SEd	708.4	7.8.4	0.063
t-test	10.69	15.45	23.89

SMP: Selective mechanization plot TP: Traditional plot

Response of mustard (*Brassica juncea* L.) varieties to different levels of plant spacings and fertilizer

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ABSTRACT

Plant height, number of branches/plant, siliqua/plant, yield/plant and seed yield were not significantly influenced by the spacing. Variety TAM-108-1 recorded significantly higher siliqua/plant, seed yield/plant and seed yield than ACN-9. 150% RDF resulted in significant higher seed yield.

Keywords: Fertilizer levels, Mustard, Spacing, Varieties

Mustard fits well as second crop in *rabi* after soybean. Therefore, developing high yielding varieties for this region is important and development of agro-techniques for improved varieties is imperative.

The Field experiment was conducted during the *rabi* season of 2016-17 at College of Agriculture, Nagpur. The soil of the experimental field was medium black and clayey in texture. Experiment was laid out in factorial randomized block design with three replications and the factors consisted of three spacings, two varieties and three fertilizer levels. Details are given in Table 1. Recommended dose of fertilizer was 50:40:0 N:P₂O₅:K₂O kg/ha.

The plant height and number of branches/plant were not significantly influenced by spacing, varieties and fertilizer levels. Seed yield was not significantly influenced by the spacing. These results are in conformity with the findings of Singh *et al.* (2016). The variety TAM-108-1 recorded significantly higher number of siliqua/plant, seed yield/plant, seed yield,

gross returns and net returns than CAN-9. Similar findings were also reported by Yadav *et al.* (2018). Application of 150% RD recorded significantly higher number of siliqua/plant, seed yield/plant and seed yield. Similar trend was noticed with respect to returns as reported by Sarma and Das (2017).

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Table 1 Performance of mustards varieties at different levels of spacing and fertilizer

Treatments	Plant height (cm)	No. of branches/plant	No. of siliqua/plant	Seed yield (g/plant)	Seed yield (kg/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Plant spacing (cm)								
30 x10	159.8	3.48	61.1	2.20	727	26899	15245	2.30
30x20	158.4	3.89	89.5	4.63	764	28269	16739	2.45
45 x10	158.1	4.06	81.4	3.42	760	28103	16533	2.43
SEm±	2.1	0.18	3.6	0.09	21	772	772	
CD(P=0.05)	NS	NS	10.2	0.27	NS	NS	NS	
Varieties								
ACN-9	159.3	3.70	70.2	3.14	696	25734	14149	2.22
TAM-108-1	158.2	3.92	84.4	3.70	805	29780	18195	2.56
SEm±	1.7	0.14	2.9	0.08	17	630	630	
CD(P=0.05)	NS	NS	8.3	0.22	49	1811	1811	
Fertilizer levels								
100% RDF	158.3	3.59	64.5	2.98	653	24160	13213	2.21
125% RDF	159.1	4.06	78.1	3.46	759	28094	16510	2.43
150% RDF	158.9	3.78	89.4	3.81	838	31016	18794	2.54
SEm±	2.1	0.18	3.6	0.09	21	772	772	
CD(P=0.05)	NS	NS	10.2	0.27	60	2217	2217	

Effect of different sources of phosphorus and sulphur on kharif groundnut (*Arachis hypogaea* L.)

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ABSTRACT

Significantly higher growth characters, yield attributes and seed yield were obtained due to 50 kg phosphorus supplied in the form of SSP + 5 t/ha FYM than 50 kg phosphorus supplied as DAP + 5 t/ha FYM.

Keywords: Groundnut, Phosphorus, Sulphur, Treatment

A field experiment was conducted during kharif 2018 at Experiment Farm, Agronomy Section, Oilseeds Research Station, Latur. The soil was clayey in texture, low in available N (189.92 kg/ha), medium in phosphorus (21.18 kg/ha), medium in potassium (280.16 kg/ha) and slightly alkaline in reaction (8.04 pH). The experiment was laid out in randomized block design with 7 treatments replicated thrice. The treatment details were given in Table 1. FYM was applied before sowing as per treatments.

Treatment T2 produced significantly greater plant height, dry weight, leaf area/plant and no. of branches/plant which was on par with T3 and T4. Similar result reported by Singh *et al.* (2014). Treatment T2 recorded significantly highest number of pods/plant, dry weight of pods/plant, seed yield/plant and seed yield over rest of the treatments. T1 recorded significantly lowest number of pods/plant, dry weight of pods/plant, seed yield/plant and seed yield. T2 recorded higher pod and seed yield/plant followed by T3. Higher level of these parameters could be attributed due to better uptake and translocation of plant nutrients to growing plants,

adequate supply of nutrients resulted in higher production of photosynthate and their translocation to sink, which ultimately increased the plant growth and yield attributes. These results are in conformity with the results Panwar and Singh (2003) and Singh *et al.* (2014).

It can be concluded that among various sources of phosphorus and sulphur fertilizer application 50 kg phosphorus through SSP + 5 t/ha FYM recorded greater seed yield than other treatments.

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Table 1 Effect of phosphorus and sulphur on groundnut

Treatments	Plant height (cm)	No. of branches/plant	Leaf area (dm ² /plant)	Dry weight (g/plant)	Number of pods/plant	Pod dry weight (g/plant)	Seed weight (g/plant)	Pod yield (kg/ha)
Control	24.4	5.4	3.13	21.0	13.7	6.55	4.43	1205
50 kg P through SSP + 5 t/ha FYM	33.0	7.2	4.37	33.0	22.7	11.69	9.03	2350
50 kg P through DAP + 5 t/ha FYM	31.4	6.3	4.31	29.6	21.0	10.71	8.27	2052
RDF + 20 kg S through gypsum	29.8	6.2	4.14	28.0	19.2	8.50	6.55	1937
RDF + 20 kg S through elemental sulphur	28.6	6.0	3.82	27.8	18.7	8.17	6.06	1820
RDF + 20 kg S through ZnSO ₄	28.0	5.8	3.78	27.4	18.2	7.49	5.80	1710
RDF + 20 kg S through FeSO ₄	27.5	5.5	3.27	24.3	17.2	7.17	4.83	1648
SE±	1.36	0.33	0.25	1.45	1.18	0.33	0.35	111
C.D (P=0.05)	4.20	1.0	0.76	4.5	3.7	1.01	1.08	341

Impact of foliar spray of nutrients seed yield and economics of soybean (*Glycine max* L. Merrill)

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ABSTRACT

Soybean yield was significantly influenced by the foliar spray of nutrients and highest yield was recorded with RDF+19-19-19 (NPK) @ 2% foliar spray at pod initiation stage (3132 kg/ha) which was on par with RDF+DAP @ 2% foliar spray (2976 kg/ha). But, highest net returns and B:C ratio was recorded with RDF+urea @ 2%.

Keywords: Foliar spray, Molybdenum, Seed yield, Soybean

Under rainfed condition when the availability of soil moisture becomes scarce, the application of fertilizers as foliar spray results in efficient absorption and usage which are economical in respect of the other methods. This is one of the fastest ways to boost up crop growth as it facilitates the nutrient availability during pod filling stage. In view of that, the present field experiment was carried out to understand the influence of foliar spray of nutrients on seed yield and economics in soybean.

A field trial was carried out during kharif seasons of 2016-18 with cultivar variety JS-335 at ARS, Adilabad, PJTSAU. The soil of the experimental field was Vertisols, medium in organic carbon 0.64%, available N (182.9 kg/ha), available P (88.9 kg/ha) and available K (226.3 kg/ha). The experiment was laid out in a RBD with 3 replications. Treatment details are given in Table 1. The RDF (50:60:40 N:P₂O₅:K₂O kg/ha) was applied as basal. The standard agronomic practices and plant protection measures were followed.

Application of RDF+19:19:19 (NPK) @ 2% at pod initiation stage recorded maximum seed yield (3132 kg/ha) and comparable with RDF+DAP @ 2% (2976 kg/ha) and RDF + urea @ 2% (2803 kg/ha) but significantly higher than RDF only (Table 1). Similar

results of increased haulm yield was reported by Bharamaraj *et al.* (2017).

Application of RDF+19:19:19 (NPK) @ 2% spray at pod initiation stages of crop growth recorded higher gross returns (₹95,516/ha), net returns (₹ 67,866/ha) and B:C ratio (2.46) and at par with RDF+DAP @ 2% (₹90,768/ha, ₹ 63,855/ha and 2.41). Similar results were reported earlier by Meena *et al.* (2018). The results of three years investigation revealed that foliar application of either 19:19:19 (NPK) @ 2% or DAP @ 2% at pod initiation stage of crop growth (R₃ stage) in addition to RDF recorded improved yield and economic returns in soybean.

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Table 1 Effect of foliar spray of nutrients on the yield and economics of soybean (pooled mean of 3 years)

Treatments	Seed yield (kg/ha)	Haulm yield (kg/ha)	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
RDF + water spray	2559	4355	24667	78039	53373	2.16
RDF + urea 2%	2803	4521	26025	85481	59456	2.30
RDF + diammonium phosphate 2%	2976	4668	26913	90768	63855	2.41
RDF + muriate of potash 0.5%	2612	4433	25680	79676	53996	2.11
RDF + 19:19:19 (NPK) 2%	3132	4829	27850	95516	67866	2.46
RDF + molybdenum 0.5%	2553	4354	26039	77867	51828	2.00
RDF + boron 0.5%	2607	4437	25492	79514	54022	2.12
RDF + zinc chelated 0.5%	2752	4575	25700	83936	58236	2.28
RDF only	2475	3925	23383	75488	52104	2.24
SEm±	169.7	213.7	938.8	5175	5500	0.3
CD (P=0.05)	359.8	453.0	1990.3	10792	NS	NS

*foliar spray at pod initiation stage

Effect of seed priming on germination and seed yield of safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Twelve treatment combinations with four varieties (Sharda, PBNS-12, PBNS-40 and NARI-6) and three seed priming treatments (hydro-priming, osmo-priming and matri-priming) were laid out in FRBD. Osmo-priming exhibited highest germination percentage at field and laboratory condition with better plant stand in field. Osmo-priming also exhibited highest seed yield as compared to hydro-priming and matri-priming. The variety, PBNS-12 showed highest germination percentage in field and laboratory condition as compared to Sharda, PBNS-40 and NARI-6.

Keywords: Germination, Priming method, Safflower, Seed yield

Seed priming is an efficient method for increasing seed vigour and improvement of germination percentage and seedling growth. Priming is simply a process done prior to conventional seed germination which allows the inhibiting mechanism to be broken and the metabolic speed increases. Seed priming reduces emergence time, boost germination percentage and favours synchronized emergence which might have great influence on weed suppression, plant stand and yield.

The present investigation was undertaken at AICRP on Safflower, VNMKV, Parbhani during the year *rabi* 2018. Treatments included four varieties (Sharda, PBNS-12, NARI-6, PBNS-40) and three seed priming treatments *viz.*, hydro-priming (seeds were soaked in distilled water for 24 hrs), osmo-priming (seeds were soaked in solution of 0.5% KNO₃ and 0.1% NaCl for 12 hrs) and matri-priming (seeds were soaked in between two layers of saturated gunny bags at 27°C for 24 hrs and 48 hrs. Experiment was laid out in FRBD with three replications. The statistical analysis of data was carried out as per the standard method.

Seed germination percentage was affected significantly due to different varieties used in seed priming. The variety, PBNS-12 showed highest germination percentage and plant stand in field after 20 days of sowing and at harvest; and also in laboratory condition as compared to Sharda, PBNS-40 and NARI-6.

Osmo-priming exhibited highest germination percentage than hydro-priming and matri-priming at field and laboratory condition. These increased yield level might be due to increase in field stand and test weight of seed. Mewael Assefa and Ravi Hanje (2010) observed that osmo-priming with GA₃ improves emergence, seed yield and quality of soybean seed. Similar results were noted by Goudarz Ahmadvand *et al.* (2012) in soybean crop. Interaction effects among priming methods and varieties were non-significant. PBNS-12 exhibited highest seed yield than Sharda, PBNS-40 and NARI-6.

To conclude, osmo-priming could be successfully used for improvement of seed vigour, germination and crop stand in safflower to achieve higher plant stand in field condition.

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Impact of change in weather on seed and oil yield of niger [*Guizotia abyssinica* (L.f.) Cass.]

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ABSTRACT

Crop grown in medium annual rainfall ranging from 665-1495 mm produced high seed yield while lower and higher rainfall yielded low seed yield. Oil content in seed did not differ with low, medium and high amount of

rainfall conditions. Medium rainfall in medium time duration is most favorable for niger production while heavy rains in long period is unfavorable.

Keywords: Climate change, Mechanism, Niger, Seed yield, Stress

Climate change affects the growth of crops both positively and negatively through multiple mechanisms, including changing phenology, heat stress, water stress, water logging and increase or reduction in pests and diseases. The impact of climate change is not only on yield but quality also.

Five niger cultivars (JNS-528, JNS-206, JNS-204, JNS-519 and JNS-9) developed by AICRP on niger, JNKVV, Zonal Agricultural Research Station, Chhindwara were tested in AICRP trials in 2014. The tested centres were Chhindwara, Igatpuri, Kanke, Semiliguda, Dharwad, Raichur which had great climate diversity. The rainfall ranged between 316.5 to 1495 mm, rainy days from 44 to 85 and temperature

maximum from 28 to 31.4°C while the minimum ranged between 16.2 to 22.3°C.

The seed yield ranged between 139 (Igatpuri) and 1250 kg/ha (Kanke). The Igatpuri center which recorded lowest yield was having 344.9 mm rainfall along with 85 rainy days and medium temperature 20.1 to 29.7°C. There was water logged condition during the crop season. The rain was continuous at flowering time which also reduced the seed yield of niger crop.

Semiliguda and Chhindwara center yielded higher production (665 and 655 kg) which exhibited rainfall 1494.9 and 665 mm respectively. No trend was found between oil percentage and weather change.

Table 1 Performance of niger in different centres

Cultivars	Chhindwara	Dharwad	Igatpuri	Kanke	Raichur	Semilighuda
Seed yield (kg/ha)						
JNS-528	655	384	139	1250	197	666
JNS-206	724	530	185	903	222	646
JNS-204	591	338	179	1215	241	723
JNS-519	603	386	174	1308	213	689
JNS-9	685	443	261	1273	223	719
Mean	652	416	188	1190	219	689
Oil content (%)						
JNS-528	24.65	24.47	39.40	39.06	39.63	32.50
JNS-206	39.09	30.70	38.51	41.25	31.21	31.90
JNS-204	30.89	32.20	42.54	36.82	42.23	33.92
JNS-519	43.56	41.45	33.37	32.53	38.28	42.42
JNS-9	30.03	41.42	33.56	42.67	33.75	41.64
Mean	33.64	34.05	37.48	38.47	37.02	36.48
Weather data						
Rainfall (mm)	665.0	852.4	3449.9	678.2	316.5	1494.9
No. of rainy days	44.0	62.0	85.0	54.0	-	76.0
Maximum temperature (°C)	32.4	30.2	29.7	-	31.3	28.4
Minimum temperature (°C)	22.3	20.0	20.1	-	20.2	16.2

Seed priming for long-term storage of sesame (*Sesamum indicum* L.)

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ABSTRACT

Mid-storage seed (4-5 months old) of five sesame genotypes *viz.*, SI-70, NIC-8316, B-9, B-14 and Saheb were subjected to invigoration treatments, both dry and wet. Dry seed treatments included aspirin, bleaching powder and red chilli powder, whereas soaking-drying was taken as a wet treatment. Both treated and non-treated seeds of five genotypes were subjected to accelerated ageing for 9 days to evaluate seed vigour and biochemical parameters like oil and protein (both crude and soluble) content as well fatty acid compositions. Treated seeds along with control were also grown in the field to study the effect of seed invigoration treatments on crop growth and yield under field conditions. A consistent beneficial response of wet treatment, soaking-drying, was recorded with regard to vigour, viability, quality and productivity, but the response varied differently in different genotypes. Among dry treatments, bleaching powder and red chilli powder appeared to be very effective to reduce the loss of vigour and viability. Accelerated ageing caused a consistent reduction in germination percentage and seedling vigour of all genotypes. Reduction in oil and protein percentage was also recorded due to accelerated ageing. But reduction percentage was higher in artificially aged control seeds as compared to soaking-drying treated seeds. Therefore, priming with mid-storage wet treatment, soaking-drying, as well dry treatments like bleaching powder and red chilli powder may be suggested for improvement of germinability and field performance and there by ideal for long term storage of sesame seed.

Keywords: Seed priming, Storage, Treatments

The maintenance of quality seeds would be of great practical importance to raise the productivity ceiling in any crop. This becomes increasingly important for the high oil yielding crops like sesame, which suffers relatively fast deterioration in seed health, which adds new dimension to the existing complex problem of its poor performance (Mandal *et al.*, 1999 and 2000). In West Bengal, sesame seeds are harvested in the month of May and then stored under ambient conditions in previously moistured containers which would show a rapid fall in germinability and by sowing time in next year February, the viability may go down to half or even less. Hence, it is imperative to develop a simple and inexpensive method of seed preservation which would enable farmers to maintain vigour, viability and productivity of stored sesame seeds. Thus the present study aimed to assess the effect of seed invigoration treatments on germination and seedling vigour as well as on ageing at laboratory condition.

Mid-storage seed (4 to 5 months old) of five popular sesame genotypes *viz.*, B 9, B 14, NIC 8316, Saheb and SI 70 comprised the experimental material. Seed invigoration treatments included one wet treatment *viz.*, soaking-drying and three dry treatments *viz.*, aspirin, bleaching powder and red chilli powder. Seed treatments were applied following the method of Basu (1976) with minor modifications. To evaluate the efficacy of mid-storage dry and wet treatments, seeds were subjected to accelerated ageing at 98% R.H and 40°C for 9 days. The treated and untreated (control) seeds were sown in the laboratory following CRD. Germination and vigour test were conducted following ISTA rules. In the field split plot design was followed with five genotypes in the main plot and five treatments *i.e.*, control, aspirin, bleaching, red chilli powder and soaking-drying in the sub plot. Biochemical studies were carried out to elucidate the effect of accelerated ageing and invigoration treatment followed by accelerated ageing on different genotypes (Fig. 1).

In laboratory overall treatment effect was more beneficial for wet treatment *i.e.* soaking-drying in maintaining germination and seedling vigour of seed especially under artificial ageing condition albeit the response varied differently in different genotypes. Dry seed treatments *i.e.* bleaching powder and red chilli powder also showed better effect in germination percentage and seedling vigour especially under artificial ageing condition. In field condition all genotypes performed very well under soaking-drying treatment with regard to productivity. The genotype, B 9 appeared to be the best when averaged over all treatments.

Biochemical studies evinced reduction in oil percentage and protein (both crude and soluble) content due to accelerated ageing. But the reduction percentage was higher in case of artificially aged control seeds as compared to soaking-drying treated seeds. Treatments also caused percentage change in various fatty acid components.

Therefore, it could be affirmed that seed priming with mid-storage wet treatment, soaking-drying, as well dry treatments like bleaching powder and red chilli powder may be suggested for long term storage of sesame seed to maintain vigour, viability, productivity as well oil and protein (both crude and soluble) content.

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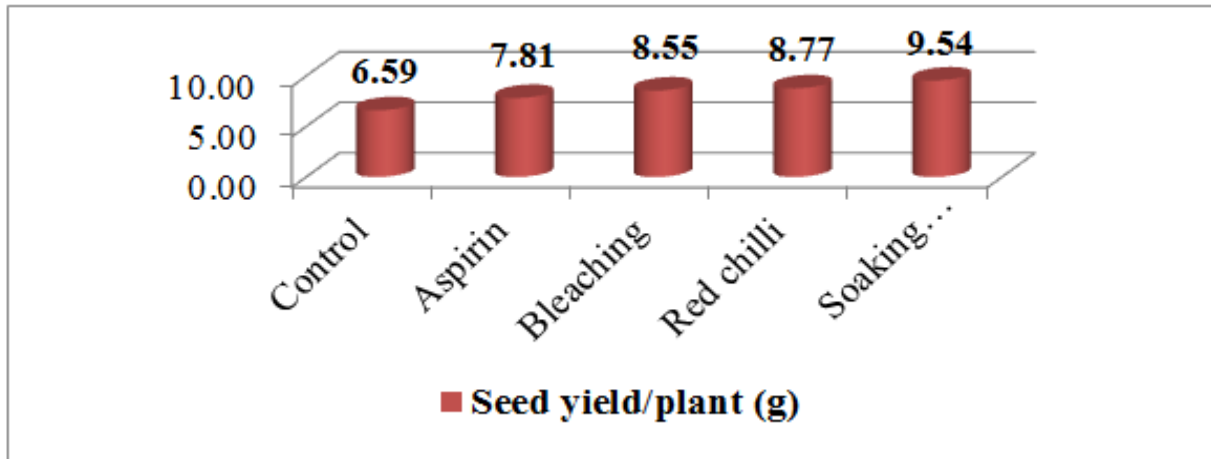
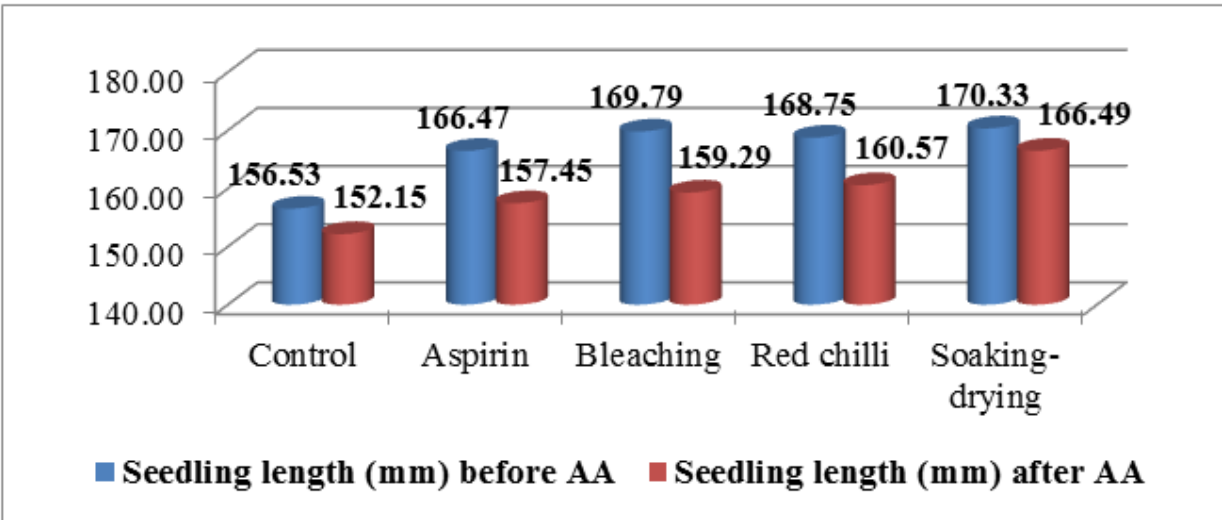
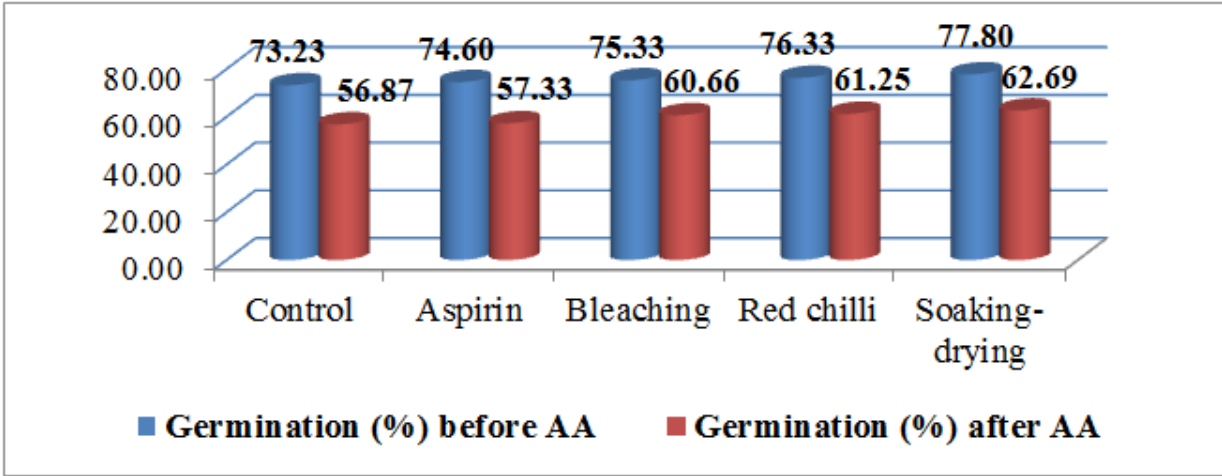


Fig. 1. Average effect of dry and wet treatments on germinability, seedling length before and after accelerated ageing (AA) and seed yield/plant of mid-storage seeds of five sesame genotypes

Comparison of screening methods for evaluating leafhopper (*Empoasca flavescens*) resistance in castor

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ABSTRACT

Leafhopper (*Empoasca flavescens*) is the most important sucking pest of castor during both *kharif* and *rabi* seasons causing severe hopper burn resulting in poor formation of capsules. Breeding for leafhopper resistance is a practical means of controlling this pest in castor. An accurate and simple evaluation method is crucial for identifying leafhopper resistance in castor breeding. In the present study, two screening methods were evaluated for their effectiveness in discriminating different characteristics of resistance/susceptibility in castor genotypes. The results revealed that screening method, adjusting sowing time during second fortnight of October and planting of infester rows (one infester row after 2 rows of test entries) can be used as reliable and cost effective method for mass screening of castor genotypes for resistance to leafhopper.

Keywords: Castor, Host plant resistance, Leafhopper, Screening method

Though castor productivity in India is more than the world average, there are several production constraints. Leafhopper, *Empoasca flavescens* F. (Cicadellidae: Homoptera) is the most important sucking pest of castor during both *kharif* and *rabi* seasons and an upsurge of the pest has been noticed in recent years (Duraimurugan and Alivelu, 2017). The nymphs and adults suck the sap from leaves and cause phytotoxic hopper burn symptoms which results in complete drying of plants (Lakshminarayana and Duraimurugan, 2014). Host-plant resistance is the most reliable, economically feasible and eco-friendly measure to control leafhopper (Anjani *et al.*, 2018). In finding and characterizing castor genotypes resistant to the leafhopper, the screening procedure is of primary importance. In the present study two screening methods were evaluated for their effectiveness in discriminating different characteristics of resistance/susceptibility in castor genotypes.

Two methods for screening castor genotypes for resistance to leafhopper under field conditions were compared: (i) Adjusting sowing time during second fortnight of October + planting infester rows (one infester row, DPC-9 after 2 rows of test entries); (ii) Adjusting sowing time during second fortnight of October + planting infester rows (one infester row, DPC-9 after 2 rows of test entries) + releasing of leafhoppers (raising of susceptible plants DPC-9 at 15 days before sowing of test entries, removal of plants after insect infestation and releasing on test entries). The effectiveness of the methods was compared in their capacity to differentiate levels of resistance/susceptibility to leafhopper in 14 castor genotypes using strip plot design. Leafhopper count was recorded from three leaves per plant on five randomly selected plants in each entry at regular intervals. The leaves were selected as one from top (excluding two topmost leaves), middle (medium matured leaves) and bottom (leaving two

bottom most leaves) on the main shoot. The hopper burn injury was recorded in 0-4 scale (Anjani *et al.*, 2018).

Results indicated that adjusting sowing time during second fortnight of October + planting infester rows + releasing of leafhoppers significantly increased population in susceptible genotypes (up to 376 leafhoppers/3 leaves/plant) as compared to screening method with adjusting sowing time during second fortnight of October + planting infester rows (up to 272.5 leafhoppers/3 leaves/plant), while there was no significant difference was observed among resistant genotypes in both the methods (1.5 to 84 leafhoppers/3 leaves/plant and 1.0 to 68 leafhoppers/3 leaves/plant, respectively). Expression of hopper burn among resistant (hopper burn grade 1 on 0 to 4 scale) and susceptible (hopper burn grade 4 on 0 to 4 scale) genotypes was similar in both the methods and was found statistically on par with each other. Hence, screening method *viz.*, adjusting sowing time during second fortnight of October + planting infester rows can be used as reliable and cost effective method for mass screening of castor genotypes for resistance to leafhopper.

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Efficacy of insecticides against groundnut defoliators, *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (F.)

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ABSTRACT

Among insect pests, lepidopteron defoliators viz., *Helicoverpa armigera* and *Spodoptera litura* are the most serious problems in groundnut crop. The present study was undertaken to test the effectiveness of some newer molecules against these pests in groundnut. Looking to the efficacy, yield and economics of the treatments indoxacarb 14.5% SC 0.007%, chlorantraniliprole 18.5 SC 0.006% and spinosad 45 SC 0.014% were the most effective and economic insecticides for the management of *H. armigera* and *S. litura* in groundnut.

Keywords: Efficacy, Groundnut, *Helicoverpa armigera*, Newer insecticides, *Spodoptera litura*

A comprehensive list of insect and non-insect pests of groundnut was given by Nandagopal and Prasad (2004). Among all insect pests, lepidopteron defoliators i.e., *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (F.) were the most serious problems in groundnut crop. Flowering stage infestation can result in 20 per cent and severe outbreak can cause 30 to 40 per cent yield loss in groundnut due to *S. litura* (Kulkarni, 1989). Crop failures due to *S. litura* were reported when despite intensive pest management practices (Wightman and Ranga Rao, 1993). It is known that these lepidopteron defoliators show certain levels of behavioural resistance to different class of insecticides making it difficult to manage these pests. Keeping this in view, the present study was undertaken to test the effectiveness of some newer molecules against these pests in groundnut.

The experiment was carried out at Entomology farm, Junagadh Agricultural University, Junagadh in randomized block design with three replications during *khari* 2016-17 and 2017-18. Insecticides, thiodicarb, chlorantraniliprole, spinosad, emamectin benzoate and indoxacarb, were tried for their efficacy. Three sprayings of respective insecticides was done at 15 day intervals. The first spraying of insecticides was done, when the larval population of *H. armigera* reached four larva and *S. litura* 1 egg mass or gregarious 1st instar larvae per 20 plants. The observations on number of *H. armigera* as well as *S. litura* larvae were recorded from randomly selected five plants from each net plot at 24 hours before spraying and after 3, 10 and 15 days of spraying. Statistical analysis of all the recorded data were subjected to analysis of variance in randomized block design with the procedure followed by Steel and Torrie (1980). The pods and haulm were weighed treatment-wise from each net plot area. The avoidable losses due to *H. armigera* and *S. litura* was calculated with the help of formula described by Poul (1976). The economics of each synthetic insecticides was calculated.

Pooled data of the year 2016-17 and 2017-18 showed that the damage of *H. armigera* and *S. litura* significantly differed in all the treatments over control. However, the lowest (0.78 larvae/five plant) larvae of *H. armigera* was recorded in the treatment of indoxacarb 14.5% SC 0.007%, while it was at par with the treatments of chlorantraniliprole 18.5 SC 0.006% (0.86 larvae/five plant) and spinosad 45 SC 0.014% (0.88 larvae/five plant) after three days of spray. The next better treatments were emamectin benzoate 5 WG 0.003% (0.98 larvae/five plant) and thiodicarb 75 WP 0.150% (1.18 larvae/five plant) after three days of spray. More or less similar trend was observed after 10 and 15 days of first spray as well as 3, 10 and 15 days after second and third spray.

The lowest (0.23 larvae/five plant) larvae of *S. litura* was recorded in the treatment of indoxacarb 14.5% SC 0.007%, while it was at par with the treatments of chlorantraniliprole 18.5 SC 0.006% (0.25 larvae/five plant) and spinosad 45 SC 0.014% (0.24 larvae/five plant) after three days of spray. Similar trend was observed after 10 and 15 days of first spray as well as 3, 10 and 15 days after second and third spray.

Pooled data of the year 2016-17 and 2017-18 showed the lowest per cent leaf damage by *H. armigera* (7.86%) was recorded in the treatment of indoxacarb 14.5% SC 0.007%, while it was at par with the treatments of chlorantraniliprole 18.5 SC 0.006% (9.49%) and spinosad 45 SC 0.014% (10.11%). The lowest per cent leaf damage by *S. litura* (7.36%) was recorded in the treatment of indoxacarb 14.5% SC 0.007%, while it was at par with the treatments of chlorantraniliprole 18.5 SC 0.006% (8.46%) and spinosad 45 SC 0.014% (9.16%). Looking to the efficacy, yield and economics of the treatments indoxacarb 14.5% SC 0.007%, chlorantraniliprole 18.5 SC 0.006% and spinosad 45 SC 0.014% were found to be the most effective and economic insecticides for the management of *H. armigera* and *S. litura* in groundnut.

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Population dynamics of major insect pests and natural enemies of sunflower

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ABSTRACT

A field study was carried out during 2018-19 to evaluate the population fluctuation of insect pests and their natural enemies in sunflower ecosystem. The data revealed that thrips and lepidopteran pests viz., head borer, *Helicoverpa armigera* and defoliator pests such as *Spodoptera litura* and *Spilarctia obliqua* were found to be the major insect pests during *kharif* season. Whereas, the sucking pests viz., leafhopper and whiteflies were found to be the major insect pests during *rabi* season. Among natural enemies, lady beetles, *Chrysoperla* and spiders were found to be the major predators throughout the crop season.

Keywords: Insect pests, Natural enemies, Population dynamics, Sunflower

Different insect pests cause various level of damage to the sunflower crop in different regions of Karnataka (Basappa and Santhalakshmi Prasad, 2005). The present study was designed to determine the relationship between insect pests and their predators along with their peak population period. The study was also aimed to find out the effect of abiotic factors on population fluctuation of insect pests.

Sunflower, hybrid KBSH-44, was sown at the farms of Main Agricultural research Station, UAS, Raichur, during 2018-19 with three replications. After fifteen days of germinations, data for the insect pests and predators were recorded on weekly basis till harvest of the crop. Sucking insect pests such as thrips, whitefly and leafhoppers, were recorded from top, middle and lower leaves of the plants. Total of 50 plants were observed. Chewing insect pests such as head borer and *Spodoptera* were recorded on whole plant basis. All natural enemies were recorded on whole plant basis.

Observations were recorded on the untreated crop (Hybrid KBSH-44) starting from 27th August 2018 to 22nd October, 2018 for the *kharif* season. The population of thrips was very high (15.10/6 leaves/plant) during 37th standard week and decreased thereafter. The population of whiteflies was very low and leafhopper population was on increasing trend upto 39th Standard week and decreased thereafter. Defoliation due *Spodoptera* increased from October with defoliation percentage up to 30 per cent. Head borer population ranged between 0.00-0.24 larvae per plant. *Spodoptera* population was moderate with population ranging between 0.00-0.20 larvae per plant. The population of natural enemies viz.,

coccinellids, *Chrysoperla* and spiders ranged between 0.00-0.18, 0.00-0.32 and 0.00-0.08, respectively.

During *rabi* season, observations were recorded on the untreated crop (Hybrid KBSH-44) starting from 48th standard week. The population of thrips was negligible ranging from 0.02 to 0.06 per 6 leaves/plant. The population of leafhopper was moderate (2.12 to 11.68 per 6 leaves/plant) and maximum population was recorded from 52nd to 3rd standard week. Whitefly population was on increasing trend upto 1st standard week and decreased thereafter and recorded population was in the range of 0.64 to 20.02 whiteflies per 6 leaves/plant. Incidence of defoliators and head borer was nil. The population of natural enemies viz., coccinellids, *Chrysoperla* and spiders ranged between 0.00-0.12, 0.00-0.02 and 0.02-0.20, respectively.

Thrips population was positively correlated with maximum temperature and negatively correlated with rainfall, minimum temperature, rainy days morning and evening relative humidity and it was non-significant. Positive and significant correlation was found between leafhopper population and rainfall. Whereas, positive and non-significant correlation was found between leafhopper population and minimum temperature, morning and evening relative humidity. Negative correlation was between leafhopper population and maximum temperature and rainy days. Whitefly population found to have positive non-significant relation with, maximum temperature. Whereas, the relation with rainy days, rainfall, minimum temperature, morning and evening relative humidity was negative and non-significant. Head borer population was found to have negative and non-significant relation with rainfall,

rainy days, morning and evening relative humidity and positive non-significant relation with maximum and minimum temperature. *Spodoptera* population was found to have negative and non-significant relation with Rainfall, minimum temperature, relation rainy days and evening relative humidity and significant negative relation with morning relative humidity. The relation

was positive and non-significant with maximum temperature.

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Management of safflower aphid through seed treatment and foliar sprays

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ABSTRACT

Seed treatment with either thiamethoxam 30FS @ 10 ml/kg (4.6-5.2 aphids/5cm twig/plant) or imidacloprid 600 FS @ 8 ml/kg (1.1-2.1 aphids/5cm twig/plant) protected the crop from aphid infestation up to 40 days compared to untreated plots (41.1-42.3 aphids/5cm twig/plant). Treatments viz., seed treatment with imidacloprid + spray with dimethoate @1000 ml/ha; or seed treatment with thiamethoxam + spray with pymetrozine @ 300g/ha; or seed treatment with imidacloprid + spray with pymetrozine @ 300g/ha recorded significantly lower aphids and resulted in significantly higher seed yields.

Keywords: Aphid, Insecticides, Management, Safflower, Seed treatment

Aphid is an economically important pest that can cause yield loss of 48.5 to 78.5 per cent (IIOR, 2015). Aphids infest the crop at all stages. Both adults and nymphs feed on tender stems and leaves and plants turn yellow and dry. In late sown conditions due to delayed

or extended rains, aphid attack coincides with early stages. Seed treatment may offer a better protection against aphids.

Table 1 Efficacy of seed treatments and foliar sprays against safflower aphids during *rabi*, 2018

Treatment	Aphid population/5cm twig/plant*					Avg	% ROC	Yield (kg/ha)
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS			
T1=Seed treatment with thiamethoxam 30 FS @ 10ml/kg seed (ST-Th)	0.7 (0.85)	4.6 (2.15)	17.6 (4.2)	55.4 (7.44)	100.2 (10.0)	35.7	42.51	240
T2=Seed treatment with imidacloprid 600FS@ 8ml/kg seed (ST-Im)	0.9 (0.95)	1.1 (1.02)	15.2 (3.9)	36.5 (5.13)	90.1 (9.49)	28.8	53.62	233
T3=ST-Th + foliar spray with pymetrozine 50 WG @ 300g/ha	1.0 (0.99)	4.7 (2.16)	8.0 (2.77)	6.3 (2.46)	27.1 (5.2)	9.4	84.80	1347
T4=ST-Th + foliar spray with difenthiuron 50WP @ 600g/ha	0.7 (0.82)	5.2 (2.28)	13.7 (3.62)	32.0 (5.33)	57.8 (7.60)	21.9	64.73	729
T5=ST- im + foliar spray with pymetrozine 50WG @300g/ha	0.3 (0.49)	1.6 (1.22)	6.6 (2.57)	2.1 (0.32)	36.5 (6.04)	9.4	84.80	1265
T6=ST-im + foliar spray with difenthiuron 50WP @600g/ha	0.5 (0.63)	2.3 (1.45)	18.2 (4.26)	7.9 (3.31)	56.6 (7.52)	17.1	72.44	887
T7=Foliar spray with pymetrozine 50WG @300g/ha	2.8 (1.67)	42.3 (6.49)	15.2 (3.9)	1.6 (1.21)	36.7 (6.05)	19.72	68.24	808
T8=Foliar spray with difenthiuron 50WP @600g/ha	5.1 (2.26)	41.1 (6.41)	35.4 (5.95)	51.2 (7.15)	69.7 (8.35)	40.5	34.78	493
T9=ST-im + Foliar spray with dimethoate 30EC @1000ml/ha	0.6 (0.75)	2.1 (1.44)	14.1 (3.74)	8.5 (2.90)	26.6 (6.04)	10.4	83.25	1502
T10=Control	7.4 (2.7)	41.7 (6.46)	60.3 (7.73)	95.6 (9.78)	115.3 (10.72)	62.1	0.00	104
LSD (P=0.05)	0.38	0.49	1.16	0.73	0.53	-	-	124

Values in the parentheses are sqrt transformed; Foliar sprays were done on 45 DAS and 60 DAS

A field trial was conducted in *rabi*, 2018-19 to evaluate seed treatment of safflower with thiamethoxam 30 FS or imidacloprid 600 FS, solely and along with foliar spray of pymetrozine 50 WG or difenthiuron 50 WP and a check insecticide, dimethoate. Trial was laid

out in a CRBD with 10 treatments replicated thrice. Aphid counts were recorded from top 5cm twig at regular intervals. Two foliar sprays were given with a spray volume of 500 l/ha. Seed yield was recorded at harvest. Data was subjected to ANOVA.

Aphids were significantly lower in plots where seed treatment was done with either thiamethoxam 30FS @ 10 ml/kg (4.6-5.2 aphids/5cm twig/plant) or imidacloprid 600 FS @ 8 ml/kg (1.1-2.1 aphids/5cm twig/plant) compared to untreated plots (41.1-42.3 aphids/5cm twig/plant) up to 40 days after sowing (Table 1). Up to 70 days after sowing, T9 (ST-im+ spray with dimethoate 30 EC @ 1000 ml/ha), T3 (ST-Th + spray with pymetrozine 50 WG @ 300g/ha, and T5 (ST-Im + spray with pymetrozine 50 WG @ 300 g/ha) recorded significantly lower aphids compared to sole foliar sprays of pymetrozine @ 300 g/ha (T7) or difenthiuron @ 600g/ha (T8). Over the crop period, the former treatments recorded the lowest aphid population of 10.4, 9.4, 9.4 aphids/5cm twig/plant respectively and reduced aphid population by 83.8%-84.8% compared to control plots. The highest seed yield of 1502 kg/ha was recorded in ST-Im + spray with dimethoate followed by

ST-Th + spray with pymetrozine, and ST- Im + spray with pymetrozine compared to 104 kg/ha in control plots. Imidacloprid and thiamethoxam were reported effective against aphids in rapeseed (Schroeder and Dumbleton, 2001) and soybean (Brian and David, 2006).

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Host plant resistance in safflower (*Carthamus tinctorius* L.) to aphid, *Uroleucon compositae* (Theobald)

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ABSTRACT

Based on aphid population, foliage drying grades, bio-physical, bio-chemical and yield attributing characters, the resistance of five out of 14 pre-identified aphid tolerant safflower genotypes was confirmed against aphid. Plant morphology plays an important role in the aphid resistance. The phenol and OD phenol contents showed no significant differences between resistant and susceptible genotypes. The safflower entries having more spines, hard thick stem, wiry peduncles, green, thin and waxy leaves, tiny capitula and small sized seeds sheltered less aphid build up. Looking to all the bio-physical and bio-chemical characters along with yield potential, only five more-spiny genotypes viz., SSF-682, SSF-695, SSF-704, SSF-714 and SSF-734 were found most promising and have confirmed resistance against safflower aphid. They may be used in breeding programme for incorporation of aphid resistance.

Keywords: Aphid, Host plant resistance, Mechanisms of resistance, Safflower

Safflower is damaged by a number of insect pests and diseases causing substantial losses in yield (Singh *et al.*, 1999). Of these, aphid (*Uroleucon compositae* Theobald) is one of the most destructive pests infesting the crop from its elongation stage to flowering period (Akashe *et al.*, 2013). Besides sucking the sap from the plants, the aphids also excrete honeydew which attracts a black sooty mould that adversely affects the photosynthesis. Losses in seed and oil content to the tune of 20 to 80 % have been reported from different parts of the country. Therefore, the present study was conducted to evaluate the bio-physical and bio-chemical parameters against the safflower aphid.

The field experiments were carried out during *rabi* season of 2017-18 and 2018-19 at ZARS, Solapur (Maharashtra). Seeds of 14 safflower genotypes and 2 checks [A-1 (National check) and CO-1(Susceptible check)] were sown with the plot of size 4.0 m x 4.5 m in

two sets viz., one under complete protection and another under unprotected condition to study the host plant resistance against aphid. The observations on number of aphids on 5 cm apical twig of genotypes in unprotected condition were recorded at weekly intervals on 15 randomly selected and tagged plants in each plot. The aphid count recorded on resistant genotypes was compared with both the checks viz., A-1 (NC) and CO-1 (SC). The percent aphid population in the test genotypes over A-1 was worked out by considering the aphid population recorded on A-1 (NC) as 100%. The genotypes were scored as per 1 (0 to 20%) to 5 (above 80 to 100%) scale on the basis foliage drying due to aphid and the aphid infestation index (A.I.I.) was calculated. The plant characters and the seed yield were recorded at harvest and the oil content was estimated by NMR technique at IIOR, Hyderabad. The biochemical analysis of 5 genotypes + 2 checks for phenol and OD

phenol contents was done in the laboratory of the Department of Biochemistry, MPKV, Rahuri, Dist. Ahmednagar.

The results revealed that mostly the plant morphology coupled with few biochemical parameters play an important role in imparting the aphid resistance. Based on aphid population, foliage drying grades, bio-physical, bio-chemical and yield characters, 5 genotypes viz., SSF-682, SSF-695, SSF-704, SSF-714 and SSF-734 have confirmed for their resistance against aphid. The safflower entries having more spines, hard thick stem, wiry peduncles, green, thin and waxy leaves, tiny capitula and small sized seeds sheltered less aphid build up. The resistant cultivars and A-1 (NC) recorded higher phenol content (7.4 to 7.8 mg/g) of leaves than the susceptible check (CO-1) (Table 1). On the contrary, lower OD phenol content was recorded in A-1 (0.863 mg/g) and resistant cultivars (1.078 mg/g) compared to 1.726 mg/g in the CO-1(SC). However, the resistant and susceptible genotypes did not differ significantly for Phenol and OD Phenol content. The minimum yield loss of 20.93, 21.50, 22.27, 21.00 and 21.80% was recorded by SSF-682, SSF-695, SSF-704, SSF-714 and SSF-734, respectively as against 24.0 % in A-1 (NC) and 85.39%

in CO-1 (SC). The oil content in these genotypes was more than that in national check (A-1) and susceptible check (CO-1). All the 14 genotypes were categorized under resistant (A.I.I.=1.30 to 2.00) whereas tolerant check A-1 and susceptible checks CO-1 were respectively categorized into moderately resistant (A. I. I.=2.20) and susceptible (A. I. I.=3.60) category.

Looking to all the bio-physical and bio-chemical characters, categorizations and seed yield, only five spiny genotypes viz., SSF-682, SSF-695, SSF-704, SSF-714 and SSF-734 were found promising and have confirmed resistance to safflower aphid.

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Table 1 Aphid population, foliage drying grades, category and seed yield (attributes) of aphid resistant genotypes

Entry	Aphids/5 cm twig/plant	% Aphids compared to A-1 (TC)	FDG (AII)	Category	Treated (kg/ha)	Un-Treated (kg/ha)	Difference Yield (kg/ha) Tr. Vs UT.	% yield loss due to aphids	% Oil content
SSF-682	88.33	54.08	1.30	R	800.00	632.50	167.50	20.93	29.39
SSF-684	115.00	70.41	2.00	R	579.35	434.50	144.85	25.00	27.41
SSF-695	95.00	58.16	1.43	R	723.91	566.10	157.81	21.80	29.32
SSF-704	95.00	58.16	1.83	R	650.00	505.24	144.76	22.27	28.55
SSF-714	105.00	64.29	1.50	R	690.55	545.53	145.02	21.00	28.64
SF-10-4	115.00	70.41	1.88	R	599.36	452.52	146.84	24.50	28.12
SSF-734	98.33	60.20	1.75	R	675.00	529.85	145.15	21.50	28.63
SSF-807	120.00	73.47	2.00	R	649.40	506.53	142.87	22.00	29.46
SAF-11-13	108.33	66.33	1.65	R	669.42	521.48	147.94	22.10	28.81
SAF-1224	118.33	72.45	1.90	R	677.12	526.80	150.32	22.20	29.23
SAF-1335	125.00	76.53	2.00	R	580.00	435.00	145.00	25.00	27.50
SAF-1356	126.67	77.55	1.43	R	610.00	460.00	150.00	24.60	28.10
SAF-13-40	126.67	77.55	1.83	R	605.00	450.00	155.00	25.62	28.50
GMU-1628	116.67	71.43	1.50	R	620.00	465.00	155.00	25.00	28.20
A-1 (TC)	163.33	100.00	2.20	MR	608.34	462.34	146.00	24.00	28.62
CO-1 (SC)	251.67	154.09	3.60	S	425.00	62.10	362.90	85.39	26.52

Effect of novel formulation of *Bacillus thuringiensis* var. *kurstaki* (DOR Bt-127) against semilooper (*Achaea janata*) in castor

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ABSTRACT

Semilooper, *Achaea janata* feeds on many different species of plants among which castor is one of the most preferred hosts. DOR Bt-127 was multiplied through solid state fermentation and subjected to milling in a planetary ball mill. 559 nm particles of Bt technical gave 100% mortality against *A. janata* @ 0.6 mg/l. Field evaluation of Bt-127 SC (33.3%) formulation lowered *A. janata* larval population (97.3 to 98.1% reduction over control by 3 days after treatment).

Keywords: *Bacillus thuringiensis* var. *kurstaki*, Castor, Formulation, Efficacy, Semilooper

Castor semilooper, *Achaea janata* is a defoliator on castor (*Ricinus communis* L.) that feeds voraciously on leaves and tender capsules. Estimated yield loss in castor *J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

is 30–50% due to *A. janata* alone (Rao *et al.*, 2012). The insecticidal bacterium *Bacillus thuringiensis* (Bt) has great promise for management of castor semilooper. We

present here under results of a study carried out for particle size reduction of a promising local *Bt kurstaki* isolate DOR Bt-127 through milling and evaluation of an SC formulation developed with the milled powder.

DOR Bt-127 was multiplied through solid state fermentation to get a technical powder containing 105 µm particles. This powder was subjected to milling in a planetary ball mill resulting in powders with mean particle sizes of 1171, 559, 252 and 210 nm for samples drawn at 30, 60, 90 and 120 min respectively (Vineela *et al.*, 2016). These powders were bioassayed against third instar *A. janata* using castor leaf disc treated on each surface with 0.5 ml of test suspension @ 0.6 mg/ml (Ravi Charan *et al.*, 2013). Larval mortality was recorded at 24h intervals till 72 h after treatment. Bt-127 powder from 60 min milling was developed into a suspension concentrate (SC). For LC₅₀ determination, bioassays were carried out against third instar larvae of *A. janata* using Bt unmilled and 60 min milled samples and SC formulation. Bt-127 SC formulation was field tested on castor hybrid DCH-519 against *A. janata* larvae during *kharif* 2014 at four concentrations *viz.*, 0.25, 0.5, 0.75 and 1 ml/l along with the commercial Bt formulation Delfin WG @ 1.0 g/l and an insecticidal check profenofos @ 1.0 ml/l and an untreated control. Observations of *A. janata* larvae were recorded before spray and 3 days after spray (DAS). Data were subjected to ANOVA using statistical package SAS 9.3 (SAS Institute).

All milled powders gave higher mortality of *A. janata* larvae in comparison to the unmilled Bt powder. Optimum mortality of *A. janata* 100% at 0.6 mg/l was obtained with 60 min milling containing 559 nm particles. LC₅₀ value of milled powder was lower at 0.1 mg/ml in comparison to 0.24 mg/ml for unmilled Bt

powder while LC₅₀ value of the (SC) formulation (with milled Bt powder) was 0.1 µl/ml containing only 0.033 mg/ml of Bt. Field evaluation of DOR Bt-127 SC formulation lowered *A. janata* larval population from 74 to 82% over control by 3DAS. Population reduction with lowest dose of SC formulation at 0.25 ml/l was on par with insecticidal check profenofos. Larval feeding was high in the control plots. Per cent defoliation was below 10% in Bt SC formulation sprayed plots (0.75 and 1.0 ml/l) and profenofos (1.0 ml/l), 11–25% with 0.25 and 0.5 ml/l of SC formulation and Delfin (1.0 g/l) while very high feeding of 51–75% was observed in control. Ball milling of *Bt kurstaki* powders is a promising approach for generation of submicron-scale Bt particles essential for development of formulations with increased efficacy and improved coverage on foliage.

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Assessment of biopriming potential of *Trichoderma* and *Pseudomonas* against seed and soil borne diseases of safflower

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ABSTRACT

A field experiment was conducted for two consecutive *rabi* seasons from 2017-18 to 2018-19 to evaluate the biopriming potential of *Trichoderma* and *Pseudomonas* as a seed dressers for management of seed and soil borne diseases of safflower. Among the different priming treatments, seed bio-priming with *Trichoderma harzianum* @ 10g/litre water for 12 hrs was found most effective as it recorded significantly highest germination (95.3%), least incidence of *Phytophthora* seedling blight (4.9%), *Fusarium* wilt (4.4%) and *Macrophomina* root rot (4.7%) and significantly highest seed yield (1023 kg/ha), net monetary returns (Rs.21260/-) and B:C ratio (2.21).

Keywords: Bio-priming, *Pseudomonas*, Safflower, Seed and soil borne diseases, *Trichoderma*

Safflower crop suffers from many seed and soil borne diseases starting from seed germination to crop maturity leading to considerable yield losses. The wilt caused by *Fusarium oxysporum* f.sp. *carthami* is reported to lead to yield losses up to 80% while the soil

borne, *Macrophomina* spp. causes root rot in safflower leading to considerable yield losses. Damping off and seedling blight of safflower caused by *Phytophthora* during seed germination and at seedling stage causes seed yield losses to the tune of 25 to 93 per cent. With

this view, the present investigation was undertaken to evaluate the biopriming potential of *Trichoderma* and *Pseudomonas* for management of seed and soil borne diseases of safflower.

A field experiment was conducted in randomized block design with three replications during *rabi* season of 2017-18 and 2018-19 to evaluate the biopriming potential of *Trichoderma harzianum* and *Pseudomonas fluorescens* having known biocontrol potential and commercialized by ICAR-Indian Institute of Oilseeds Research, Hyderabad for management of seed and soil borne diseases of safflower. The safflower variety, PBNS-12 was sown during 2nd fortnight of September at 45 x 20 cm spacing with the gross plot size of 2.25 x 4.0 m and net plot size of 1.35 x 3.60 m and 50 : 25 kg N and P₂O₅ were applied at the time of sowing as basal dose. Safflower seeds soaked overnight in the solution of *T. harzianum* and *P. fluorescens* were dried in shade and then sown in the field. The fungicidal and bioagent seed treatment was given at the time of sowing.

The results in respect of germination, disease incidence, seed yield and economics of safflower are presented in Table 1. Among different priming treatments, seed biopriming with *Trichoderma harzianum* @ 10 g/litre water for 12 hrs was found most effective as it recorded significantly high germination (95.3%), least incidence of *Phytophthora* seedling blight (4.9%), *Fusarium* wilt (4.4%) and *Macrophomina* root rot (4.7%) and significantly high seed yield (1023 kg/ha), net monetary returns (₹21260) and B:C ratio (2.21). The next effective treatments as regards *Phytophthora* seedling blight, *Fusarium* wilt and *Macrophomina* root rot control were seed treatment with *Trichoderma harzianum* @ 10 g/kg seed 1 hr before sowing (6.5%, 8.6% and 7.5%, respectively) and seed treatment with cymoxanil 8% + mancozeb 64% (2 g/kg seed) 1 hr before sowing (8.6%, 12.1% and 9.5%, respectively).

In the present investigation, most effective and economical management of seed/soil borne diseases of

safflower and higher seed yield could be obtained by seed biopriming with *Trichoderma harzianum* @ 10 g/litre water for 12 hrs. Prasad and Anjani (2008) reported that seed treatment with *Trichoderma harzianum* and *T. viride* @ 10 g/kg seed was very effective in reducing wilt incidence and increasing seed yield under field conditions. Moreover, Prasad and Suresh (2012) reported that seed treatment with carbendaim @ 1 g/kg seed or *Trichoderma viride* @ 10 g/kg seed or thiram @ 3 g/kg+*T. harzianum* + *T. viride* (1:1) @ 4g/kg seed have been found effective against seed/soil borne pathogens of safflower. Furthermore, Murumkar *et al.* (2016) reported that Cymoxanil 8% + Mancozeb 64% @ 2 g/kg or *Trichoderma harzianum* Th4d SC @ 1 ml/kg seed was found to be effective for the management of *Phytophthora* seedling blight of safflower. The results of the present investigation are also in agreement with these findings. From the above study, it could be concluded that seed biopriming with *Trichoderma harzianum* @ 10 g/litre water for 12 hrs was found most effective and economical for management of seed/soil borne diseases of safflower.

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Table 1 Effect of priming of safflower seeds with biological agents and recommended fungicide on germination, disease incidence and seed yield of safflower under dryland conditions (Pooled data: 2017-18 and 2018-19)

Treatments	Germination (%)	Disease incidence (%) [*]			Seed yield (kg/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	B:C ratio
		<i>Phytophthora</i> seedling blight	<i>Fusarium</i> wilt	<i>Macrophomina</i> root rot					
Seed biopriming with <i>Trichoderma harzianum</i> @ 10g/litre water for 12 hrs	95.3	4.9 (12.8)	4.4 (12.1)	4.7 (12.5)	1023	38874	17614	21260	2.21
Seed biopriming with <i>Pseudomonas fluorescens</i> @ 10g/litre water for 12 hrs	90.3	12.1 (20.3)	12.2 (20.3)	9.7 (18.1)	780	29640	17621	12019	1.67
Seed treatment with <i>Trichoderma harzianum</i> (10g/kg seed) 1 hr before sowing	91.7	6.5 (14.9)	8.6 (17.0)	7.5 (15.9)	867	32946	17614	15332	1.87
Seed treatment with <i>Pseudomonas fluorescens</i> (10g/kg seed) 1 hr before sowing	88.0	15.2 (22.9)	15.8 (23.4)	12.2 (20.4)	676	25688	17614	8074	1.46
Seed priming with only water (hydropriming) for 12 hrs	89.7	19.5 (26.2)	20.0 (26.6)	13.5 (21.5)	599	22762	17584	5178	1.29
Seed priming with cymoxanil 8% + mancozeb 64% @ 2g/litre water for 12 hrs	89.0	14.5 (22.4)	19.0 (25.8)	14.5 (22.4)	631	23978	17621	6357	1.36
Seed treatment with cymoxanil 8% + mancozeb 64% (2g/kg seed) 1 hr before sowing	90.7	8.6 (17.0)	12.1 (20.3)	9.5 (17.9)	781	29678	17614	12064	1.68
Control (untreated)		26.7 (31.1)	23.6 (29.1)	17.0 (24.3)	491	18658	17584	1074	1.06
C.D. at 5 %	3.4	1.7	2.6	2.2	142				

*Figures in parentheses are arcsine values. Market rates: Safflower- ₹ 3800/q; *Trichoderma harzianum* - ₹ 300/kg; *Pseudomonas fluorescens*- ₹ 300/kg; Cymoxanil 8% + Mancozeb 64% - ₹ 1850/kg

Seasonal incidence and population dynamics of castor pests and their natural enemies in Tamil Nadu

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ABSTRACT

Seasonal occurrence of insect pests and natural enemies on castor recorded consecutively for four years (2015-19 to 2018-19) showed that the sucking pests incidence was higher compared to defoliators and capsule borer. The peak incidence of leafhopper started from November to January in all the years with the peak population ranging from 24.8 to 84.5 leafhoppers/3 leaves/plant. Thrips population peaked during November and highest population of 432.8 thrips/spike was recorded during 2016-17. Whitefly population was recorded during December to January with peak population of 224.3/plant noticed in 2016-17. Defoliator population was recorded from October to November and the parasitisation of semilooper by *Snellenius maculipennis* was up to 66.6 per cent.

Keywords: Castor, Insect pests, Natural enemies, Population dynamics

The yield loss in castor (*Ricinus communis* L.) due to insect pests has been estimated in the range of 35-60 per cent. Number of insect pests, mostly the defoliators and sucking pests at different growth stages has also been reported in several places. The castor semilooper and tobacco caterpillar are the most common and regular pests of castor, which can cause complete defoliation (Lakshminarayana, 2010). The main objective of the present study was to determine the population fluctuation pattern of pests of castor crop in Tamil Nadu. Studies on occurrence and population dynamics of insect pests of castor and their natural enemies were carried out at Tapioca and Castor Research Station, Yethapur at weekly intervals on Castor hybrid, YRCH 1 during *khari* 2015-16 to 2018-19. Observations on the population levels of different insect pests, their natural enemies along with weather parameters were recorded throughout the crop season. The incidence of sucking pest population was estimated by counting the number of leafhoppers, thrips and whitefly from three leaves per plant on 10 randomly selected plants.

Survey on insect pests showed that defoliators *viz.*, semilooper (*Achaea janata*), tobacco caterpillar (*Spodoptera litura*), hairy caterpillars (*Ergolis merione*, *Euproctis* spp.), leafminer (*Liriomyza trifolii*), sucking pests *viz.*, leafhopper (*Empoasca flavescens*), whitefly (*Trialeurodes ricini*) and thrips (*Scirtothrips dorsalis*) and shoot and capsule borer (*Conogethes punctiferalis*) were recorded. Larval parasitoid, *Snellenius (Microplitis) maculipennis*, was recorded on semilooper. The observations showed that, among the castor pests, the sucking pests incidence was higher compared to defoliators and capsule borer. The peak incidence of leafhopper started from November to January in all the years with the peak population ranging from 24.8 to 84.5 leafhoppers/3 leaves/plant and highest during 2016-17. Thrips population was peak during November to January in all the years and highest population of 432.8/spike

during 2016-17. Whitefly population was recorded during December to January of 2016 and 2017 with peak population of 224.3/plant in 2016-17. The reason for severity of the sucking pest incidence might be due to long dry spell in 2016-17 and such similar results of sucking pests incidence in hot weather period was reported by Naik *et al.* (2010). Defoliator population was recorded from October to November in all the years with the parasitisation on semilooper being high (66.6 %) during 2017-18. These results were similar to the previous findings of Madhuri *et al.* (2006) who reported that the population was found from first fortnight of November and continued till January and these variations might be due to weather parameters prevailing in that locality.

The detailed observations during 2018-19 showed that, leafhopper population was low to moderate during October to February with the peak population 81.2 numbers/3 leaves/plant during 8 to 14th January with the hopper burn grade of 3. Defoliators population were observed from 45th to 3rd standard meteorological weeks (5th November to 21st January) with the population ranged from 0.1 to 1.1 semilooper larvae/plant, 1.6 to 26.4 *Spodoptera litura* larvae/plant and 0.2 to 5.0 larvae/plant for hairy caterpillars. The parasitisation of semilooper larvae by the parasitoid, *Snellenius maculipennis* was found during 3rd December to 21st January with highest parasitisation of 66.6 per cent during 51st standard week (17 to 23rd December). Negligible incidence of capsule borer was recorded during November to January. Thrips population was low to moderate during the season with high population of 34 numbers/3 leaves/plant recorded during 12 to 18th November during 2018-19. The data generated would be useful for predicting outbreaks of castor pests under varied climatic conditions and to evolve suitable management strategies.

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Evaluation of storage containers and botanical oils for bruchid management in groundnut

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ABSTRACT

Storage containers and botanical oils were evaluated for managing bruchids in groundnut. After six months storage, damage to pods in airtight plastic container, APC was less (34.0 and 35.0%, respectively for neem and castor oils) than air-permeable galvanized iron tin, APGIT (75.8 and 73.8%, respectively). Similarly, weight loss of pods stored in APC was less (33.5 and 31.4%, respectively for neem and castor oils) than APGIT (77.8 and 76.1%, respectively). When tested alone, APC was superior to APGIT while, neem and castor oils were statistically non-significant. It was noted that treatments and length of storage had no impact on germination.

Keywords: Botanical oils, Bruchid, Groundnut, Management, Storage containers

Bruchid, *Caryedon serratus* Oliviera is the primary pest of stored groundnut in India. They inflict both quantitative and qualitative losses. Generally, farmers save some portion of their groundnut produce as seed (in the form of pods) for the next cropping season. Jute and plastic interwoven bags offer no protection from bruchids. An economical and feasible storage practice can save a lot of money to farmers, at least the seed cost. Hence, this study was undertaken to evaluate locally available storage containers and botanical oils.

About 7 kg of insect- and damage-free groundnut pods (cv. GG-20) were treated with either neem oil 5% (v/w) or castor oil 5% (v/w) at 50 ml/kg pod and stored, in either APC or APGIT. Initial seed germination was recorded from a sub-sample of 50 g pods from each treatment combination. Freshly emerged adult bruchids were released into the container at 10 pairs/kg pod. Similarly, bruchid adults were released into two container types having 7 kg of untreated pods. Entire set up was incubated at ambient room temperature in the field laboratory. Pod samples (100 g) drawn at the end of 180 days of storage were used to record following observations: number of damaged and undamaged pods, and weight of damaged and undamaged pods. Pod damage (%) and weight loss of pods (%) was calculated by following Harish *et al.* (2012). Final seed germination (%) was also recorded from another sub-sample of 50 g pods drawn from of each treatment combination.

After 180 days of storage, damage and weight loss in pods of APC + untreated (57.1 and 56.4%, respectively) were less than that of APTIG + untreated

(98.5 and 98.5%, respectively). This was largely due to reduced availability of oxygen for bruchids in APC. Neem oil and castor oil treatments were at statistically par and registered lowest damage and weight loss in pods. This may be attributed to the physico-chemical properties of oils (Harish *et al.*, 2012). However, damage and weight loss in pods of APC + neem oil (34.0 and 33.5%, respectively) and APC + castor oil (35.5 and 31.4%, respectively) were less than APTIG + neem oil (75.8 and 77.8%, respectively) and APTIG + castor oil (73.8 and 76.1%, respectively). This may be ascertained to additive effect of containers and oils. There was no significant loss in the seed viability as there was only a slight reduction germination values from initial (92-100%) to final (88-94%). Results were in congruence with that of Murlidhar *et al.* (2013). These findings may be helpful to farmers for the safe and economical storage of groundnut seed.

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Evaluation of sunflower germplasm for resistance against leafhopper, *Amrasca biguttula biguttula* (Ishida)

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ABSTRACT

Sixty accessions of sunflower were screened under natural infestation in *rabi*, 2017-18 for their reaction to leafhopper (*Amrasca biguttula biguttula* Ishida). Out of 60 germplasm lines screened, 42 lines were recorded the lowest injury grading of I. Two accessions GMU-339 and TSG-349 were found promising with the lowest leafhopper population and the lowest injury grade of I.

Keywords: Leafhopper, Plant resistance, Screening, Sunflower

Sunflower (*Helianthus annuus* L.) is an important edible oilseed crop grown in India. Leafhopper, *Amrasca biguttula biguttula* is the major sucking pest that predominantly occur during *rabi*/summer seasons. Both nymphs and adults suck sap from the lower surface of leaves and cause yellowing and hopper burn symptoms. Yield loss up to 40-50% was recorded due to leafhopper damage (Anonymous, 1997). Host plant resistance offers a better protection to crop from leafhoppers in an environmentally safer way than the conventional chemical control. Identifying resistant sources from available germplasm is an essential step in developing resistant cultivars. Therefore, present study was carried out to identify the sources of resistance in sunflower against leafhoppers.

A total of 60 accessions of sunflower including a susceptible check, Morden were evaluated in *rabi*, 2017-18 under natural infestation at IIOR, Hyderabad. Each accession was sown in single row of 3m length with a spacing of 60 x 30 cm and was replicated twice. Susceptible check, morden was repeatedly sown after every 10 entries. Okra (*Abelmoschus esculentus*) was sown in one row as an infester crop for leafhopper after every two rows of sunflower entries. One row of the susceptible check was also maintained around the experimental field as infester crop.

Leafhoppers (both nymphs and adults) were counted from top, middle and lower leaves from 5 randomly selected plants in each replication, from 30 days after sowing. During flowering stage, when leafhopper

damage was higher, injury grading was given to 5 randomly selected plants in each replication. Injury grading was based on a 1-5 scale: 0-10 per cent yellowing or hopper burn of foliage (I), 11-20 per cent yellowing or hopper burn of foliage (II), 21-30 per cent yellowing or hopper burn of foliage (III), 31-50 per cent yellowing or hopper burn of foliage (IV) and above 50 per cent yellowing or hopper burn of foliage (V).

Mean number of leafhopper nymphs per plant ranged from 0.4 (TSG-349) to 19.8 (Morden). The lowest number of leafhopper nymphs were observed in two accessions TSG-349 (0.4/six leaves/plant) and GMU-339 (0.7/six leaves/plant). Based on the intensity of yellowing and hopper burn symptoms, the sunflower accessions were graded into resistant/susceptibility classes (Table 1). Out of 60 lines screened 42 lines were found highly resistant with an injury grade of I (less than 10 per cent yellowing), 11 lines were resistant with an injury rating of II. Four lines were categorized into scale III. One accession (PSERM-139) was susceptible with an injury grading of IV. Susceptible check, Morden and GMU-4 were highly susceptible with an injury grade of V. These reactions need to be confirmed with further experimentation.

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Table 1 Rating of sunflower accessions for leafhopper resistance based on per cent yellowing of leaves (2017-18)

Resistance rating	Name of the accessions
I (HR)	TSG-349, GMU-339, TSG-278, GP9472-4-13, GP6-570, TSG-287, TSG-298, TSG-320, TSG-400, TSG-258, TSG-HA89-B, TSG-297, TSG-197, PSERM-138, GMU-669, TSG-HA-430-B, TSG-217, TSG-195, AKSFI-46-2, PSCIM-117, TSG-216, GMU-504, TSG-238, PSMO-53-D, PSECO-86, GMU-696, GMU-776, GMU-1029, TSG-196, TSG-198, TSG-296, TSG-302, TSG-337, TSG-338, TSG-339, TSG-401, PSECO-70, OCRM, GMU-556, TSG-295, PSECO-79, PSECO-81
II (R)	PSCIM-115, PSCIM-122, GMU-595, GMU-922, PSCIM137, GMU-327, GMU-343, GMU-713, Syngenta-275, PSCIM-186, PSCIM-127
III (MR)	GMU-405, GMU-25, GMU-243, PSMO-53-B-1
IV (S)	PSERM-139
V (HS)	Morden, GMU-4

Estimation of yield loss in soybean triggered by *Spodoptera litura*

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ABSTRACT

Pest infestation has been identified as the major biotic factor limiting soybean yield worldwide. The current scenario of management mainly focuses on insecticides with a quick knockdown effect, not with host plant resistance techniques. The present work is for comparing both chemical and plant resistance. Fifty soybean genotypes with four replications (2 treated + 2 untreated) screened against *Spodoptera litura* infestation. Among them eleven varieties were resistant and high yielding (R-HY), seventeen were resistant and low yielding (R-LY) and twenty two varieties were susceptible and low yielding (S-LY). The grain yield range from 475.0 to 2375.0 kg/ha and 450.0 to 2263.0 kg/ha, in treated and untreated varieties, respectively. The grain yield loss ranged from 0.67 to 17.71 per cent in different varieties.

Keywords: Genotypes, Infestation, Soybean, *Spodoptera litura*, Yield, Yield loss

Soybean [*Glycine max* (L.) Merrill] is a unique crop with high nutritional value, thus is also known as "Miracle bean, Golden bean, and Crop of the planet". Soybean production in India for the year 2018-19 is estimated at 134.59 lakh tonnes as per first advance estimates of MoA & FW, up from 109.81 lakh tonnes of production estimated for the year 2017-18. Pest infestation has been identified as the major biotic factor limiting soybean yield worldwide. The current scenario of management mainly focuses on insecticides with a quick knockdown effect, not with host plant resistance techniques. Entries were categorized into resistant and susceptible groups with high and low yielding against pests according to the maximum-minimax method (Odulaja and Nokoi, 1993). Resistant-high yielding (R-HY), Resistant-low yielding (R-LY), Susceptible-high yielding (Tolerant) (S-HY), Susceptible-low yielding (S-LY).

All the entries were grown in two sets, one with complete plant protection measures and others with no plant protection measures. One spray of chlorpyrifos 20EC @ 1.5 l/ha variably increased grain yield in all the varieties. The grain yield ranged from 475.0 to 2375.0 kg/ha in treated and 450.0 to 2263.0 kg/ha in untreated varieties, respectively. The grain yield loss ranged from 0.67 to 17.71 percent in different varieties. Based on the

Maximin-minimax method, 11 varieties were resistant high yielding (R-HY), whereas 17 varieties were resistant low yielding (R-LY) and 22 varieties were susceptible low yielding (S-LY). The present experiment findings confer grain yield loss range from 0.67 to 17.71 percent in different varieties. Similarly Pillai and Palaniswami (1983) reported that *Spodoptera litura* to be the pest of economic importance and the extent of damage from 16 to 18 percent. Ramesh *et al.* (2018) also reported the loss in the yield by *S. litura* is 42.68 percent on JS-95-60.

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A review on management of major insect pests in castor

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ABSTRACT

The productivity of castor is affected by different insect pests. Out of which shoot and capsule borer, tobacco caterpillar and semilooper are having national significance. By adopting IPM practices we can suppress pest level to below economic injury with least damage to agro-ecosystem. This article reviews the damage and integrated management of these pests to reduce risks with respect to human health and environment.

Keywords: Castor, Insect pests, Integrated management, Productivity

Castor is grown in areas where mean temperature across growing season ranges from 22.7°C to 34.3°C which is favorable for most of the insect pests (Akashe *et al.*, 2015). The crop is affected by 107 species of insects at different stages of the crop among which shoot and capsule borer, tobacco caterpillar, castor semilooper are of national significance.

Shoot and capsule borer, *Conogethes punctiferalis* (Lepidoptera: Crambidae): The pest attacks at flowering stage and continues till crop maturity. Larvae bore into the shoot and feeds on developing capsules. It can be characterized by silk and frass found between capsules (Sujatha *et al.*, 2011). The larvae remain active during October to January with a peak activity during November (Akashe *et al.*, 2015).

Early instar of tobacco caterpillar, *Spodoptera litura* (Lepidoptera: Noctuidae) feed by scraping the leaves and on growing, feed on entire leaves. The pest completes 7-8 generations in a year (Sujatha *et al.*, 2011). Incidence of *S. litura* starts at vegetative stage with a peak activity during July and August (Akashe *et al.*, 2015).

Early instars of castor semilooper, *Achaea janata* (Lepidoptera: Noctuidae) scrape the outer tissues and cause small holes on leaves. Older larvae feed voraciously and cause complete defoliation of the plant (Sujatha *et al.*, 2011). The pest caused defoliation of 1.3-2.2% by young larvae and 21.7-23.3% by mature larvae resulting in 1.3% and 23.3% yield loss, respectively (Gahukar, 2018).

Collection and destruction of attacked shoots and capsules reduce the survival rate of capsule borer (Basappa, 2003). Handpicking and destruction of *S. litura* and *A. janata* larvae minimize the defoliation (Sujatha *et al.*, 2011). Infestation by *C. punctiferalis* was 9.8% in castor+ cluster bean system against 20.8% in monocrop (Gahukar, 2018). Basappa (2003) recorded

Theronia sp., *Diadegma ricini*, *Apanteles* sp., *Habrobracon hebetor* on capsule borer. Sujatha *et al.* (2011) observed *Trichogramma evanescens*, *Apanteles prodenia*, *Cotesia* spp., *Tetrastichus ayyari* on *S. litura*. Basappa (2003) recorded 25-90% parasitism by *Microplitis maculipennis* on semilooper larvae in field condition. If high incidence of capsule borer prevails, acephate 0.075% or profenophos 0.05% are sprayed (Sujatha *et al.*, 2011). Gahukar (2018) suggests chlorpyrifos 20EC at 1.25 l/ha and placing poison baits (prepared by mixing monocrotophos 36SL @ 1 l/ha or carbaryl 50WP against *S. litura*). Sujatha *et al.* (2011) suggests spraying of monocrotophos 0.05% or quinalphos 0.05% when semilooper damage exceeds 25%. Correct identification of pest is major criteria in controlling of the pest. Unnecessary use of pesticides causes threat to human health and environment. By adopting IPM practices we can suppress pest level to below economic injury with least damage to agro-ecosystem.

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Effect of different plant extracts on growth indices of tobacco caterpillar (*Spodoptera litura*) on soybean under laboratory conditions

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ABSTRACT

Spodoptera litura (F.) is a polyphagous insect among which soybean is one of its hosts. Six different botanicals i.e., three plant extracts (Datura leaf extract, Marigold leaf extract and Annona leaf extract) and three plant oils (Neem oil, Eucalyptus oil and Karanj oil) were used by preparing 5% aqueous solutions. Soybean leaves were treated with botanicals by leaf dip method and fed to prestarved second instar larvae and further studied their growth indices. The results indicated that Eucalyptus oil showed least larval index (0.45 in 3rd instar, 0.47 in 4th instar, 0.58 in 5th instar, 0.51 in 6th instar and 0.61 in pre-pupa), pupal index (0.44), adult index (only in case of males as 0.52) and lowest oviposition index (0.20). While, neem oil showed least adult index in females (0.82) and lowest total growth index (2.29).

Keywords: Growth indices, Plant extracts, *Spodoptera litura*, Soybean

Tobacco caterpillar *Spodoptera litura* (F.) is a defoliating lepidopteran pest and feeds on a wide range of hosts among which 40 species are known in India (Anurag Sharma *et al.*, 2008). It feeds on leaves and tender pods and causes extensive damage by defoliation leading to 40–60% yield loss (Audrey and Murray, 2004). Over the recent times higher emphasis on botanicals has been done with respect to their bioactivity on insects in different manner and they are considered a promising alternative to chemical insecticides. Thereby the results of the present study on effect of botanicals on growth indices of *Spodoptera litura* proving the reliability on botanicals as growth inhibitor of the test insect.

The egg masses collected from soybean fields were maintained in the laboratory by rearing them on clean fresh soybean leaves in controlled environment chamber at 25±2°C temperature, 70±5% R.H and a photoperiod of 12:12 (L:D) the larvae from the eggs laid by later generations reared in lab were used as test insect (El-Kholy *et al.*, 2014). The botanicals among which the plant extracts were prepared by taking 500g of fresh leaves, soaked them in water overnight and their extracts were obtained by blending them individually in a blender and filtering the resultant solution in whatmann filter paper to obtain the extract. These plant extracts and plant oils are prepared into 5% aqueous solutions while teepol is added in the solutions prepared using plant oils). Fresh soybean leaves were taken and treated by leaf dip method. The second instar larvae were used as the test insect they were pre-starved for 2h and released onto treated leaves and kept in Petri dishes, 10 larvae for each treatment were taken, after 24h the leaves were changed with fresh and clean leaves. The total growth parameters until the insect completed its entire life cycle were recorded. The growth indices like larval index, pupal index, adult index, oviposition index and total growth index were computed using different formulas. The growth indices are quantitative depiction that was used here for comparing the development of untreated

insect with the treated insect by calculating an index (Rajguru and Amar, 2012). Data were subjected to ANOVA using Completely Randomized Design.

The growth indices which are nothing but the rate of growth of treated test insect over the control were calculated and the results obtained revealed that the larval growth index in second instar showed no significant difference among all the treatments while, the least larval growth index in all larval instars in eucalyptus oil (0.45 in 3rd instar, 0.47 in 4th instar, 0.58 in 5th instar, 0.51 in 6th instar and 0.61 in pre-pupa). The pupal growth index recorded show that the least index was found in eucalyptus oil (0.44), followed by pongamia oil (0.77), while the highest among treatments in datura (0.83), followed by neem oil (0.81). The adult index was recorded lowest in eucalyptus (0.52) followed by neem oil (0.71) in case of males while lowest in neem oil (0.68), followed by eucalyptus (0.75) in case of females. The oviposition index was least in eucalyptus (0.20) followed by neem oil (0.23). The total growth index was found to be lowest in neem oil (2.29), followed by eucalyptus oil (2.55) and highest was recorded in control (4.14). It is concluded from the results obtained that the plant materials has effect on the bioactivity of *Spodoptera* to a certain degree and could be considered as an alternative to chemical insecticides.

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Management of groundnut diseases through organic amendments, bio products and biocontrol agents

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ABSTRACT

Field experiments were conducted at the Main Oilseeds Research Station, Junagadh Agricultural university, Junagadh (Gujarat) during *kharif* for three consecutive seasons to evaluate the efficacy of application of organic amendments enriched with biological control agents and application of biological control agents and bio-product as foliar spray in managing soil borne as well as foliar diseases of groundnut. Pooled analysis of the data of three years revealed that the management of collar rot (1.80 %) and stem rot incidence (1.52%) was obtained in the treatment where *Trichoderma harzianum* was used as a seed treatment@ 10 g/kg seed along with its furrow application @ 4 kg enriched in FYM @ 300 kg/ha at the time of sowing.

Keywords: Biological control, Groundnut, Seed treatment, *Trichoderma*

Groundnut (*Arachis hypogaea* L.) is an important food and oil crop in tropical and subtropical areas. The collar rot (*Aspergillus niger*) causes 25-50 % losses and stem rot up to 27% losses (Mayee, 1995). It has been found from different research works that *Trichoderma* can reduce the disease incidence caused by *Aspergillus niger* (Gajera *et al.*, 2011). *Trichoderma viride* and *T. harzianum* were also found to be capable of reducing the sclerotial population of *Macrophomina phaseolina* (Sharma, 1982; Sharma and Dureja, 2004).

Field experiments were conducted at the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh during *khari* 2016-17 to 2018-19 for three consecutive seasons. The experiment was laid out in randomized block design, replicated three times. Gross plot size 5 x 3.6 m and net plot size of 4 x 2.4 m was maintained. Groundnut variety GG-20 was sown with 120 kg seed rate at 60 x 10 cm spacing. Eight treatments comprised of seed treatment with *Trichoderma harzianum* and *Pseudomonas fluorescens* @ 10 g/kg seed alone and their combination with furrow application @ 4 kg enriched with FYM @ 300 kg/ha at the time of sowing was imposed with other treatments of foliar application of neem seed kernel extract @ 5 % at 30, 45 and 60 DAS and cow urine @ 10% as a spray at 20, 40, 60, and 80 DAS along with control.

Farmers who are interested in organic cultivation of groundnut are advised to apply *Trichoderma harzianum* as a seed treatment @10 g/kg seed along with furrow application @ 4.0 kg/ha enriched in 300 kg FYM at the time of sowing for management of collar rot and stem rot diseases. Whereas, for effective and economical management of tikka disease, farmers are advised to spray neem seed kernel extract @ 5% (500 ml/10 lit of water) at 30, 45 and 60 DAS or to spray cow urine @ 10% (1 litre/10 lit of water) at 20, 40, 60 and 80 DAS.

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Table 1 Effect of different treatments and economics (Pooled data of three years)

Treat. No.	Treatment	Collar rot (%)	Stem rot (%)	PDI of LLS**	Pod yield (kg/ha)	Haulm yield (kg/ha)	Income increased over control	Total cost (₹)	Net realization (₹)	ICBR
1	Seed treatment with <i>T.harzianum</i> @ 10 g/kg seed	1.52 (2.31)	1.27* (1.60)	39.74 (40.88)	1238	2325	7640	385	7255	1:19.84
2	Seed treatment with <i>P. fluorescens</i> @ 10 g/kg seed	1.79 (3.21)	1.35 (1.82)	40.46 (42.11)	1307	2405	10720	430	10290	1:24.93
3	Furrow application of FYM @ 10 tonnes/ha at time of sowing	1.78 (3.16)	1.57 (2.46)	41.12 (43.24)	1388	2448	14132	10500	3632	1:1.34
4	Furrow application of vermicompost @ 1 ton/ha enriched with <i>T. viride</i> (2.5 kg) at the time of sowing	1.62 (2.64)	1.43 (2.03)	39.52 (40.50)	1334	2596	12564	5675	6889	1:2.21
5	Foliar application neem seed kernel extract @ 5 % at 30, 45 and 60 DAS	1.78 (3.18)	1.49 (2.21)	36.00 (34.55)	1328	2887	13488	1750	11738	1:7.70
6	Seed treatment with <i>T. harzianum</i> @ 10 g/kg seed + furrow application of <i>T. harzianum</i> @ 4 kg enriched with FYM @ 300 kg/ha at the time of sowing	1.34 (1.80)	1.23 (1.52)	37.13 (36.44)	1528	3053	22152	1470	20682	1:15.06
7	Seed treatment with <i>P. fluorescens</i> @ 10 g/kg seed + furrow application of <i>P. fluorescens</i> @ 4 kg enriched with FYM @ 300 kg/ha at the time of sowing	1.73 (2.99)	1.32 (1.74)	40.87 (42.81)	1329	2513	12032	1830	10202	1:6.57
8	Application of cow urine @ 10% as a spray at 20, 40, 60, and 80 days DAS -	2.10 (4.39)	1.76 (3.11)	36.20 (34.88)	1318	2733	12472	2100	10372	1:5.93
9	Control (without any treatments)	2.31 (5.35)	2.08 (4.34)	47.23 (53.89)	1086	1935	---	---	---	---
	S.Em±	0.07	0.08	2.11	44.72	102.48				
	C D at 5 %	0.20	0.23	6.31	127.27	291.68				
	C V %	11.78	15.94	9.05	10.18	12.08				
	Y- S.Em±	0.04	0.05	1.22	25.82	59.17				
	Y-C.D. at 5 %	0.11	0.13	3.65	73.48	168.40				
	YXT-S.Em±	0.12	0.14	2.08	77.45	177.50				
	YXT-C.D. at 5 %	NS	NS	5.92	NS	NS				

Numerals in parentheses is retransformed values.

Evaluation of fluorescent *Pseudomonads* and *Trichoderma* for growth promotion and control of soil borne diseases of groundnut

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ABSTRACT

A potential method for suppressing soil-borne pathogens is to apply, or encourage growth of, plant growth-promoting rhizobacteria. Many isolates of *P. fluorescens* are efficacious for improving plant growth and yields and for suppressing soil-borne plant pathogens. The antibiotic DAPG (2,4-diacetylphloroglucinol) is one of the metabolites produced by *Pseudomonas* which can suppress other pathogens, and can affect plant vigor, including root weights and lengths and root branching and trigger induced systemic resistance (ISR). In the present investigation, three DAPG-producing and 2 non-DAPG producing fluorescent pseudomonads and a *Trichoderma* strain were found effective in amelioration of biotic and abiotic stresses and enhance groundnut seed yield.

Keywords: DAPG (2,4-diacetylphloroglucinol), Groundnut, Fluorescent *Pseudomonads*, Soil borne diseases, *Trichoderma*

The main problems that limit production of groundnut (*Arachis hypogaea* L.) are biotic stresses and use of chemical fungicides leads to inadequate protection. Plant growth promoting microbes play a major role in soils in mitigating stresses caused by biotic and abiotic factors. The role of fluorescent *Pseudomonads* and a strain of *Trichoderma* in control of soil borne diseases, plant growth promotion and yield enhancement in groundnut was investigated.

The study was conducted during *kharif* season of 2014, 2015 and 2016 at Regional Agricultural Research Station, Polasa, Jagtial, Karimnagar (TS) to evaluate effectiveness of DAPG producing fluorescent *Pseudomonads* and *Trichoderma* species for enhancing nutrient use efficiency, bio-control of soil borne diseases and yield of groundnut. Seven treatments consisting of T1: Control, T2: DAPG 1, T3: DAPG 2, T4: DAPG 4, T5: FP 86, T6: FP 98 and T7: *Trichoderma* sp. using groundnut cv. Kadiri-6 in a RBD experiment replicated thrice. Disease incidence (collar rot and stem rot) and yield were recorded and analyzed statistically.

The pooled mean of three seasons data revealed that significantly superior dry pod yield (1990 kg/ha) recorded with seed treated with *Pseudomonad* strain FP-86 with less disease incidence of collar and stem rot (Table 1). *Pseudomonad* strains FP-86 and DAPG-2 recorded maximum dry pod yield respectively (1919 and 1706 kg/ha) than other seed inoculants like DAPG-4 (1385 h/ha) and control (1052 kg/ha) with more disease incidence.

Soil available P is significantly low in treatments except in DAPG 1 and 2 indicating the potential role played by the DAPG 4, FP 89, FP 98 and *Trichoderma*

sp. In making plants utilize the nutrient more efficiently. Similarly, soil available N was significantly low after harvest in all treatments except in control indicating efficient utilization of N by groundnut mediated by microbes.

Seed treatment adopted through different microbial agents resulted in enhancement of nutrient use efficiency in groundnut, increased seed yield and with lesser disease incidence indicating potential role of microbes in enhancement of productivity in groundnut.

Table 1 Effect of Fluorescent *Pseudomonads* and *Trichoderma* on pod yield, soil available N and P and disease incidence

Treatments	Pod yield (kg/ha)	Soil available N after harvest (kg/ha)	Soil available P after harvest (kg/ha)	Disease affected plants/m ²
T1; Control	931	331	91	2.7
T2; DAPG 1	1371	113	90	2.3
T3; DAPG 2	1538	124	79	2.3
T4; DAPG 4	1356	186	70	2.6
T5; FP 86	1957	124	66	2.0
T6; FP 98	2069	145	72	2.4
T7; <i>Trichoderma</i> sp.	1601	165	63	2.0
S.Em. ±	74.7	41.3	5.1	0.2
CD (p=0.05)	231.7	128.7	15.8	0.5
CV (%)	11	42.2	11.6	10.7

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Association of late leaf spot (LLS) and rust resistance with yield in selected peanut genotypes

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ABSTRACT

In this study, seventy five peanut genotypes of groundnut were analyzed for association between disease resistance and kernel yield in *kharif* under two locations (Coimbatore and Aliyar Nagar). The result indicated non-significant association between the disease severity and yield.

Keywords: Genotypes and correlation coefficient, Late leaf spot, Peanut

The most devastating and co-occurrence of late leaf spot (LLS) and rust can reduce the production up to 70% in groundnut. Association study is key index for selection of desirable characters with absence of undesirable linkage and improving breeding value in terms of additive gene action. Genetic association is a prerequisite for selection of desirable plant types which implicated in breeding pipelines for genetic enhancement.

The experiment was carried out with seventy five genotypes derived from different parent combinations with standard checks CO7, VRI 8, TMV(Gn)13, TMV 14 and ICGV 0722. It was tested in Coimbatore (Latitude and Longitude of 11°02'S and 76°92'W) and Aliyar Nagar (epidemic region for LLS and rust- Latitude and Longitude of 10°48'S and 76°97'W) during *kharif* season under field conditions. Completely Randomized Block Design was followed with two replications. The phenotypic screening was carried out according to 9-point scale given by Subrahmanyam *et al.* (1995) and correlation coefficient was estimated and inferred.

An association study revealed that the disease scores which related to yield and the diseases namely LLS and rust had high significant positive association among them and it showed non-significant association with kernel yield per plant in *kharif* under two locations (Table 1). Late leaf spot had positive correlation with rust and single plant yield (g) had negative association with LLS (Rathod and Toprope, 2018). In conclusion, resistance trait existing in genotypes showed same pattern of expression under two locations without variation.

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Table1 Correlation study for disease scoring with kernel yield/plant in *kharif* season

Characters	Coimbatore			Aliyar Nagar		
	LLS	Rust	Kernel yield/plant (g)	LLS	Rust	Kernel yield/plant (g)
Late leaf spot	1			1		
Rust	0.577**	1		0.625**	1	
Kernel yield/plant (g)	0.029	0.015	1	0.067	0.012	1

PGPR for the management of sunflower major diseases of north eastern dry zone of Karnataka

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ABSTRACT

Field experiment was conducted during *rabi* 2017-18 and *kharif* 2018 to study the effect of PGPR (plant growth promoting rhizobacteria) on sunflower diseases. Among treatments, seed treatment with *Pseudomonas fluorescens* @ 10g/kg seed + soil application of 2.5 kg *P. fluorescens* @ 2.5 kg fortified with 250 kg FYM + three foliar spray of

P. fluorescens @ 30, 45 and 60 DAS had recorded least PDI of *Alternaria* leaf spot (28.9%), powdery mildew (28.8%) and percent disease incidence of necrosis (24) with highest yield of 1612 kg/ha compared to other treatments.

Keywords: *Alternaria* leaf blight, Management, PGPR, Sunflower

Sunflower (*Helianthus annuus* L.) is known to be affected by many diseases and among them *Alternaria* leaf blight, powdery mildew, necrosis and leaf curl are major diseases found in North Eastern Dry Zone of Karnataka. All four diseases can cause more than 80% yield loss under severe epiphytotic conditions. Owing to the serious environmental and health hazards posed by the chemical pesticides, there is an increasing public pressure and market demand for the use of safer alternatives for crop protection. This has necessitated the researchers and pesticide industries to shift their focus to more reliable, sustainable and environmental friendly bioagents-the biopesticides. Therefore, the present experiment was aimed at the use of PGPR for the management of *Alternaria* leaf spot, necrosis and powdery mildew diseases.

Field experiment on PGPR for the management of sunflower major diseases of North Eastern Dry Zone of Karnataka conducted at MARS, Raichur during *rabi* 2017-18 and *kharif*, 2018. The experiments were laid out on beds of 4.2 × 3.0 (12.6 sq m) size in a randomized complete block design (RCBD) with seven treatments replicated thrice. The susceptible check KBSH-44 was used in the experiment.

The present investigation was carried out using *Pseudomonas fluorescens* for the management of *Alternaria* leaf blight, powdery mildew and necrosis diseases of sunflower. Our results indicated that least PDI of *Alternaria* leaf spot (28.9%), powdery mildew

(28.88%) and percent disease incidence of necrosis (24) was observed in seed treatment with *P. fluorescens* @ 10g/kg seed + soil application of 2.5 kg *P. fluorescens* @ 2.5 kg fortified with 250kg FYM + three foliar spray of Pf @ 30, 45 and 60 DAS which gave more yield of 1612 kg/ha and the highest B:C ratio of 1:60. In the control treatment, highest PDI for *Alternaria* leaf spot (52.1%), Powdery mildew (68.8%) and Percent disease incidence of necrosis (44.9%) and yield of 1122 kg/ha were recorded. In similar type of results have been obtained by Silva *et al.* (1998) with fluorescent *Pseudomonas* spp. in controlling *Alternaria* leaf spot on castor caused by *A. ricini* under greenhouse conditions. Karthikeyan *et al.* (2008) reported that consortium of three antagonists *viz.*, *P. fluorescens* (Pf1), *B. subtilis* and *T. viride*, were most effective in reducing the onion leaf blight disease (*A. palandui*) under glasshouse and field conditions.

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Influence of powdery mildew disease on sunflower and its possible management using *Ampelomyces* spp.

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ABSTRACT

Among the different sunflower entries tested under artificial net-house conditions against powdery mildew disease, COSF 15 B showed highly susceptible reaction (HS) compared to CO 2 Hybrid (S), Sunbred 275 (S), Morden (HS) and CO 3 Hybrid (MR). Further, the entry recorded less mean seed volume weight (33.5 g/100 ml), oil content (33.5%) with a disease score of 9 under field conditions. An attempt has been made to isolate the naturally occurring mycoparasitic pycnidial fungi *Ampelomyces* spp. from powdery mildew infected leaves and four isolates were obtained. These isolated were slow growing on potato dextrose agar medium and produced pycnidia. These four isolates gave a 560 bp amplicon from the ITS region.

Keywords: *Ampelomyces* spp., Powdery mildew, Seed yield, Sunflower

Several biotic and abiotic factors influence performance of sunflower (*Helianthus annuus* L.) and can lower the yield levels by 25-40 %. During the past decade, powdery mildew (white mould) caused by

Golovinomyces orontii has become an important and serious problem in India (Sujatha *et al.*, 2016). To manage, chemical spray is the normal practice and due to its adverse effect, exploitation of hyper parasite *viz.*,

Ampelomyces quisqualis is essential which is widespread in nature (Angeli *et al.*, 2012). Hence, the present study was undertaken to find out the impact of powdery mildew and to isolate, and characterize *Ampelomyces* spp.

A greenhouse and field experiment was conducted during Rabi using Sunflower COSF 15B with other entries for the incidence of powdery mildew. Two separate plots were maintained to assess the grain yield loss under field conditions. In first plot, three sprays of fungicide (sulphur 80% WP two spray and one spray with propiconazole) were given to arrest the infection and in the second plot, no sprays were done. In each case, 105 plants were maintained and disease severity (per cent disease index PDI; on 0-9 scale), seed volume weight and oil content were recorded. The powdery mildew leaves were collected during cropping season and examined under the stereo microscope for the presence of *Ampelomyces* spp. *pycnidia* (ash to dark brown). The medium Potato Dextrose and Czapek-Dox with 2% malt extract and 0.5% chloramphenicol was tried for isolation of *Ampelomyces* spp. Morphological and molecular characterization was carried out for the isolates.

Under artificial net-house conditions, COSF 15 B showed highly susceptible reaction (HS) selected for the yield loss assessment study compared to CO 2 Hybrid (S), Sunbred 275 (S), Morden (HS) and CO 3 Hybrid

(MR). The result showed that sprayed/treated plot recorded mean seed volume weight (39.5 g/100ml) with the oil content (37.8 %) with the disease score of 0 compared to unsprayed plot which recorded mean volume weight (33.5 g/100 ml) with the oil content (33.5%) with 9 disease score. Four isolates of *Ampelomyces* were obtained. They were slow growing on PDA and CDA (14 to 21 days) under 25°C and molecular characterization showed amplification of ITS region at 560bp. Angeli *et al.* (2012) reported that the use of mycoparasites is a highly elegant method of biocontrol and it presents no risk to the environment. *Ampelomyces quisqualis* best typifies the potential of mycoparasites, as it is highly specific to powdery mildews.

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Integrated management of castor wilt disease

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ABSTRACT

Field trials were conducted for management of the wilt disease in castor during 2016-17 and 2017-18. Soil solarisation during summer followed by seed treatment and soil application of carbendazim as well as soil solarisation along with seed treatment and soil application of *Trichoderma harzianum* were effective in reduction of wilt disease. Pathogen population had also decreased in soil samples collected at the time of harvest in plots with solarization, neem cake, and *Trichoderma* applied treatments.

Keywords: Castor, Management, Seed treatment, Soil application, Wilt

Wilt occurs in all castor growing areas in India and has potential to cause yield loss ranging from 39 to 77% (Pushpavathi *et al.*, 1998). As disease is both seed and soil borne, integrated disease management (IDM) including cultural, biological and chemical methods is appropriate for the management.

Management trials were carried out during *kharif* season of 2016-17 and 2017-18 under field conditions. The main treatments includes soil solarisation during peak summer months; application of metham sodium; application of neem cake before sowing in the plot and control. The sub treatments were seed treatment and soil

application of *T. harzianum*; seed treatment and soil application of carbendazim; soil application of carbofuran and control. The trials were carried out with castor hybrid GCH-4 with spacing of 90 x 60cm in strip plot design, replicated thrice. The initial plant stand was recorded. The wilt incidence was recorded at 90, 120 and 150 days after sowing and seed yield were recorded. The pathogen population in soil was recorded before starting of trial and at the time of harvest by soil dilution method. During 2016-17, soil solarisation followed by seed treatment with carbendazim recorded wilt incidence of 33% with seed yield of 853 g/plot. Application of neem

cake combined with seed treatment and soil application of *T. harzianum* gave a seed yield of 830 g/plot. Control plots recorded high wilt incidence of 91%.

During 2017-18, soil solarisation followed by seed treatment and soil application of carbendazim gave 21.9% wilt with seed yield of 807 g/plot followed by soil solarisation of plot along with seed treatment and soil application of *T. harzianum* gave 22.4% wilt incidence. Application of neem cake along with seed treatment and soil application of *T. harzianum* followed by application of neem cake combined with seed treatment and soil application of carbendazim showed 33.6 and 34.4% wilt incidence respectively. The wilt incidence was 96.4% in control plots. The wilt incidence was less in solarized plots than unsolarized plots.

Fusarium population reduced in the soil in solarized plots, metham sodium fumigated plots and neem cake applied plots. Dange *et al.* (2006) reported that application of biocontrol agents like *Trichoderma* spp.

and carbendazim as seed treatment as well as cultivation of resistant cultivars with proper cultural practices provides an effective control of the disease. Pooled data revealed that soil solarisation combined with seed treatment (2 g/kg) and soil application of carbendazim (1 ml/l) as well as soil solarisation followed by seed treatment (10 g/kg) and soil application of *T. harzianum* (1 kg mixed with 100 kg FYM) were effective in reduction of castor wilt disease.

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Management of pod rot of groundnut using new fungicide molecules under field condition

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ABSTRACT

Under field evaluation of different fungicides to manage pod rot in groundnut, minimum per cent incidence of pod rot, maximum pod yield, haulm yield and test weight and least pod rot incidence (28.39 %) was obtained in the treatment combination of seed treatment with *Trichoderma harzianum* at 10 g/kg of seeds + soil drenching with propineb at 30 days after sowing and fluopyram 17.7 % + tebuconazole 17.7 % @ 0.2% at 60 days after sowing which recorded as compared to other treatments.

Keywords: Fungicides, Groundnut, Pod rot, *Trichoderma*

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops in India. Low production of groundnut is attributed to the disease pod rot, and it has become a major constraint in groundnut producing areas in northern parts of Karnataka.

A field experiment on management of pod rot was carried out during *khari* 2018 at Main Agricultural Research Station, UAS, Dharwad, by soil drenching of *in vitro* effective fungicides at 30 and 60 days after sowing. Treatments included, T1: Soil drenching with non systemic fungicide @ 30 DAS + 60 DAS; T2: Soil drenching with systemic fungicide @ 30 DAS + 60 DAS; T3: Soil drenching with combi fungicide @ 30 DAS + 60 DAS; T4: Soil drenching with non-systemic fungicide @ 30 DAS + combi fungicide @ 60 DAS; T5: Soil drenching with non systemic fungicide @ 30 DAS + combi fungicide @ 60 DAS; T6: Recommended check – seed treatment of tebuconazole 2 DS @ 1.5 g per kg of seeds; T7: Seed treatment of *Trichoderma harzianum* @ 10 g per kg of seeds; T8: Control. Seed treatment with

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Trichoderma harzianum was done commonly at 10 g per kg of seeds in treatments.

The results revealed that treatment combination of seed treatment with *Trichoderma harzianum* at 10 g per kg of seeds, soil drenching with propineb at 30 DAS and fluopyram 17.7 % + tebuconazole 17.7 % at 60 DAS at 0.2 per cent concentration recorded less pod rot incidence (28.39 %) followed by treatment combination of seed treatment with *Trichoderma harzianum*, soil drenching with fluopyram 17.7 % + tebuconazole 17.7 % (29.50 %) alone at 0.2 per cent concentration as against untreated check (50.03 %). The result obtained in the present investigations was in agreement with the findings of Mehan *et al.* (2008) who reported that inhibitory effect of propineb on fungal growth and its toxic nature by the activity of anti-sporulant and inhibition of protein synthesis. Thiessen *et al.* (2014) and Jadon *et al.* (2015) reported that per cent incidence pod rot of 31 and 29 per cent, respectively with propineb fungicide at 0.2 per cent concentration.

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Bio-efficacy of fungicides and bio control agents against root rot of soybean incited by *Rhizoctonia solani*

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ABSTRACT

Bioagents, fungicides and their combinations were tested under net house conditions to know their efficacy in controlling root rot of soybean. The parameters recorded included percent germination, dry weight, vigour index and vigour index mass. Seed dressing with *Azoxystrobin* + *T. viride* showed highest significant effect on germination per cent and dry weight. However, seed dressing with *T. harzianum* were significant on fresh weight and vigour index.

Keywords: Bio control agents, *R. solani*, Root rot, Soybean

Soybean [*Glycine max* (L.), Merrill] is known as “Golden Bean” of the 20th century (Hymowitz and Harlan, 1983) and it is most important pulse as well as oil seed crop as it contains 20% oil and 40% high-quality protein. *Rhizoctonia* spp. that causes root rot are the most destructive pathogens for this crop causing heavy yield losses every year. By considering economic importance of the crop and the disease, the present investigation was undertaken to evaluate bio-agents and fungicide to assess their efficacy against *R. solani* under *in vivo* conditions.

The inoculum of *R. solani* was mass multiplied on sterilized sorghum grains. These sterilized sorghum grains were inoculated with seven days old culture (*R. solani*) and incubated at 25±1°C for 15 days after which dense colony were obtained. This inoculum was mixed @ 4 g/kg soil. After inoculation the soil was incubated at room temperature for 15 days. Five seeds were placed in one earthen pot and three replications were maintained. Seed treatment was performed with bioagents and fungicides viz. *T. harzianum*, *T. viride*, *T. longibrachiatum*, Thiram, Carbendazim, Azoxystrobin and combination of Thiram + Carbendazim (0.25%) under net house. Observations were recorded for percent germination, vigour index and vigour index mass as described. Treatments used were: T1-Seed inoculated with *R. solani* + Seed untreated (control); T2- Seed dressing with *T. harzianum*; T3-Seed dressing with *T. viride*; T4-Seed dressing with *T. longibrachiatum*; T5-Seed dressing with Carbendazim; T6-Seed dressing

with Azoxystrobin; T7-Seed dressing with Thiram + Carbendazim; T8-Seed dressing with T5 + T2; T9-Seed dressing with T5 + T3; T10-Seed dressing with T5 + T4; T11-Seed dressing with T6 + T2; T12-Seed dressing with T6 + T3, T13-Seed dressing with T6 + T4; T14-Seed dressing with T7 + T2, T15-Seed dressing with T7 + T3; T16-Seed dressing with T7 + T4 and T17-Control 2 sterilized soil + healthy seed.

Maximum germination per cent was recorded with T12: Seed dressing with *Azoxystrobin* + *T. viride* (93.33%) and minimum germination per cent was recorded with T1: Control (53.33). Maximum fresh weight was recorded with T2: Seed dressing with *T. harzianum* (1.44g) followed by T3 Seed dressing with *T. viride* (1.41g) treatment. Minimum fresh weight was recorded with T1 (1.01g). Maximum dry weight was recorded with T2: Seed dressing with *T. harzianum* (0.90g). Minimum dry weight was recorded with T12: Seed dressing with *Azoxystrobin* + *T. viride* (0.11g) followed by T1 (0.11g), T10 (0.11g), T15 (0.11g) and T16 (0.11g). Maximum vigour index per cent was recorded with treatment T2: Seed dressing with *T. harzianum* (78.26). Minimum vigour index mass per cent was recorded with T1 : control (6.30%).

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Impact of seed mycoflora of soybean on seed quality

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ABSTRACT

The seeds collected from major soybean growing areas of northern Karnataka were tested for the association of mycoflora and seed quality parameters. The mycoflora associated with soybean were *Colletotrichum truncatum*, *Cercospora kikuchii*, *Fusarium oxysporum*, *Rhizoctonia solani*, *Rhizopus stolonifer* and saprophytic fungi *Aspergillus flavus*, *Aspergillus niger* and *Penicillium* spp. *Alternaria* spp., *Cercospora kikuchii*, *Fusarium* spp., *Penicillium* spp. led to deterioration and germination failure of soybean seeds. The seeds collected from Bidar region recorded high seed quality parameters.

Keywords: Seed mycoflora, Seed quality, Soybean

Seed borne diseases are regarded as major constraints in soybean production. Infected seeds serve as the source for the spread of the pathogen in disease free area. The loss of more than 7 MT of soybean in world is documented due to diseases alone. Some of the seed lots are discarded due to low germination influenced by biotic factors. However, the records regarding the mycoflora coupled with soybean seed is scarce. Hence, it is necessary to know the seed borne mycoflora present in prominent seed production areas.

The experiment consisted of seeds of two varieties of soybean viz., DSb 21 and JS 335 collected from five locations of major soybean growing districts of Karnataka viz., L1: Bagalkot, L2: Belagavi, L3: Bidar, L4: Dharwad and L5: Haveri. These collected seeds were tested for the association of mycoflora and seed quality parameters.

The mycoflora associated with soybean were *Colletotrichum truncatum*, *Cercospora kikuchii*, *Fusarium oxysporum*, *Rhizoctonia solani*, *Rhizopus stolonifer* and saprophytic fungi, *Aspergillus flavus*, *Aspergillus niger* and *Penicillium* spp. The results of the present investigation showed the dominance of *Cercospora kikuchii* (8.4%), followed by *Colletotrichum truncatum* (8.3%), *Rhizoctonia bataticola* (7.6%) and *Rhizopus stolonifer* (4.5%). The results are in

accordance with the findings of Nivedita *et al.* (2013). The seeds collected from Bidar region recorded higher seed germination (84.8%), seedling vigour (2986) and lower electrical conductivity (0.275 dS/m) and seed infection (14.0%). Agarwal *et al.* (1990) and Ahammed *et al.* (2006) observed decreased soybean seed germination loss and vigor by fungal pathogen.

The seeds collected from Bidar region showed higher seed quality parameters and lower seed infection. This region could be used for the seed production of soybean with minimal infection of seed borne diseases.

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New source of Fusarium wilt resistance in castor

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ABSTRACT

Fusarium wilt (*Fusarium oxysporum* f. sp. *ricini*) is the major yield limiting biotic factor in castor. The castor germplasm accession RG-1624 was identified as a source of resistance to wilt under artificial epiphytotic conditions at multi locations and confirmed its reaction over years. RG-1624 would serve as a reliable donor for developing wilt resistant cultivars.

Keywords: Castor, *Fusarium* wilt, Root dip inoculation, Sick plot

Castor (*Ricinus communis* L.) is highly susceptible to the soil borne wilt disease caused by *Fusarium oxysporum* f. sp. *ricini* which can cause 39–85% yield losses (Pushpavathi *et al.*, 1998; Dange, 2003). Chemical control is not effective in managing wilt. Host-plant resistance approach is an effective measure to manage wilt. A castor germplasm accession, RG-1624 was screened for its resistance reaction against *Fusarium* wilt under artificial epiphytotic conditions at multi locations in different years. The results of multi-year screening against wilt are presented in the paper.

RG-1624 along with susceptible checks *viz.*, GCH-4, GAUCH-1, Kranti, JI-35, VP-1 and Aruna were screened against wilt in wilt sick plots at IOR, Hyderabad, S. K. Nagar and Palem for the five years and under glasshouse conditions using root dip method for two years at all the three locations.

The germplasm accession RG-1624 showed resistance to *Fusarium* wilt and it consistently exhibited resistant reaction (0-18% wilt incidence) in wilt sick plots when screened for five years at 2-3 locations, while susceptible check exhibited 76.9-100% wilt incidence (Table 1). Its resistant reaction was further confirmed in glasshouse using root-dip inoculation method (0-20% wilt incidence) at three locations in two years (Table 1). It can serve as a diverse source of resistance and to broaden wilt resistance in castor breeding pools.

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Table 1 Reaction of RG-1624 against *Fusarium* wilt at multi locations in wilt sick plots and glasshouse over years

Year	Method of screening	Wilt reaction (%)								
		RG-1624			Resistant check*			Susceptible check*		
		SKN	PAL	IOR	SKN	PAL	IOR	SKN	PAL	IOR
1997-98	WS	0.0	11.11	11.11	0.0 (48-1)	18.8 (48-1)	20 (DCS-9)	100 (GCH-4)	81.8 (Aruna)	71.42 (Aruna)
2002-03	WS	0.0	-	18.0	0.0 (48-1)	-	9.1 (DCS-9)	96.6 (GAUCH-1)	-	76.9 (Aruna)
2003-04	WS	0.0	-	15.0	0.0 (48-1)	-	20.1 (DCS-9)	98.5 (GAUCH-1)	-	88.5 (VP-1)
2009-10	WS	0.0	-	0.0	0.0 (48-1)	-	0 (DCS-9)	78.9 (JI-35)	-	100 (JI-35)
2013-14	WS	16.7	0.0	14.3	0.0 (48-1)	0 (Haritha)	0.0 (48-1)	94.7 (JI-35)	90.0 (Kranti)	100 (JI35)
2013-14	RD	8.8	0.0	8.3	0.0 (48-1)	0 (Haritha)	0.0 (48-1)	100 (JI-35)	90.0 (Kranti)	85.7 (JI-35)
2016-17	RD	0.0	7.1	20.0	0.0 (48-1)	6.7 (48-1)	7.5 (48-1)	100 (JI-35)	86.7 (JI-35)	100 (JI-35)

<20% -Resistant; >21% -Susceptible

*Name of resistant and susceptible checks is given in parentheses; '-' no screening was done. SKN: S. K. Nagar; PAL: Palem; IOR: ICAR-Indian Institute of Oilseeds Research, Hyderabad; WS-wilt sick plot, RD-root dip inoculation in glass house

Bio-efficacy of bio-agents against *Aspergillus niger* inciting collar rot in groundnut (*Arachis hypogaea* L.)

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ABSTRACT

In vitro studies of fungal and bacterial antagonists *viz.*, *Trichoderma* spp., *Pseudomonas fluorescens* and *Bacillus subtilis* indicated that *T. viride* was more effective in inhibiting *Aspergillus niger* causing collar rot of groundnut. Among the fungal bioagents, *Trichoderma*, strain Tv- 3 recorded maximum inhibition of 77.7% and among bacterial bioagents *P. fluorescens* strain pf-7 which recorded maximum inhibition of 66.9% was followed by *B. subtilis* strain Bs-10 (64.1%).

Keywords: *Aspergillus*, Bioagents, Groundnut

Groundnut is infected by several soil borne pathogens causing diseases like collar rot, *Sclerotium* stem rot and dry root rot etc., which limit the yield considerably. Of these, pre and post emergence damping off and collar rot caused by *Aspergillus niger* van Tieghem is the most prevalent disease causing seedling losses up to 50%. As seed treatment with chemical fungicides cannot give season long protection it has

become inevitable to go for seed treatment with bioagents for management of diseases. The main objective of the present study was to screen in *in vitro* and select effective *Trichoderma* and bacterial bioagents (*P. fluorescens* and *B. subtilis* strain) than can be used as one of the components in the integrated disease management.

Bio-agents were evaluated for their efficacy through dual culture technique. The activity of antagonistic organisms were recorded by measuring the colony diameter of *A. niger* in each treatment and compared with control. Inhibition percentage of pathogen by bioagents was calculated as per formula given below.

$$I = \frac{(C-T)}{C} \times 100$$

where; I = Per cent mycelial inhibition
C = Radial mycelial growth of fungus in control
T = Radial mycelial growth of fungus in treatment

Among the ten *Trichoderma* isolates, strain Tv-3 recorded maximum inhibition of 77.7% of the pathogen followed by strain Tv-18 and Tv-29 which have shown an inhibition of 75.6 and 69.6% respectively. *P. fluorescens* strain pf-7 superior showed maximum inhibition of 66.96% among bacteria followed by *P. flourescens* strain pf-2 (66.2 %). The antifungal activity of *P. fluorescens* was attributed to the production of iron chelating agent siderophore, hydrocyanic acid, indole

acetic acid, wide variety of secondary metabolites such as fluorescent pigment, antibiotics, enzymes, phyto-hormones associated with microbial antagonism reducing phytopathogenic fungi (Kloepper *et al.*, 1988). Among *Bacillus* strains, *B. subtilis* Bs-10 recorded maximum inhibition of 64.1% followed by *B. subtilis* strains Bs-2 and Bs-9 with a per cent inhibition of 62.3 and 61.4, respectively. Antifungal nature of *B. subtilis* is reported to be because of bio-surfactant, iturin and fengycin (Mnif and Ghribi, 2015).

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Biochemical changes induced by compost tea and seaweed formulation spray inhibiting *Alternaria* leaf blight of sunflower

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ABSTRACT

Compost tea and seaweed extract were tested against *Alternaria* blight of sunflower. Foliar spray of compost tea (1:10) @ 30, 45 DAS and propiconazole @ 1 ml/l at 60 DAS was effective in controlling the *Alternaria* blight of sunflower with least disease severity which was on par with foliar spray of seaweed formulation at 30, 45 DAS and propiconazole at 60 DAS. The defense enzymes such as superoxide dismutase, peroxidase, secondary metabolites such as phenolics and flavonoids increased in foliar spray of compost tea and also in propiconazole treated plants.

Keywords: *Alternaria*, Flavonoids, Compost tea, Peroxidase, Phenolics, Superoxide dismutase

Alternaria blight has been causing significant yield losses in sunflower (*Helianthus annuus* L.). Integrated organic practices in agriculture like compost tea and seaweed formulation to combat the plant diseases are being explored to reduce use of chemical protectants. Compost tea is a liquid extract made from compost that contains a variety of nutrients, growth compounds and beneficial microorganisms. Seaweed extract can be applied as a foliar spray and enhance plant growth, tolerance to abiotic stress, photosynthetic activity and resistance to diseases, improving the yield and productivity of many crops.

Field trail was conducted with seven treatments *viz.*, 1. Foliar spray of compost tea (1:10) @ 30, 45 and 60 DAS, 2. Foliar spray of LBD-1 (*Kappaphycus alvarezii*) @ 2ml/L at 30, 45 and 60 DAS, 3. Foliar spray of *J. Oilseeds Res.*, 37 (Special Issue), Feb., 2020

compost tea @ 30, 45 DAS and propiconazole @ 60 DAS, 4. Foliar spray of LBD-1 @ 30, 45 DAS and propiconazole @ 60 DAS, 5. Foliar spray of propiconazole @ 1ml/L at 45 and 60 DAS, 6. Foliar spray of mancozeb @ 3.0 g/L at 45 and 60 DAS, and 7. Control. The observations of yield and disease severity were recorded. Estimation of defense related enzymes such as peroxidase isoenzyme, superoxide dismutase, phenols and flavonoids was carried out using standard protocols.

The highest yield and least disease severity was recorded in foliar spray of compost tea (1:10) @ 30, 45 DAS and propiconazole @ 1 ml/L at 60 DAS with 2201 kg/ha and 10.37 per cent respectively. Foliar spray of compost tea (1:10) @ 30, 45 DAS and propiconazole @ 1 ml/L at 60 DAS showed increased defense enzymes

such as superoxide dismutase (39.47 µg and 50 per cent inhibition) and peroxidase (16.86 µg/min/mg protein), and also secondary metabolites such as phenolics (67.92 mg/g FW) and flavonoids (60.01 mg/g FW) when compared to control plants. The compost tea treated plants showed significant increase in the activities of chitinase, β-1,3-glucanase and peroxidase activities due to stimulation of induction of systemic resistance and suppression of tomato early blight and onion purple blight (Haggag and Saber, 2007).

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Identification of resistant sources against phyllody and foliar diseases of sesamum (*Sesame indicum* L.)

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ABSTRACT

Advanced breeding and mutant lines of sesamum from different geographical regions were evaluated against Phyllody, *Alternaria* and *Cercospora* leaf spot under natural epiphytotic conditions. Two genotypes viz., LW-2 and SDSN-15-98 were found to be promising against phyllody, *Alternaria* and *Cercospora* leaf spot, whereas ten lines were resistant to powdery mildew. Based on two seasons screening, LW-2 was identified as multiple disease resistant line.

Keywords: *Cercospora*, Foliar diseases, Phyllody, Resistance sources, Sesamum

Sesamum (*Sesame indicum* L.) crop suffers from severe yield losses due to diseases caused by fungi and phytoplasma. Keeping the importance of the crop and constraint posed by the diseases in sesamum, the present study was planned to identify the multiple disease resistant genotypes for utilization in future breeding programmes.

Experimental material included advanced mutant breeding lines, germplasm lines, local cultivars, RILs, germplasm lines, coordinated trial entries, popular and local cultivars, National check (TKG-22), Zonal check (Pragathi) and Local check (Swetha til) and other station material received from AICRP on Sesame, RARS, Polasa, Jagtial. The experiment was laid in Randomized Block Design with three replications. The screening was taken up under natural conditions. The location is considered as "hot spot" for evaluation of sesame genotypes for disease resistance. The incidence of foliar diseases (powdery mildew, *Alternaria* and *Cercospora* leaf spot) was recorded and percent disease index (PDI) was calculated (Wheeler, 1969). For phyllody, per cent disease incidence was calculated.

Of the 133 genotypes evaluated for the major diseases in field during *khariif* 2017, two genotypes (LW-2 and SDSN-15-98) were found to be resistant to

phyllody. None of the lines were found to be resistant to *Alternaria* and *Cercospora* leaf spot. The incidence of phyllody in susceptible check ranged from 86-92% indicating the sufficient disease pressure for evaluation of germplasm and advanced breeding lines (Ramana Rao *et al.*, 2011). During summer 2018, same set of genotypes were evaluated against powdery mildew and this trial revealed that, ten genotypes viz., V-72, IISL-4, 10KRE8-2, 30KRDS-1-14, TKG-22, SDSN-15-70, SDSN-15-99, RT-376, 30KRDS-1-13, 30KRDS-1-7 were resistant. The phyllody promising line i.e. LW-2 showed moderately resistant reaction to powdery mildew during summer 2018.

Table 1 Promising genotypes against phyllody and powdery mildew

Season	Disease	Genotypes
<i>Khariif</i> , 2017	Phyllody	LW-2, SDSN-15-98
Summer, 2018	Powdery mildew	V-72, IISL-4, 10KRE8-2, 30KRDS-1-14, TKG-22, SDSN-15-70, RT-376, SDSN-15-99, 30KRDS-1-13, 30KRDS-1-7

REFERENCE

Based on the two seasons screening, LW-2 was identified as multiple disease resistant line and this can be used as donor parent in the hybridization programmes for development of disease resistant and high yielding varieties

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Efficacy of different fungicides and *Trichoderma* spp. against stem rot of groundnut incited by *Sclerotium rolfsii* Sacc.

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ABSTRACT

Stem rot caused by *Sclerotium rolfsii* Sacc. is one of the major diseases of groundnut causing serious crop losses. Six fungicides and sixteen *Trichoderma* isolates were screened *in vitro* against *Sclerotium rolfsii*. Among fungicides, carboxin 37.5 % + thiram 37.5 %, tebuconazole 2% DS and mancozeb 75% WP were effective in inhibiting the growth of the pathogen. *Trichoderma* isolates viz., T16, Th and Th11 were able to significantly inhibit mycelial growth of *S. rolfsii*.

Keywords: Groundnut, Fungicides, *Trichoderma*

Stem rot caused by *Sclerotium rolfsii* Sacc. is a major problem in groundnut cultivation and responsible for low productivity. Since the pathogen is very difficult to manage with chemical fungicides alone due to its soil borne nature efforts were made to identify effective *Trichoderma* and few fungicides under *in vitro* conditions to develop management strategy against stem rot.

Six chemical fungicides viz., carboxin 37.5 % + thiram 37.5 %, tebuconazole 2% DS, mancozeb 75% WP, thiram 75% DS, captan 50% WP and cymoxanil 8% + mancozeb 64% WP at different concentrations viz., 20, 50, 100, 250, 500, 750 and 1000 ppm were tested against *S. rolfsii* by using poisoned food technique (Nene and Thapliyal, 1979). Inoculation was done by transferring of 5 mm mycelial disc taken from periphery of seven-day-old culture and plates were incubated at 25+1°C. Per cent inhibition over control was calculated as per Vincent (1927). The antagonistic potentials of sixteen *Trichoderma* isolates viz., T16, TJ, TN13, Ta4, Ta5, Ta7, Ta9, Ta11, Th10, Th11, Th, Th 17, Ta, TaDOR673, 294 and I-36 was tested against the pathogen *S. rolfsii* by dual culture technique (Dennis and Webster, 1971). Per cent inhibition of growth of the pathogen was calculated by using the following formula:

$$I = \frac{C-T}{C} \times 100$$

where, C= Radial growth in control, T= Radial growth in the treatment and I=inhibition in percentage

Among the six fungicides tested, carboxin 37.5 % + thiram 37.5% were highly effective at all seven concentrations tested and inhibited mycelial growth of *S.*

rolfsii completely (Table 1). Tebuconazole 2% DS and mancozeb 75% WP showed 100% inhibition of the pathogen at 250 ppm. Cymoxanil 8% + mancozeb 64% WP was highly effective at higher concentration as it inhibited the mycelial growth of *S. rolfsii* up to 91.1% and 100 per cent at 750 and 1000 ppm, respectively. Thiram 75% DS and captan 50% WP were least effective in inhibiting the growth of *S. rolfsii*. Among sixteen *Trichoderma* isolates, maximum inhibition of mycelial growth in *in vitro* was observed with T16 (52.0 %) followed by Th (42.2 %) and Th11 (40.3 %).

Table 1 Effect of fungicides and *Trichoderma* isolates against *S. rolfsii*

Fungicides / <i>Trichoderma</i> isolates	Inhibition of pathogen (%)
Carboxin 37.5% + thiram 37.5 %	100
Tebuconazole 2% DS	100
Mancozeb 75% WP	100
<i>Trichoderma</i> (T16)	52.0
<i>Trichoderma harzianum</i> (Th)	42.2
<i>Trichoderma harzianum</i> (Th11)	40.3

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Efficacy of biocontrol agents against seed mycoflora of groundnut at different storage periods

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ABSTRACT

Groundnut seeds were treated with commercial formulations of *Bacillus subtilis*, *Pseudomonas fluorescens*, *Trichoderma viride* and their combinations and were stored in butter paper bags along with chemical (Carbendazim 0.2%) and untreated controls. The effect of biocontrol agents on seed mycoflora was assessed by employing standard blotter method. Frequency and per cent seed infection were calculated. Seed treatment with *Bacillus subtilis* + *Trichoderma viride* was found significantly superior with least (53.78%) per cent seed infection.

Keywords: Biocontrol, Groundnut, Seed mycoflora

Seed health plays an important role in successful cultivation and yield exploration of a crop. Fungi are the main component of microflora associated with seeds and are the main cause of deterioration and loss observed during storage. Stem rot, tikka leaf spot, pepper leaf spot, aflaroot or yellow mold and crown rot or collar rot are the major seed borne diseases in groundnut. It was reported that 30-40 per cent loss in yield of groundnut (Agropedia, 2012) were due to seed borne diseases.

Groundnut seeds were treated with commercial formulations of *Bacillus subtilis*, *Pseudomonas fluorescens* (10 g/kg), *Trichoderma viride* (4 g/kg) and their combinations and were stored in butter paper bags along with chemical (Carbendazim 0.2%) and untreated controls. The effect of biocontrol agents on seed mycoflora was assessed by employing standard blotter method (ISTA, 1996) upto three months along with controls. Data on number of seeds infected by different fungi and a specific fungus were recorded separately to calculate per cent seed infection (Aslam *et al.*, 2015) and frequency (Neha and Razia, 2013) respectively.

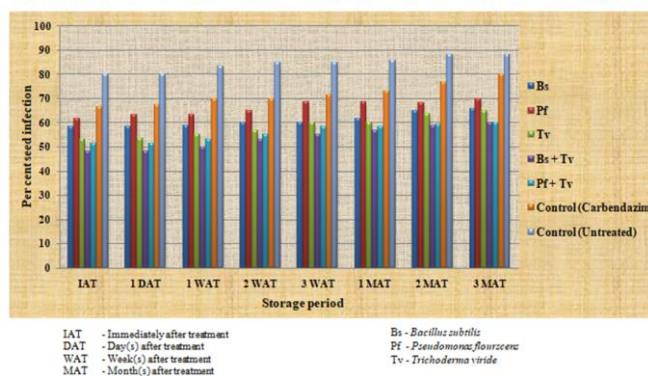
All the biocontrol agents were found significantly effective in suppressing seed mycoflora (Fig 1). Among the biocontrol agents, *Bacillus subtilis* + *Trichoderma viride* (53.7%) was found significantly superior followed by *Pseudomonas fluorescens* + *Trichoderma viride*

(55.8%), *Trichoderma viride* (58.3%) and the least effective (66.1%) was *Pseudomonas fluorescens*. Across the storage periods tested, *Aspergillus niger* was found to be predominant in all the treatments tested followed by *Aspergillus flavus*, *Rhizopus* sp., *Penicillium* sp. and *Fusarium* sp. The mycoflora viz., *Macrophomina phaseolina* and *Rhizoctonia* sp. were recorded with less abundance, while other fungi viz., *Alternaria* sp., *Trichoderma* sp., *Aspergillus ochraceus*, *Aspergillus ustus*, *Chaetomium* sp. and *Cladosporium* sp. were rarely recorded throughout the storage periods evaluated.

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Fig. 1. Efficacy of biocontrol agents against seed mycoflora of groundnut at different storage periods



Field evaluation of Bt 127 SC formulation against *Spodoptera litura* (F.) in soybean

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ABSTRACT

Bt 127 SC formulation was field tested against *Spodoptera litura* larvae infesting soybean at Dharwad. Among the biopesticides, Bt 127 SC formulation @ 3 ml/l of water has proved to be significantly superior over commercial Bt formulation Delfin and untreated control and recorded lowest *S. litura* after both the sprays. There was a higher reduction in larval population on the seventh day after treatment both in Bt 127 SC formulation (0.54 l/ml) and Bt commercial Delfin (0.75 l/ml) treated plots as bacterial infection starts to manifest leading to high mortality of larva within 3-5 days after treatment. Soybean seed yield due to treatment by Bt 127 SC formulation (1733 kg/ha) and Bt commercial Delfin (1694 kg/ha) were on par but lower in comparison to the broad spectrum chemical insecticides that are effective against different orders of insects. There was negligible population of natural enemies in the plots before and after the treatments.

Keywords: Bio-efficacy, Bt 127 SC, *Spodoptera litura*, Soybean

Soybean is leguminous crop cultivating in different agro climatic regions in India. The leaf eating caterpillar, *Spodoptera litura* (Fab.) cause significant yield loss (Singh and Singh, 1990) and is a serious and regular pest in Dharwad. *Bacillus thuringiensis* var. *kurstaki* (Btk) cry toxin have employed globally for insect pest management on several crops. Among these, Bt 127 SC formulation was field evaluated against *S. litura* for the effective management in soybean.

The formulation of Bt 127 SC supplied by the ICAR-IIOR, Rajendranagar, Hyderabad was field evaluated at Dharwad (Karnataka) under AICRP on Soybean for two consecutive years during *kharif* 2017 and 2018 against *Spodoptera litura* larvae infesting soybean. The experiments were laid out at RBD design with four replications and six treatments including standard check with untreated control. Ten plants (one meter row) were selected randomly and tagged in each plot to take observations on number of *spodoptera* larvae/ml, day before spray (DBS), three and seven days after spray (DAS) and subjected for statistical analysis.

Bt 127 SC @ 3 ml/l recorded lower population of *S. litura* (0.69 and 0.63 l/ml) and proved to be significantly superior over commercial Bt formulation Delfin (1.32 & 1.41) and untreated control after first and second spray, respectively. There was a higher reduction in larval population on the 7th day after treatment both in Bt 127 SC formulation and Bt commercial Delfin treated plots as bacterial infection starts to manifest leading to high mortality of larva within 3-5 days after treatment. There will be no phytotoxic effect on the plants observed by treatment with Bt 127 SC formulation on soybean crop. The present result was in accordance with Murali Krishna *et al.* (2018) who reported that Bt isolates was effective for the management of *S. litura*.

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Effect of different media, temperature, pH on the growth of *Macrophomina phaseolina* (Tassi) Goid causing root rot of sesame

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ABSTRACT

Among fungal diseases, stem root rot or charcoal rot caused by *Macrophomina phaseolina* (Tassi) Goid is widely distributed and highly destructive disease of sesame. Different synthetic media were tested to select suitable media for the growth of *M. phaseolina*. Among them, oat meal agar, malt dextrose, Elad and Chet medium showed

significantly high mycelial growth at 120 hrs. The maximum growth of *M. phaseolina* was observed at 30, 35 and 40°C which indicates preference towards higher temperatures and also maximum growth recorded at 5 and 7 pH. Extracts of safflower, mustard, sunflower, groundnut, soybean and sesame amended in media have shown more mycelial growth of *M. phaseolina* while castor stem extract recorded lowest growth.

Keywords: Media, Growth, *Macrophomina*, Sesame

The main reason for the low productivity of sesame is mainly due to the attack of various diseases. *M. phaseolina*, a pycnidia-producing fungus is one of the most important soil borne pathogens infecting over 500 plant species in more than 100 plant families around the world (Khan, 2007). The present investigation was carried out to find out the effect of media, temperature and pH levels that suit the growth and sporulation of *M. phaseolina*.

The growth of *M. phaseolina* on different solid media was compared by pouring 20 ml of each solid media in Petri dishes. Inoculation was done by transferring 5 mm mycelial disc taken from the periphery of seven-day-old culture on various media and plates were incubated at 25±2°C replicated thrice and radial mycelial growth was measured at different intervals after incubation. The growth of *M. phaseolina* was recorded by incubating at different temperatures of 15, 25, 30, 35 and 40°C and also at different level of pH 5, 7, 9 and 11 on PDA medium at different time intervals. The growth of fungus was recorded on extracts of semi mature stage of plant parts i.e. capsule/pod/head, leaf, stem, root of different oilseeds crops viz., castor, safflower, mustard, sunflower, groundnut, soybean and sesame at 50, 200, 300, 400 and 500 g/l as Plant extract dextrose Agar (PEDA) and PDA.

Among ten media tested, oat meal agar, malt dextrose agar, Elad and Chet agar, Czapeks agar showed significantly high growth at four intervals. However,

minimum radial growth was recorded in Bug agar followed by nutrient agar. The highest growth of mycelium covering entire Petri plate (90 mm) within 72 hours was recorded at temperatures of 40, 35 and 30°C and lowest growth recorded at 15 and 20°C. Sukanya *et al.* (2016) reported that *M. phaseolina* grew faster at 30°C and mycelial growth was not observed at temperature of 35 and 45°C. The mycelium of fungus covered 90 mm within 120 hrs at 5 and 7PH of PDA. The extracts of capsule, leaf, stem, root of oilseed crops viz., castor, mustard, safflower, soybean, sesame, groundnut (leaf, root) and sunflower had shown superior growth of mycelium. However, extracts of castor (stem), safflower (leaf) had shown lowest mycelium growth over control (PDA). The media amended with crop extracts had shown significant mycelial growth when compared with synthetic media and PDA which can be used further for *in vitro* studies.

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Studies on transmission of sesame phyllody through different methods

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ABSTRACT

Phyllody is a destructive disease of sesame worldwide. The disease has been causing significant economic losses by stunting, leaf proliferation and altering floral parts into leafy structures with no capsules. The transmission studies were conducted to transmit the phytoplasma from diseased plants to healthy plants. Using different methods like sap abrasion and sap injection methods to sesame and grafting, leafhopper transmission to periwinkle plants. Among host plants tested, sesame, sunhemp and periwinkle were identified as suitable hosts for the rearing of leafhopper (*Orosius albicinctus*). Among these methods, phytoplasma was successfully transmitted by grafting and leafhopper from infected sesame to periwinkle.

Keywords: Phyllody, Phytoplasma, Sesame, Transmission

Sesame phyllody is a very serious disease in most sesame growing regions. Infected plants showed characteristic symptoms of witch's broom, bushy

appearance, floral virescence, phyllody, and proliferation. Sesame phyllody can cause yield losses up to 80% (Salehi *et al.*, 2017). Due to paucity of

information on transmission of phytoplasma investigations were carried out on the transmission of this disease.

The leaf samples from phyllody infected plants were collected and then grounded in 0.02M phosphate buffer, the sap was filtered through muslin cloth (Akhtar *et al.*, 2009) and inoculated into 20, 25, 30, 35 days old healthy sesamum plants. For graft inoculation, the cut was made 2 cm below the tip in 30 days old plants of periwinkle and then grafted with the shoot exhibiting the phyllody disease symptom. A pot culture experiment was conducted to study the suitability of host plants for the rearing of leafhopper *viz.*, sunhemp, sesame, periwinkle, common bean and mint under caged conditions. For leafhopper transmission, the leafhoppers were collected from the phyllody infected field and then released into the 30 days old plants of healthy periwinkle plants. The inoculated plants were continuously monitored for development of phyllody symptoms.

Transmission of the infectious agent through the sap could not be achieved under greenhouse conditions, which indicated that sesame phyllody is not sap

transmissible. The periwinkle plants transmitted through grafting showed symptoms of yellowing, mottling at 45 days after inoculation. When periwinkle were placed in cages with infected leafhopper they showed symptoms of yellowing at 60 days after inoculation. Among the hosts studied for suitability, multiplication of leafhopper was observed on sesame, sunhemp and periwinkle. Hence, it indicated that grafting and leafhopper can successfully transmit the disease from diseased sesame to periwinkle.

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Foraging pattern of major pollinator fauna of sunflower

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ABSTRACT

The activity of pollen and nectar foragers were assessed in sunflower hybrid KBSH 53. Their foraging activity commenced from 6.00 hrs and continued till 18.00 hrs. The major *Apis* bee pollinators included *Apis dorsata*, *A. cerana indica* and *A. florea* and non *Apis* bees included *Xylocopa pubescens* F., *Xylocopa fenestrata* F., *Tetragonula iridipennis* S. and *Ceratina binghami* C. This study carried out for four consecutive years revealed that *A. dorsata* foraged for maximum time of 11 hours (7.01-8.00 hrs to 17.00-18.00 hrs) compared to other foragers. *A. cerana* and *A. florea* were active for only 10 hour (8.01-9.00 to 17.01-18.00 hours) and *Tetragonula iridipennis* for 5 hrs (13.01-14.00 to 17.00-18.00 hrs).

Keywords: Foragers, Pollinators, Honey bees, *Apis dorsata*, *Apis florea*, *Apis cerana*

Sunflower inflorescence creates good foraging source for bees by producing plenty of nectar and pollen. Honey bees visit sunflower in greater number, unlike other insects, which visit only for their own food, being eusocial, bees collect both nectar and pollen to fulfil the requirements of their entire colony (Muller *et al.*, 2006) thus facilitating cross pollination which is vital for seed set. The most frequent insect pollinators visiting sunflower are *Apis* bees besides, which significantly increase the seed yield of sunflower (Nderitu *et al.*, 2008). Therefore, with the above background the investigation was taken up to study the abundance and diversity of pollinators especially honey bees and their utilization in pollination is considered as an economical and eco-friendly approach in maximizing the yield of sunflower.

This field investigation on foraging pattern of pollinators was carried out for four consecutive years from *kharif* 2013 to *kharif* 2016 at the Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bengaluru. The experimental plot measuring 10 × 10 m size with KBSH 53 hybrid was selected for recording the abundance and diversity of pollinator fauna. In order to record the species abundance of bee pollinators ad libitum sampling of 10 heads was done for 5 minutes duration during each hour, commencing from 06.00 to 18.00 hrs during peak flowering stage. The frequency of visits by each pollinator species was recorded in order to identify the most abundant species visiting sunflower inflorescence.

Ad-libitum sampling of 10 heads for every one hour from 6.00 hrs to 18.00 hrs on KBSH-53 inflorescence in the full bloom stage of sunflower crop during kharif 2013 revealed the prevalence of pollinator viz., *Apis dorsata*, *A. cerana*, *A. florea*, *Tetragonula irridipennis*, *Xylocopa latipus*, *X. aestuans*. In general, the activity of all these pollinators was more between 9.00 and 12.00 hrs. The first sign of *A. dorsata* activity was observed during 7.00-8.00 hrs (0.30 ± 0.44) which gradually increased and reached a peak during 9.00-10.00 hrs (8.30 ± 1.74). *A. cerana* activity first commenced from 9.00-10.00 hrs (0.20 ± 0.24) and continued even up to 16.00 - 17.00 hrs (0.20 ± 0.40), with a peak in its activity during 11.00-12.00 hrs (1.50 ± 0.00). Activity of *A. florea* commenced from 9.00-10.00 hrs (0.60 ± 0.44) and continued till 14.00-15.00hrs (0.20 ± 0.40), with greater foraging activity during 9.00-10.00 hrs (0.60 ± 0.44) and 11.00 - 12.00 hrs (0.60 ± 0.24).

During kharif 2014, Ad-libitum sampling of 10 heads for every one hour from 6.00 hrs to 18.00 hrs on KBSH-53 inflorescence in the full bloom stage of sunflower crop revealed the prevalence of pollinator viz., *Apis dorsata*, *A. cerana*, *A. florea*, *Tetragonula irridipennis*, *Xylocopa latipus*, *X. aestuans*. The first sign of *A. dorsata* activity was observed during 6.00-7.00 hrs (0.35 ± 0.49) which gradually increased and reached a peak during 10.00-11.00 hrs (4.80 ± 0.95). *A. cerana* activity first commenced from 9.00-10.00 hrs (0.25 ± 0.44) and continued even upto 16.00 -17.00 hrs (0.20 ± 0.41), with a peak in its activity during 11.00-12.00 hrs (1.15 ± 0.59). Activity of *A. florea* commenced from 9.00-10.00 hrs (0.20 ± 0.41) and continued till 16.00-17.00hrs (0.25 ± 0.44), with greater foraging activity during 12.00-13.00 hrs (0.65 ± 0.67).

Ad-libitum sampling of 10 heads for every one hour from 6.00 hrs to 18.00 hrs on KBSH-53 inflorescence in the full bloom stage of sunflower crop during kharif 2015 revealed the prevalence of pollinator viz., *Apis dorsata*, *A. cerana*, *A. florea*, *Tetragonula irridipennis*, *Xylocopa latipus*, *X. aestuans*. The first sign of *A. dorsata* activity was observed during 7.00-8.00 hrs (0.25 ± 0.44) which gradually increased and reached a peak during 12.00-13.00 hrs (3.15 ± 0.99). *A. cerana* activity first commenced from 9.00-10.00 hrs (0.20 ± 0.41) and continued even upto 16.00 -17.00 hrs (0.15 ± 0.37), with a peak in its activity during 13.00-14.00 hrs (0.95 ± 0.60). Activity of *A. florea* commenced from 8.00-9.00 hrs (0.45 ± 0.60) and continued till 14.00-15.00hrs (0.20 ± 0.41), with greater foraging activity during 10.00-11.00 hrs (0.75 ± 0.64).

During kharif 2016, Ad-libitum sampling of 10 heads in every one hour from 6.00 hrs to 18.00 hrs on KBSH-53 inflorescence in the full bloom stage of sunflower crop revealed the pollinators viz., *Apis dorsata*, *A. cerana*, *A. florea*, *Xylocopa sp.*, *Tetragonula irridipennis*, and *Ceratina binghami*. In general, the pollinators activity was observed from 7.01 to 18.00 hrs. The first sign of *A. dorsata* activity was observed during

7.00 -8.00 hrs (6.23 ± 2.33) which gradually increased and reached a peak during 10.01-11.00 hrs (13.30 ± 2.37). *A. cerana* activity first commenced from 8.01-9.00 hrs (1.17 ± 0.87) and continued even up to 17.01 - 18.00 hrs (2.23 ± 1.41), with a peak in its activity during 10.00-11.00 hrs (2.50 ± 0.63). Activity of *A. florea* commenced from 8.01-9.00 hrs (1.03 ± 0.89) and continued till 17.01-18.00hrs (2.67 ± 0.92), with greater foraging activity during 10.01-11.00 hrs (3.07 ± 1.01).

Similar studies carried out by Devaramane *et al.* (2018) also revealed *Apis* pollinators were the dominant pollinators in sunflower variety Morden. This study for four consecutive years revealed that *A. dorsata* foraged for maximum time of 11 hours (7.01-8.00 hrs to 17.00-18.00 hrs) compared to other foragers. *A. cerana* and *A. florea* were active for only 10 hour (8.01-9.00 to 17.01-18.00 hours) and *Tetragonula irridipennis* for 5 hrs (13.01-14.00 to 17.00-18.00 hrs). The non *Apis* bee *Xylocopa* sp. also foraged for 10 hrs (8.01-9.00 to 17.01-18.00 hrs). Similarly, *Ceratina binghami* foraged for just 2 hours (14.01-15.00 hrs – 15.01-16.00 hrs). *A. dorsata* appeared to be the most predominant pollinator on sunflower under Bengaluru conditions. In an earlier study, Srikanta Nath (2008) observed that, *A. dorsata* was the most abundant pollinator on Morden variety of sunflower constituting 97.33 per cent of the total pollinators and remaining pollinators altogether constituted 2.67 per cent. Basavaraj *et al.* (2016) reported that, in the sunflower variety DRSF-108, *A. dorsata* was the most predominant natural visitor, which foraged for the maximum period of all 12 daylight hrs, followed by *A. cerana* (10 hrs) and *A. florea* (8 hrs). In conclusion, pollen and nectar foragers activity commenced from 6.00 and continued till 18.00 hrs. *Apis dorsata* was the most dominant species followed by *A. cerana* > *A. florea* > *T. irridipennis*.

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Management of rust red flour beetle (*Tribolium castaneum*) in stored sesame

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ABSTRACT

Red rust flour beetle (*Tribolium castaneum* Herbst) is one of the major constraints of stored sesame in India. They damage the stored-sesame seed by feeding, and severely reducing the quality of seed due to product excrement and larval feces. Experiment was conducted to evaluate the persistency of chemicals and plant products to manage *T. castaneum* in stored sesame. The data revealed that spinosad 45SC was the most effective treatment and recorded highest mortality of adult beetles at 24th, 5th after release during first (83.75% and 100%), second (73.13% and 79.38%) and third months (68.75% and 80.63%) after release. NSK and neem leaf powder were also found effective and recorded 93.75 and 86.25%, 85 and 73.75% and 81.25 and 72.50% mortality of beetles at 25th day after release during 1st, 2nd and 3rd months after release respectively.

Keywords: Management, Sesame, Storage pest, *Tribolium castaneum*

Post-harvest losses of food grain in storage by insect pests are a serious problem, particularly in the developing and underdeveloped countries. In spite of direct consumption of food grains, insect pests damage the food grains also by accumulation of exuviae, webbing, and cadavers. The red flour beetle, *Tribolium castaneum* (Herbst) is the most destructive and cosmopolitan insect pest of stored grains posing severe threat to post-harvest storage of sesame. It is the most abundant stored product insect pests found in flour mills and also causes serious damage on dried fruits, pulses and prepared cereal foods, such as cornflake, pasta, biscuit, beans, nuts, etc. Both grub and adults of this beetle damage the food grains and spend its entire life cycle outside of the seed. The reproductive potential of this beetle is very high it can breed throughout the year in warm areas. So, the present work has undertaken study of the persistency of chemicals and plant products to manage *T. castaneum* in stored sesame.

An experiment was conducted in the laboratory of Project Coordinating Unit Sesame and Niger, College of Agriculture, JNKVV, Jabalpur to evaluate the persistency of chemicals and plant products against *T. castaneum* in stored sesame. Healthy sesame seed of variety TKG-22 was procured from PC Unit sesame and Niger and bring down the moisture of the seed to less than 8%. Treated 500g sesame seed with respective treatments, mixed thoroughly and kept in plastic containers. The specified doses of insecticides were diluted by using 10 ml water/kg seed. The seed were dried in shade and the sample of 60 g seed (20 g/replication) were taken from each treatment at 24 hr. after treatment in small plastic containers. Twenty adults of mixed sex were released in each jar containing treated seed as well as in the control. The mouth of the

containers were covered with muslin cloth and tightened with a rubber band and stored at room temperature. To calculate per cent adult mortality, numbers of dead adults were counted from infested jars after 24 hours and 5, 10, 15, 20, 25 days after release. Moribund beetles were counted as dead.

The data revealed that during first month, mortality of *T. castaneum* at 24 hours after release was observed to be maximum (83.75%) in spinosad 45 SC followed by deltamethrin (82.50%) treated seed. The results of our study are in line with Andric *et al.* (2010), who examined the susceptibility of *T. castaneum* and proved that the most toxic insecticide for adults was deltamethrin. In chemical treated seed 100% mortality was recorded at 5th day after release, while in case of NSK powder and neem leaf powder it was only 10.0 and 6.25 % respectively. During second month 100% mortality was observed in all the chemical treated seed at 20 days after release while in case NSK powder and Neem leaf powder it was only 76.25 and 62.50 respectively. During third month, mortality of beetle was reduced in all the treatment. However, in spinosad and deltamethrin it was observed 71.25% and 67.25% respectively at 24 hours after release which increased gradually and recorded to be maximum of 100% after 20 days of release. Present findings are corroborated with the findings of Bonjour *et al.* (2008) and Yousafnezhad (2007), they reported that spinosad provided long term control on *Rhizopertha dominica* and *T. castaneum* population up to 96 weeks.

In the light of the findings of present study, it could be stated that spinosad 45SC was found most effective to reduce the population of *T. castaneum* in stored sesame. It is a commercial biological insecticide based on fermentation product of *Actinomycetales bacterium*,

Saccharopolyspora spinosa. It provides us an opportunity to use in an eco-friendly way to manage *T. castaneum* and it could also be used as a component in integrated pest management approaches for managing stored grain pests.

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Bioefficacy and evaluation of newer insecticides against whitefly in castor

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ABSTRACT

Castor is attacked by several sucking pests. Among them, whitefly, *Trialeurodes ricini* is the major pest during *rabi* season resulting in extensive losses in the yield. A field trial was conducted to evaluate the bio-efficacy of seven newer insecticides for the management of whitefly. After two rounds of spraying, the pooled mean population of whiteflies was lowest in the treatment profenophos 50EC @ 2 ml/l followed by buprofezin 25SC @ 1.5 ml/l. Reduction of whitefly population over control indicated that buprofezin 25SC @ 1.5 ml/l reduced the whiteflies population up to 71.2% followed by profenophos 50EC @ 2 ml/l (67.5% reduction over control).

Keywords: Castor, Newer insecticides, Whitefly, Cost benefit ratio

Castor is attacked by number of insect pest right from sowing to harvesting. Among these, sucking pests viz., leafhopper, whitefly and thrips played an important role in early stages resulting in extensive losses in the grain yield. Repeated applications of broad spectrum insecticides with similar mode of action resulted in development of resistance. Considering the seriousness of the problem, newer insecticides were evaluated for the management of whitefly in the present experiment.

Field experiments were carried out at Tapioca and Castor Research Station, Yethapur, Tamil Nadu to evaluate the efficacy of newer insecticides against whitefly of castor. Seven new insecticides viz., buprofezin 25SC @ 1.5 ml/l, diafenthiuron 50WP @ 1 g/l, flonicamid 50WG @ 0.2 g/l, acetamiprid 20SP @ 0.2 g/l, thiamethoxam 30FS @ 0.5 g/l, imidacloprid 17.8SL @ 0.5 ml/l, Siliguri botanical pesticide @ 4g/l along with conventional insecticides (profenophos 50EC @ 2 ml/l and dimethoate 30EC @ 1.7ml/l) were evaluated against whitefly. The trial was laid out during *rabi* 2018-19 with 10 treatments in a plot size of 4.5 m x 6.0 m adopting a spacing of 90 cm x 60 cm using the castor hybrid DCH-519 and replicated thrice. Sowing was taken on 12.11.2018 and first spray was done on 22.02.2019 followed by second spray on 09.03.2019. The treatments were imposed two times (at about 100 DAS and 115DAS) and data on population of the pest one day

before and 1, 3, 7 and 14 days after imposition of the treatment was recorded.

The pooled mean pre-treatment population of whiteflies ranged from 8.8 to 17.7 whiteflies/3leaves/plant in different treatments. After two rounds of spraying, the pooled mean population of whiteflies was lowest in the treatment profenophos 50EC @ 2 ml/l which recorded 7.9 whiteflies/3 leaves/plant followed by buprofezin 25SC @ 1.5 ml/l which recorded 10.7 whiteflies/3 leaves/plant. Similar results was obtained by Duraimurugan and Alivelu (2017) and Patel and Muralidharan (2014). Reduction of whitefly population over control indicated that buprofezin 25SC @ 1.5 ml/l reduced the whiteflies population up to 71.2% followed by profenophos 50EC @ 2 ml/l, registered 67.5%.

Significantly high seed yield was recorded in buprofezin 25SC @ 1.5 ml/l treated plots (1210 kg/ha) with 87.6% increase over untreated control, followed by profenophos 50EC @ 2 ml/l (1041 kg/ha) and thiamethoxam 30FS @ 0.5 g/l (1009 kg/ha) with 40.4 and 38.5% increase over untreated control, respectively as against the minimum yield of 620 kg/ha recorded in the untreated control (Table 1). Highest cost benefit ratio was obtained from buprofezin 25SC @ 1.5ml/l (1:2.74) followed by profenophos 50EC (1:2.29) and imidacloprid 17.8SL @ 0.5 ml/l (1: 2.15).

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Table 1 Evaluation of new insecticides of whitefly on yield and economics in castor

Treatments/Dose	Yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	C:B Ratio
T1 Buprofezin 25 SC (1.5 ml/l)	1210	22020	60500	38480	1:2.74
T2 Diafenthiuron 50WP (1.0g/l)	920	22240	46000	23760	1:2.06
T3 Flonicamide 50 WG (0.2g/l)	990	23754	49500	25746	1:2.08
T4 Acetamiprid 20 SP (0.2g/l)	850	25340	42500	17160	1:1.67
T5 Thiomethaxam 30 FS (0.5 g/l)	1009	23800	50450	26650	1:2.11
T6 Imidacloprid 17.8 SL (0.5ml/l)	940	21770	47000	25230	1:2.15
T7 Dimethoate 30EC (1.7 ml/l)	810	22080	40500	18420	1:1.83
T8 Profenophos 50EC (2.0 ml/l)	1041	22710	52050	29340	1:2.29
T9 Siliguri botanical pesticide (4.0 gm/l)	901	21200	45050	23850	1:2.12
T10 Untreated control	620	19000	31000	12000	1:1.63
CD(P=0.05)	147.9		-	-	-

Traps: a low cost IPM tool for pest monitoring and management in groundnut ecosystem

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ABSTRACT

Monitoring of insect pests in groundnut ecosystem using traps (pheromone and yellow sticky traps) was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Raichur, Karnataka for a period of seven years (2012-2018). The pooled data of the trap catches showed that highest numbers of *Spodoptera litura* were caught during the 45th standard meteorological week (79.80/trap), while the leafhopper, thrips and leaf miner catches recorded highest numbers during 43rd (7.2/trap), 40th (7.6/trap) and 38th (4.2/trap) standard meteorological week, respectively.

Keywords: Groundnut, Integrated pest management, Pheromone traps, Yellow sticky traps

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop and the yield of which is affected by some of the severe pests attacking it. The low productivity hurdles comprises a number of components specially the pest management in groundnut ecosystem. The major pests viz., *Spodoptera litura*, leaf miner and thrips cause economic loss and apart from that, thrips act as vector of peanut bud necrosis disease which may account to cent percent yield loss if not managed timely. However, much chemical insecticides are used by the farmers to manage these pests which increase the cost of management and also result in ecological imbalance (Ghewande and Nandagopal, 1997). In order to minimize the cost of management and economic sustainability, low cost tool selection like traps is the need of the hour (Cork and Hall, 1998).

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Field experiment on monitoring of pests on groundnut was carried out for seven years (2012-2018) at Main Agricultural Research Station, Raichur. Five traps per hectare (for *Spodoptera litura*) and ten yellow sticky traps per hectare (for thrips, leafhoppers and leaf miners) were installed in the field. The trap catches were recorded every week throughout the crop duration. Further the number of individuals caught in the trap were averaged and presented in the table. Monitoring of *Spodoptera litura* through pheromone traps indicated moth activity throughout the cropping period with peaks during 42nd (69.4 moths/trap), 43rd (75.6 moths/trap) and 45th (79.8 moths/trap) standard meteorological weeks during the *kharif* season (Figure 1). Meanwhile, *rabi* season trap catches indicated highest population during 51st (100 moths/trap) standard week followed by 52nd

(70 moths/trap) and 1st (64 moths/trap) standard meteorological weeks respectively (Fig. 2).

Further, the activity of thrips was noticed from first week of August to fourth week of October with peak population during second fortnight of August and first fortnight of September. Among the different species of thrips, *Thrips palmi* Karny and *Frankliniella schultzei* Trybom were predominant. The trap catches during *kharif* season showed peak catches during 40th (7.6/trap) and 41st (7.0/trap) standard meteorological weeks during *kharif* and 2nd (5.8/trap) and 4th (6.0/trap) standard meteorological weeks respectively during *rabi* seasons. Highest activity of leafminer was noticed during 38th (4.2/trap) standard meteorological week, while much leafhopper activity was noticed during 37th (6.6/trap), 40th (6.6/trap) and 43rd (7.2/trap) standard meteorological week respectively during *kharif* season. Meanwhile, *rabi*

season traps catches recorded highest leafhopper activity during 1st (3.5/trap), 2nd (3.5/trap), 3rd (3.9/trap) standard meteorological week respectively (Figure 1 & 2).

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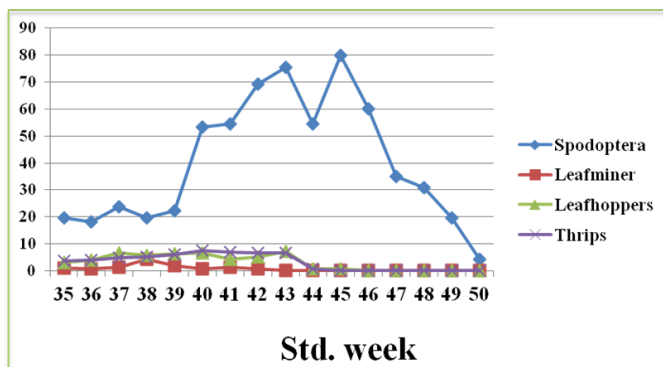


Fig. 1. Trap catches of groundnut insect pests (*kharif*, pooled)

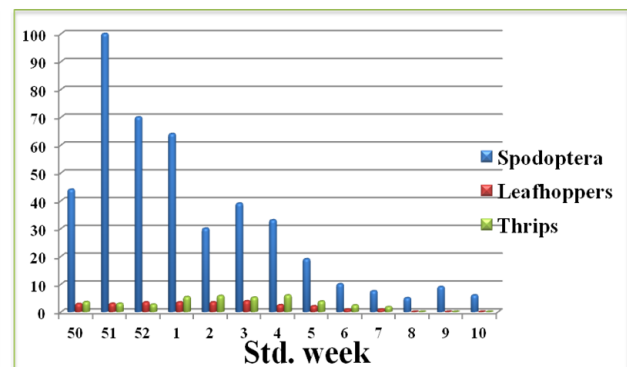


Fig. 2. Trap catches of groundnut insect pests (*rabi*, pooled)

Bio-intensive IPM module for management of mustard aphid

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ABSTRACT

IPM module viz., dimethoate 30EC @ 1ml/l followed by its second application after 10 days, *Azadirachtin* 300ppm @ 5 ml/l followed by application of *Verticillium laecanii* @ 2 gm/l and *Azadirachtin* followed by application of *Beauveria bassiana* @ 2 g/l after 10 days of spray were at par and reduced aphid population effectively (4.43, 6.73 and 9.16 /10 cm twigs, respectively).

Keywords: IPM module, Management, Mustard aphid

Mustard aphid alone is causing up to 95 per cent reduction in the yield under various agro climatic conditions. A field trial was conducted at Oilseed Farm, C S Azad University of Agriculture & Technology, Kanpur. The trial was laid out in RBD with three replications using mustard cultivars Urvashi. Six IPM modules viz., *Azadirachtin* 300 ppm @ 5 ml/l followed by its second spray after 10 days, *Azadirachtin* followed by application of *Beauveria bassiana* @ 2g/l after 10 days of *Azadirachtin* application, *Beauveria bassiana*

followed by its second application after 10 days, *Azadirachtin* followed by application of *Verticillium loecanii* @ 2 g/l after 10 days of *Azadirachtin* application, *Verticillium loecanii* @ 2 g/l followed by its second application after 10 days and Dimethoate 30EC @ 1 ml/l followed by its second application after 10 days. The treatment of dimethoate 30EC @1ml/l followed by its second application after 10 days, *Azadirachtin* 300ppm @ 5 ml/l followed by application of *Verticillium laecanii* @ 2 gm/l and *Azadirachtin*

followed by application of *Beauveria bassiana* @ 2 g/l after 10 days of spray were at par and reduced aphid population effectively i.e. 4.43, 6.73 and 9.16/10 cm twigs, respectively. Treatment *Azadirachtin* followed by its second spray after 10 days also minimized aphid

population upto 12.63 aphids/10 cm twigs as compared to control 202.70 aphids/10 cm twigs. The spray of Dimethoate followed by its second application after 10 days was gave highest yield i.e. 1825 kg/ha with IBCR (56.52).

Seasonal incidence of major insect pests in the multi-storey farming of Mahaneem, pulses and castor in south west Haryana

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ABSTARCT

In the present study, no. of insect pest infestation was observed on the Mahaneem (*Ailanthus excelsa*) plant. The major loss in the form of mean infestation level in castor was observed by red hairy caterpillar, *Amsacta moorei* (30% defoliation); castor semilooper, *Achaea janata* (25% defoliation); tobacco caterpillar, *Spodoptera litura* (55% defoliation) and leafhopper, *Empoasca flavescens* (20 % leaf infestation). It was noticed that castor shoot and capsule borer *Conogethes punctiferalis* infestation was only 8 percent capsule damage, however, its damage was 25% on capsule in monocrop of castor. The major infestation in the pulses i.e. urd bean, cowpea and mung bean was observed by spotted pod borer *Maruca testulalis* 80 percent pod damage, red hairy caterpillar (25% defoliation) and leafhopper *Empoasca kerri* (27% leaf infestation). It was concluded in the present study that there was no effect on the incidence of insect pests on mahaneem, pulses and castor except castor capsule borer damage. It might be due to least host preference of this insect towards multi-storey farming system plantation. The study proved successful multi-storey farming system of Mahaneem, pulses and castor in reference to insect pests attack in south west Haryana.

Keywords: Agri-silviculture, Castor, Infestation, Insect-pests, Intercrops, Mahaneem, Multi-storey

Food security for people is a must and mandatory for the speedy developing country, India in the current over populated era. In such over populated situation intensive farming is done due to quite low land holding per capita. Therefore, intercropping, relay cropping, mixed cropping, crop rotation even multi storey farming with effective integrated pest management is essential for at least sustainable agricultural production. Mahaneem is an important tree used in pulp and paper industry and has been found suitable tree species for agri-silviculture system in South-West Haryana. Castor is an important non edible and industrial crop of India which is gaining acreage in Haryana too. Mung bean, urd bean and cowpea are kharif pulses which can be successfully grown in wide row spaced crops like castor Singh (2009) and Keshavmurthy and Yadav (2019). Hence, considering the above target, this study was undertaken.

An experiment to study incidence of major insect pests causing losses to plantation in the multi-storey farming of Mahaneem (*Ailanthus excelsa*), pulses and castor was laid out in the research farm of Regional Research Station, Bawal (Rewari), Haryana during the *kharif*, 2019. All the crops were sown on July 31, 2019 in the field having sandy soils under irrigated conditions. Improved varieties of all the intercrops *viz.*, MH-421 (mung bean), UH-1(urd bean) and Pant-1 of cowpea

were sown in castor (DCH-177) at 180 x 90 cm spacing. Mahaneem (*Alianthus excelsa*) had been planted seven years back. Fortnightly observations were recorded for insect pest infestation level of major insect pests proved responsible for the losses in the multi-storey farming starting 30 days after sowing. Mean of all the observations were calculated and tabulated.

No infestation of any major insect pest was observed on the Mahaneem plant in multi-storey as well as sole plantation. The major losses as shown in the Table 1 in the form of mean infestation level in castor in multistorey farming (Agri-silvi) was observed by red hairy caterpillar, *Amsacta moorei* (30.5% defoliation); castor semilooper, *Achaea janata* (25.4% defoliation); tobacco caterpillar, *Spodoptera litura* (55.7% defoliation) and leafhopper, *Empoasca flavescens* (20.3% leaf infestation) and capsule borer *Conogethus punctiferalis* 8.2 per cent. In case of cow pea the mean infestation of red hairy caterpillar, castor semilooper, tobacco caterpillar, leafhopper and spotted boll worm (*Maruca testulalis*) was found 10.4, 0.6, 1.7, 17.2 and 80.4 percent, respectively. In case of urd bean the mean infestation was observed by red hairy caterpillar (10.0), castor semilooper (0.5), tobacco caterpillar (1.9), leaf hopper (16.8) and spotted boll worm (69.1 per cent). The mean infestation (%) in mung bean was observed by red hairy caterpillar (9.3), castor semilooper (0.2), tobacco

caterpillar (1.5), leafhopper (15.1) and spotted boll worm (74.5). However, the mean percent infestation in sole crop system of castor, cowpea, urd bean and mung bean was observed by red hairy caterpillar (30.80, 9.8, 11.0 and 9.9, respectively), castor semilooper (26.2, 0.9, 0.3, and 0.3, respectively), tobacco caterpillar (54.4, 1.6, 1.8, and 1.0, respectively), leafhopper (21.1, 17.6, 17.9 and 16.5 respectively) and spotted boll worm (0.0, 76.7, 60.2 and 65.1 respectively). It was noticed that castor shoot and capsule borer *Conogetus punctiferalis* infestation led to 25 percent capsule damage in sole crop of castor. No infestation of capsule borer was observed in cow pea, urd bean and mung bean. Kumar and Jayakumar (2018) have also reported infestation (defoliation) in castor.

It was concluded in the present study that there was no effect on the incidence of insect pests on Mahaneem, pulses and castor except more castor capsule borer

damage in sole crop. It might be due to least host preference of this insect towards multi-storey farming system plantation. The study proved successful multi-storey farming system of Mahaneem, pulses and castor in reference to insect pests attack in south west Haryana.

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Table 1 Seasonal incidence of major insect-pests in inter-crops in multi-storey agri-silvi farming system

Cropping system	Crops	Mean Infestation of Insect-pests on <i>Alianthus</i> and inter crops (%)					
		Red hairy caterpillar	Castor semilooper	Tobacco caterpillar	Leafhopper	Castor shoot and capsule borer	Spotted boll worm
Agri-silvi	Castor	30.5	25.4	55.7	20.3	8.2	-
	Cowpea	10.4	0.6	1.7	17.2	-	80.4
	Urdbean	10.0	0.5	1.9	16.8	-	69.1
	Mungbean	9.3	0.2	1.5	15.1	-	74.5
Sole crops	Castor	30.80	26.2	54.4	21.1	25.0	-
	Cowpea	9.8	0.9	1.6	17.6	-	76.7
	Urdbean	11.0	0.3	1.8	17.9	-	60.2
	Mungbean	9.9	0.3	1.0	16.5	-	25.1

Integrated management of root rot of sesamum caused by *Macrophomina phaseolina* (Tassi) Goid.

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ABSTRACT

Integrated treatment viz., seed treatment with *Trichoderma viride* + *Pseudomonas fluorescens* @ 5 g/kg each + soil application of *P. fluorescens* @ 2.5 kg/ha + *T. viride* @ 2.5 kg/ha enriched in FYM + neem cake @ 250 kg/ha at the time of sowing resulted in minimum root rot incidence (13.0 %) and maximum percent reduction of disease over control (68.8%) and yield (304 kg/ha).

Keywords: Integrated management, *Macrophomina phaseolina*, Root rot, Sesamum

The production and productivity of sesame is constrained by many biotic and abiotic stresses. Among the biotic stresses, root rot caused *Macrophomina phaseolina* (Tassi) Goid is an economically important and widespread soil borne disease of sesame causing substantial yield losses in farmer field's during kharif and summer season especially in turmeric and cotton fallows. The present study was aimed at developing an integrated disease management (IDM) module for management of root rot in sesamum.

The field experiment was conducted consecutively for three years (*kharif* seasons of 2014, 2015 and 2016) and 2 summer seasons (2015 and 2018) in randomized block design (RBD) with 3 replications, 2.4×3 m² plot size per replication at Regional Agricultural Research Station, Polasa, Jagtial, Telangana state. The per cent disease incidence was calculated by counting the number of affected and healthy plants at random quadrat selection in each plot.

The pooled mean of three *kharif* seasons revealed that, the minimum root rot incidence (13.0 %) and maximum percent reduction of disease over control (68.8%) and yield (304 kg/ha) was realized in integrated treatment T5 i.e. seed treatment *T. viride* (Tv) + *P. fluorescens* (Pf) @ 5 g/kg each + soil application of *P. fluorescens* @ 2.5 kg/ha + *T. viride* @ 2.5 kg/ha enriched in FYM + neem cake @ 250 kg/ha at the time of sowing, whereas the maximum incidence (41.7 %) and minimum yield (127 kg/ha) was recorded in untreated check (Nayan *et al.*, 2019). Similar kind of results were obtained during summer season also (Table 1). Overall, the incidence of root rot was less during summer as compared to *kharif*. However, maximum yield was realized in summer over *kharif*. The yield reduction during *kharif* was due to severe incidence of

phyllody in experimental plots. It was found that, combined application of bio-control agents (*T. viride* and *P. fluorescens*) as seed treatment and soil application showed the minimum root rot incidence and higher yields as compared to application of bio-control agent alone and over untreated check.

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Table 1 Integrated management of root rot disease of sesame

Treatment	Pooled data (<i>Kharif</i> , 2014, 2015 and 2015)			Pooled (Summer, 2015 and 2018)	
	Root Rot (%)	Phyllody (%)	Yield (kg/ha)	Root Rot (%)	Yield (Kg/ha)
T1-Seed treatment <i>T. viride</i> @ 4 g/kg + soil application of Tv @ 2.5 kg/ha enriched in 100 kg of FYM at sowing.	18.5 (25.1)	21.3 (26.8)	231	11.9 (19.6)	664
T2-Seed treatment <i>P. flourescens</i> @ 10 g/kg + Soil application of Pf @ 2.5 kg/ha enriched in 100 kg of FYM at sowing.	24.0 (28.8)	22.4 (27.7)	204	12.9 (19.9)	654
T3-Seed treatment <i>T. viride</i> @ 4 g/kg + soil application of Tv @ 2.5 kg/ha enriched in 100 kg of FYM + neem cake @ 250 kg/ha at sowing.	23.1 (28.4)	25.0 (29.3)	226	6.8 (14.1)	611
T4-Seed treatment <i>P. fluorescens</i> @ 10 g/kg + soil application of Pf @ 2.5 kg/ha enriched in 100 kg of FYM + neem cake 250 kg/ha at sowing.	22.6 (27.6)	23.4 (28.3)	261	16.1 (23.4)	672
T5-Seed treatment Tv + Pf @ 10 g /kg + Soil application of Pf @ 2.5 kg/ha + Tv @ 2.5 kg/ha enriched in 100 kg of FYM + neem cake @ 250 kg/ha at sowing.	13.0 (20.9)	17.8 (24.7)	304	9.3 (15.8)	769
T6-Seed treatment Carbendazim @ 2 g/kg + soil drenching with Carbendazim @ 1 g/l.	33.4 (35.1)	19.8 (25.9)	183	13.5 (21.2)	561
T7-Untreated check	41.7 (40.1)	27.8 (31.6)	127	27.7 (31.7)	473
S.Em ±	2.7	2.2	17.1	3.1	70.1
CV%	18.7	17.0	13.6	23.5	19.3
LSD (5%)	7.7	6.3	49.0	9.0	204

*mean of 3 replications; figures in parenthesis are angular transformed values

Genetic variability for Alternaria leaf blight resistance in groundnut genotypes

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ABSTRACT

Fifty genotypes were screened for resistance to *Alternaria* leaf blight during three successive summer seasons during 2013 to 2015. Pooled analysis of variance indicated significant genotypic differences observed for resistance of *Alternaria* leaf blight indicating the existence of genetic variability among the 50 genotypes. *Alternaria* leaf blight had high heritability coupled with high genetic advance as per cent of mean revealed selection would be effective for improving this trait in studied genotypes. Based on three year data two advanced breeding lines *viz.*, PBS-12169,

PBS-12190 found resistance to *Alternaria* leaf blight. These genotypes can be used in breeding programme for developing high yielding groundnut cultivars resistance to *Alternaria* leaf blight.

Keywords: *Alternaria* leaf blight, Genetic variability, Genotypes, Groundnut

Groundnut (*Arachis hypogaea* L.) is an important self-pollinated oilseed crop grown in 117 countries with different agro-climatic conditions between 40°N to 40°S latitudes. In India, last 4-5 years it has been observed that incidence of *Alternaria* leaf blight has continued to increase in farmers field of summer groundnut in Gujarat. *Alternaria* leaf blight is becoming a major disease in *rabi*-summer groundnut particularly in major groundnut growing states like Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat and Maharashtra. These five states account for about 80% area of total *rabi*-summer groundnut area of country. It has been reported that *Alternaria* leaf blight reduced 13-22% pod yield, 24-63% haulm yield and it also affects kernel quality in groundnut (Kumar *et al.*, 2012). The objective of this investigation was to evaluate groundnut genotypes for resistance to *Alternaria* leaf blight and to identify resistance sources.

A total of 50 genotypes including advanced breeding lines, interspecific derivatives and cultivars recommended for summer season were screened for resistance to *Alternaria* leaf spot during three successive summer seasons during 2013 to 2015 following RBD with three replications and disease was scored using modified 1-9 scale. Data on pod yield (kg/ha), shelling out-turn (%), days to maturity and 100 kernel weight (g), SPAD chlorophyll meter reading (SCMR) and Specific leaf area (cm²/g) at 50 and 80 DAS were recorded. Analysis was performed using DSAASAT (Onofri, 2007).

Pooled analysis of variance indicated significant genotypic differences observed for all the traits. Disease incidence ranged between 3 and 9 on 1-9 scale.

Maximum average disease score was observed in an advanced breeding line PBS 12092 (8.7 on 1-9 scale). Two advanced breeding lines *viz.*, PBS-12169, PBS-12190 had disease score ≤ 4.3 which was at par with resistant check NRCGCS 349 (with 4.3 score). High heritability along with high genetic advance as per cent of mean observed for *Alternaria* leaf blight indicated that this disease is least influenced by environmental effect. Hence selection would be rewarding for improving this trait due to additive effect. Based on pod yield (kg/ha), top five high yielding and low yielding genotypes were selected and observed difference between these two groups for all characters. High yielding genotypes had tolerance to *Alternaria* leaf blight (≤ 6.0 on 1-9 scale), high shelling out-turn (68%), short duration (114 days), high HKW (39g), high SCMR (33), low SLA (176 and 160 cm²/g at 50 and 80 DAS respectively) while low yielders were susceptible to *Alternaria* leaf blight and were also having lower value of all the studied traits except SLA.

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Evaluating bio-safety of newer and conventional insecticides against parasitoids and predators of castor whitefly

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ABSTRACT

This investigation was carried out to evaluate the bio-safety of newer and conventional insecticides tested against *Eretmocerus mundus*, *Nephus regularis*, *Chilocorus nigirita* under laboratory conditions at Tapioca and Castor Research Station, Yethapur. The results showed that diafenthiuron 50 WP @ 0.8g/l and buprofezin 25 SC @ 0.8 ml/l recorded lowest adult mortality of *Eretmocerus mundus* (60 and 65 percent), *Nephus regularis* (40.60 and 39.40 per cent) and *Chilocorus nigirita* (39.20 and 34.60 per cent) respectively and highest adult emergence (74.41 and 73.49 percent) in *Eretmocerus mundus*. However, thiomethaxam 25 WG0.4 g/l and dimethoate 30 EC1.7 ml/l were very harmful to parasitoid and predators.

Keywords: Bio-safety, Castor, Insecticides, Parasitoids, Predators, Whitefly

The average productivity of castor is low in *rabi* season (309 kg/ha) in Tamil Nadu and other states in Southern and Central India due to castor whiteflies. The yield losses to the tune of 12.4 to 15 % due to whitefly were reported from Gujarat (Khanpara and Patel, 2002). *Rabi* Castor ecosystem which is predominantly infested by the castor whitefly also harbours parasitoid like *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae), and predators like *Nephus regularis*, *Chilocorus nigrita* (Coleoptera: Coccinellidae) naturally controlling the pest population. The insecticides commonly used to control the pest population have indirect effect on these natural enemies. Hence, the study was conducted to assess the effect of different newer molecule and other conventional molecules used in castor ecosystem on these natural enemies under laboratory conditions and search for comparatively less toxic insecticide against natural enemies to be incorporated into IPM programs.

The parasitoid of castor whiteflies, *Eretmocerus mundus* and predators, *Nephus regularis*, *Chilocorus nigrita* was maintained at Tapioca and Castor Research Station, Yethapur used for the study. Commercial formulations of nine newer chemical insecticides along with one conventional insecticide (clothianidin 50 WDG @ 0.1 g/l, flonicamid 50 WG @ 0.2 g/l, acetamiprid 20 SP @ 0.2 g/l, thiomethaxam 25 WG @ 0.4 g/l, imidacloprid 17.8 SL @ 0.5 ml/l, buprofezin 25 SC @ 0.8 ml/l, diafenthiuron 50 WP @ 0.8 g/l, profenophos 50 EC @ 2 ml/l, dimethoate 30 EC @ 1.7 ml/l along with an untreated control) were used in the experiment. The bioassay was conducted in completely randomized design with nine insecticide treatments along with an untreated control and replicated five times. Dry film residue method described by Desneux (2006) was used to evaluate the toxic effect of insecticides to adults under laboratory conditions and the adult mortality of parasitoids and predators were recorded at 24 and 48 hrs after treatment (HAT).

The insecticidal effect on life stages and was classified as per International Organisation for Biological Control, West Palaearctic Regional Section (IOBC/WPRS) Working Group (Nasreen 2000). The per cent mortality values were converted to arcsine percentage and subjected to analysis of variance (ANOVA) followed by means separation using least significant difference (LSD) test at 5% level of significance.

The results revealed that there were significant differences between the insecticidal treatments with respect to percentage adult mortality of *E. mundus*. Untreated control caused no mortality whereas diafenthiuron 50 WP @ 0.8g/l and buprofezin 25 SC @ 0.8 ml/l recorded low adult mortality of 60 and 65 per

cent and were found at par with each other. Dimethoate 30 EC @ 1.7ml/l and thiomethaxam 25 WDG @ 0.4g/l recorded highest mortality of 100 per cent. Based on the criteria suggested by IOBC to evaluate the toxicity of insecticides to *E. mundus* adults the insecticides like diafenthiuron 50 WP @ 0.8g/l, buprofezin 25 SC @ 0.8 ml/l, flonicamid 50 WG @ 0.2 g/l and acetamiprid 20 SP @ 0.2g/l were rated as slightly harmful (30-79% mortality). Buprofezin 25 SC 0.8 ml/l and diafenthiuron 50 WP 0.8 g/l recorded highest per cent adult emergence of 74.41 and 73.49 respectively.

The results revealed that there were significant differences between the insecticidal treatments with respect to percentage adult mortality of *N. regularis*. Diafenthiuron 50 WP @ 0.8g/l and buprofezin 25 SC @ 0.8 ml/l recorded low adult mortality of 40.60 and 39.40 per cent and were found at par with each other, while dimethoate 30 EC @ 1.7 ml/l and thiomethaxam 25 WDG @ 0.4g/l recorded highest mortality of 94.50 and 92.60 per cent respectively. Based on the criteria suggested by IOBC to evaluate the toxicity of insecticides to natural enemies the insecticides like diafenthiuron 50 WP @ 0.8g/l, buprofezin 25 SC @ 0.8 ml/l were rated as harmless (< 50%) whereas thiomethaxam 25 WDG @ 0.4g/l was rated as moderately harmful (80-99%) to adults of *N. regularis*.

The results also revealed that there were significant differences between the insecticidal treatments with respect to percentage mortality of adult of *C. nigrita*. Untreated control caused no mortality whereas diafenthiuron 50 WP @ 0.8g/l and buprofezin 25 SC @ 0.8 ml/l recorded low adult mortality of 39.20 and 34.60 per cent respectively. While dimethoate 30 EC @ 1.7ml/l and thiomethaxam 25 WDG @ 0.4g/l recorded highest mortality of 90.40 and 92.10 per cent. Based on the criteria suggested by IOBC to evaluate the toxicity of insecticides to *Chilocorus nigrita* adults the insecticides like diafenthiuron 50 WP @ 0.8g/l, buprofezin 25 SC @ 0.8 ml/l, were rated as harmless (< 50% mortality), while dimethoate 30 EC @ 1.7ml/l and thiomethaxam 25 WDG @ 0.4g/l were moderately harmful (80 - 99%) to adult of *C. nigrita*.

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Response of newly developed sunflower hybrids and varieties against downy mildew disease

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ABSTRACT

Sunflower entries under AICRP sunflower were tested in downy mildew sick plot and the data revealed that 10 entries were susceptible to the disease. Six hybrids *viz.*, IIOSH-2, NCSH-2431, BLSFH-15005, SVSH-498, SVSH-475 and LSFH-1751 were totally free from downy mildew incidence.

Keywords: Downy mildew, Hybrids/varieties, Sunflower

Sunflower (*Helianthus annuus* L.) downy mildew disease incited by *Plasmopara halstedii* (Farl) Berl & De-Toni is one of the yield limiting factors. Due of seed-borne nature of the fungus, the disease has rapidly distributed through-out the world by seed trade (Leepik,1966). Downy mildew sick plot has been developed at Oilseeds Research Station, Latur which facilitates effective screening of sunflower genotypes against this disease under high disease pressure condition. Some newly developed sunflower hybrids and varieties included in All India co-ordinated trials were screened against downy mildew disease in downy mildew sick plot to know the downy mildew disease reaction of these hybrids/varieties for further exploitation.

Newly developed 16 sunflower hybrids/varieties with one check (Morden) included under All India Co-ordinated programme were screened against downy mildew under high disease pressure during *kharif* season of 2017-18 in downy mildew sick plot. In order to have effective screening of sunflower hybrids/varieties, a radical inoculation technique (Patil *et al.*, 1992) was followed. At the time of sowing one row (3 m) of each test entry was alternated with a row of downy mildew

susceptible variety Morden, which served as infector row. After germination, all the test entries were sprayed on daily basis with downy mildew fungal inoculum for a period of 15 days in order to create maximum disease pressure. Observations on downy mildew incidence on each test entry were recorded on fortnightly basis for 60 days.

The downy mildew incidence ranged from 0% to a maximum of 82.5% in the screening trial. In initial hybrids trial (IHT), only five hybrids *viz.*, NCSH-2431, BLSFH-15005, SVSH-498, SVSH-475 and LSFH-1751 were found totally free from downy mildew incidence. In advanced hybrid trial (AHT) only one hybrid *viz.*, IIOSH 2 was found free from downy mildew disease incidence. The downy mildew susceptible check entry cv. Morden recorded a maximum disease incidence of 82.5%.

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Table 1 Reaction of newly developed sunflower hybrids and varieties against downy mildew

Trial	No. of entries	Name of entry	Downy mildew incidence (%)
Advanced hybrid trial (AHT)	4 entries	IIOSH-2	0.0
		RSFH-130	28.0
		LSFH-4951	55.0
		BLSFH-15001	40.0
Initial hybrid Trial (IHT)	12 entries	IOSH-15-10	75.0
		KBSH-80	55.0
		NCSH-2431	0.0
		BLSFH-15005	0.0
		CSFH-14638	30.0
		SVSH-498	0.0
		CSFH-15020	50.0
		KBSH-79	30.0
		SVSH-475	0.0
		SH-2150	22.5
		SS-1319	42.5
		LSFH-1751	0.0
Morden (c)	82.5		

Effect of potassium on yield and the rust incidence of soybean

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ABSTRACT

In soybean, soil application of muriate of potash (MOP) @ 40 kg/ha and foliar spray of sulphate of potash (SOP) @ 2% at pod development helped in realizing high seed yield and low rust severity.

Keywords: Potassium, Rust, Soybean, Yield

Potassium is an important nutrient that is known to play a role in the resistance of plants. Different sources of potassium are also known to have an effect on the availability of this important nutrient. A field study was conducted to know the effect of different sources and doses of potassium on the growth and disease resistance in soybean.

A field study was conducted to find out effect of soil and foliar application of potassium through muriate of potash (MOP) and sulphate of potash (SOP) on yield and rust incidence of soybean during *khari*, 2014 at Agricultural Research Station, Kasbe Digraj (MPKV, Rahuri), Dist. Sangli in a split plot design. Different dosages of MOP (K₂O/ha) as 0, 20, 40 and 60 kg were applied in soil. Similarly, SOP was applied as foliar spray as 1% and 2% at flowering 30 DAS, 1 % and 2 % at 60 DAS.

Soil application of potassium @ 40 kg/ha produced significantly higher grain yield (14.8 q/ha) and stover yield (17.2 q/ha). Foliar application of SOP @ 2% at 60 DAS produced significantly highest soybean grain yield (14.8 q/ha) and stover yield (17.3q/ha) as compared to

rest of the spray schedules of SOP. Interaction effects between soil application of potassium and foliar application of SOP were found to be significant in respect of grain and stover yield of soybean. Soil application of potassium @ 40 kg/ha along with spraying of SOP @ 2% at 60 DAS produced significantly higher soybean grain yield (16.8 q/ha) and stover yield (19.2 q/ha) and it was at par with soil application of potassium @ 60 kg/ha associated with spraying of SOP @ 2% at 60 DAS.

Rust severity on soybean was influenced significantly due to soil application of potassium and spraying of SOP. Rust severity decreased with increased dosage of MOP in soil along with foliar spray of SOP. A disease severity of 60 and 68% were recorded in treatment with 1 and 2% foliar spray of SOP and soil application of potassium @ 40 kg/ha, respectively. With this study it could be concluded that soil application of MOP @ 40 kg/ha and foliar spray of SOP @ 2% at pod development stage would be the best management strategy in order to minimize fungicide applications for management of rust.

Identification of temperature tolerant sunflower (*Helianthus annuus* L.) inbreds

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ABSTRACT

Forty seven lines including CMS and R lines with 4 hybrids DRSH-1, KBSH-44, CO-2 and CSFH-12205 were evaluated for temperature tolerance under field conditions by taking two sowing dates one normal and one delayed sowing to expose the crop to high temperatures. Six lines were found tolerant with <15% yield reduction for a mean temperature rise of 6.1°C during the crop growth period.

Keywords: Inbreds, Sunflower, Temperature tolerance

Sunflower is predominantly grown as a rainfed crop. Although, this crop shows wide adaptability due to its photo insensitivity, yield is destabilized by both biotic and abiotic stresses. The plant grows well within a temperature range of 20-25°C. High temperatures may

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cause stomatal closure, a rise in respiration rate, leaf temperature, cell membrane injuries, disruption of the photosynthetic apparatus and the induction of stress specific growth regulators which decrease the total growth period due to changes in crop phenology,

biomass, fruiting sites, gamete sterility, seed size and quality (Moriondo *et al.*, 2011). Temperatures over 26 °C were supra-optimal for pollen production in sunflower, even under well-watered conditions (Astiz and Hernandez, 2013). Constant high temperature decreases final grain weight and oil yield. Therefore, improvement for high temperature tolerance in sunflower is vital to stabilize the yield. Keeping this in view, an experiment was planned to screen the sunflower genotypes to high temperature stress.

Field experiments were conducted by taking two sowings (normal at Feb 1, 2019 and delayed sowing at Mar 1, 2019) with 47 lines in three replications laid out in split plot design at IIOR-Narkhoda farm, Rajendranagar during summer season, 2019. Fertilizers were applied as per the recommended dose. All recommended package of practices were followed to raise the crop. Not to subject the crop to water stress, crop was irrigated whenever necessary. Seed yield/plant was recorded on 5 plants and converted to g/plant.

Days to flowering and days to harvest were reduced for delayed sowing when compared to the normal sowing. Mean maximum and minimum temperatures recorded from sowing to flowering in normal sowing

were 34.5°C, 17.4°C and in delayed sowing they were 37.5°C, 20°C. The same from sowing to harvest were 36.4°C, 19.1°C and 42°C, 25.6°C in normal and delayed sowing respectively. Six entries AKO-AKSF-6-3B, BLR-CMS 59B, BLR-CMS-135B, BLR-CMS144B, BLR-CMS127B, BLR-CMS107B showed tolerance to high temperature with <15% reduction in yield. Temperature stress advanced days to flowering by 4 days and days to harvest by 9 days. The selected entries for temperature tolerance can be utilized in breeding programme for the development of thermo tolerant sunflower hybrids.

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Yield and oil quality of groundnut (*Arachis hypogaea* L.) genotypes under elevated temperature and carbon dioxide

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ABSTRACT

The biomass and seed yield of groundnut (*Arachis hypogaea* L.) genotypes were affected by elevated temperature of +3°C (eT) and the presence of elevated CO₂ of 550 ppm (eT+eCO₂) ameliorated these impacts to some extent. K-6 and Narayani are sensitive to high temperature and responsive to eCO₂ and K-9 showed better tolerance to higher temperature (>40°C). The eT and eT+eCO₂ conditions significantly altered the oil content, saturated and unsaturated fatty acid levels of groundnut genotypes.

Keywords: Elevated temperature, Elevated CO₂, Oil quality, Seed yield

Increased temperature and carbon dioxide are the major climate change factors that impact crop productivity. In oilseed crops, quality of seed oil and fatty acid composition also change with eT and CO₂. In rapeseed, with increase in temperature, the proportion of C18:3 and C18:2 fatty acids decreased (Werteker *et al.*, 2010). To see the effect of eT and CO₂ on seed yield and oil quality in groundnut, an experiment was conducted at CRIDA with elevated temperature (+3°C) and elevated CO₂ (550ppm) in Free Air Temperature Elevation (FATE) facility.

Four popular groundnut genotypes *viz.*, Narayani (TCGS-29), Dharani (TCGS-1043), Kadiri-6 (K-6) and

Kadiri-9 (K-9) were assessed under FATE facility for the impact of elevated temperature (+3°C) and its interaction with elevated CO₂ (550ppm). The crop during the vegetative to pod maturity stage experienced maximum air temperature from 32.4 to 42.2°C with an average of 37.9°C and minimum temperature from 20.8 to 27.4°C with an average of 22.9°C. Data on plant biomass, seed yield and yield components were recorded at harvest. Oil content and fatty acid profile was analyzed.

Increase in temperature (eT) reduced total biomass and seed yield of groundnut. Among the genotypes studied, highest reduction in total biomass was recorded

with K-6 (39%) followed by Narayani (28%) and Dharani (14%), whereas K-9 showed a positive response to eT with improved seed yield (6%). The eCO₂+eT condition significantly improved the total biomass, oil content of all groundnut genotypes. Elevated CO₂ significantly improved the oleic (18:1) (omega-9) to linoleic acid (18:2) ratio and nutritional value. Yadav *et al.* (2011) also reported decrease of saturated fatty acids and increase of oleic acid at elevated CO₂ condition in groundnut. Thus, the changes in the atmospheric CO₂ and temperature not only affected the growth and productivity but also altered the oil quality of groundnut crop.

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Present status of resistance to collar rot disease caused by *Sclerotium rolfsii* Sacc in soybean

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ABSTRACT

Till date, none of the soybean cultivars are reported as immune to *Sclerotium* blight. A very meagre work has been done on understanding of genetics resistance to *S. rolfsii* in soybean. Crosses were made between collar rot resistant soybean genotype PK 327 with other agronomically superior parents and the F₁ seed was collected. Mapping populations are being developed to identify genes/QTL governing resistance.

Keywords: Collar rot, *Sclerotium rolfsii*, Soybean

Fungal diseases including collar rot caused by *Sclerotium rolfsii* are serious threat to the soybean [*Glycine max* (L.) Merr.] production especially for poorly drained soils in India. Seedling mortality up to 65% has been reported under high soil moisture conditions (Gupta and Nair, 2015). On account of its 30-40% yield loss potential, it is a major obstacle in harnessing full potential of soybean production in most soybean growing areas including India. Development of resistant varieties is considered as an economical and durable method of disease management. Till date, none of the soybean cultivars are reported as immune/absolute resistant to *Sclerotium* blight; therefore, there is an urgent need to screen soybean germplasm and to develop resistant genotypes against *S. rolfsii*.

Study was conducted at ICAR-IISR, Indore during *kharif* 2019. Soybean 'PK 327' 'NRC 37' and AMS 5-18 were reported as tolerant/resistant, validated in the field screening during the season; therefore, crosses were made, so as to transfer the resistance in to agronomic superior varieties as well as to develop mapping populations. Crosses 'JS 20-69 x PK 327', 'AMS 5-18 x Bragg' and 'PK 327x AMS 5-18' and F₁ seeds were collected for further genetic studies. The causal organism (*S. rolfsii*) was isolated for artificial screening against collar rot and maintained.

Earlier reported 'PK 327' as tolerant and 'NRC 37' as resistant (Sharma *et al.*, 2014) were validated during *kharif* 2019 season. Further, identification of resistant sources, molecular mapping of genes/QTL governing collar rot resistance in resistant sources and their transfer to agronomically superior but susceptible cultivars is the only way to achieve the breeding goal. Therefore, we started standardization of screening techniques for collar rot resistance, hybridization among reported resistant sources to develop improved breeding lines for collar rot resistance. Crosses 'JS 20-69 x PK 327', 'AMS 5-18 x Bragg' and 'PK 327x AMS 5-18' were made and their F₁ seeds were collected for further genetic studies. Mapping populations are being developed to identify genes/QTL governing resistance.

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Evaluation of advanced breeding genotypes of castor for resistance to sucking pests

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ABSTRACT

Leafhopper, *Empoasca flavescens* (Cicadellidae: Homoptera) and thrips, *Scirtothrips dorsalis* (Thripidae: Thysanoptera) are the major yield limiting biotic factors in castor. Growing resistant cultivars is an effective and economical approach to manage these insect pests. Thirty advanced breeding genotypes of castor were screened against the sucking pests along with susceptible and resistant checks during *rabi* 2018-19. The results exhibited that two genotypes (PCH-566 and JHB-1066) were found highly resistant and 13 genotypes (SHB-1027, SHB-1021, ANDCH-1507, ICH-86, JHB-1061, ICH-538, ICH-515, BioMaruthi-999, JHB-1062, SHB-1033, SHB-1034, SHB-1029 and ICH-404) were found resistant to leafhopper. Three genotypes (SHB-1034, ICH-404, JHB-1066) were found promising against thrips.

Keywords: Advanced breeding genotypes, Castor, Leafhopper, Resistance, Thrips

Leafhopper, *Empoasca flavescens* (F.) and thrips, *Scirtothrips dorsalis* Hood are the most important sucking pests during both *kharif* and *rabi* seasons in all the castor growing areas of India. Nymphs and adults of leafhopper suck sap from the under surface of the leaves and inject toxin causing hopper burn symptoms resulting in loss of vitality, stunted growth and poor formation of capsules. Thrips damage tender leaves and floral parts resulting in characteristic wrinkling of plants and withering of developing spikes (Lakshminarayana and Duraimurugan, 2014). Control of these pests through application of insecticides not only increases the cost of cultivation, but also leads to environmental and health hazards. Host-plant resistance is recognized as the most effective, economic and sustainable method of limiting the incidence of these sucking pests in castor. In the present study, advanced breeding genotypes of castor have been evaluated for their resistance to leafhopper and thrips.

A total of 30 advanced breeding genotypes of castor entered into coordinated trial under All India Coordinated Research Project on Castor were screened against sucking pests along with susceptible and resistant checks. The experiment was laid out in an augmented block design during *rabi* 2018-19 at the ICAR-Indian Institute of Oilseeds Research, Hyderabad. Each genotype was planted in a 6m row. The spacing followed between rows was 90 cm and between plants was 60 cm. Susceptible and resistant checks were planted after every 5 rows of test entries. Single row of susceptible check was grown as infester crop along the field border to increase insect infestation in test entries. The data on leafhopper (jassid) were recorded on three leaves, representing top, middle and lower canopy of each genotype and the respective hopper burn was recorded on 0-4 scale (Anjani *et al.*, 2018). Thrips population was

observed on the top most tender leaf and on immature spike (Duraimurugan and Alivelu, 2017). The observations on the sucking pest populations recorded at regular intervals and the highest population recorded were reported.

Among the 30 advanced breeding genotypes of castor screened, two entries *viz.*, PCH-566 and JHB-1066 recorded low pest infestation (4.0 to 6.2 leafhoppers/3 leaves/plant) and did not exhibit any hopper burn (0 on 0-4 scale) and were found to be highly resistant to leafhopper as compared to susceptible check DPC-9, which recorded high pest infestation of 125 leafhopper/3 leaves/plant with hopper burn grade of 4 on 0-4 scale. Thirteen entries *viz.*, SHB-1027, SHB-1021, ANDCH-1507, ICH-86, JHB-1061, ICH-538, ICH-515, Bio Maruthi-999, JHB-1062, SHB-1033, SHB-1034, SHB-1029 and ICH-404 found resistant to leafhopper and recorded hopper burn grade 1 on 0-4 scale. The thrips infestation ranged between 4.0 thrips/spike (SHB-1034) to 33.6 thrips/spike (ICH-576). Three entries *viz.*, SHB-1034, ICH-404, JHB-1066 found promising and recorded low infestation of 4.0 to 9.6 thrips/spike as compared to the check, DCS-9 (37.6 thrips/spike). The resistant genotypes reported in this paper may be recommended for testing their performance under different agroclimatic conditions and/or further use as donor parents in breeding programs.

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Screening of soybean genotypes for antixenosis against *Spodoptera litura*

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ABSTRACT

Among 95 soybean genotypes screened against *Spodoptera litura*, 2 genotypes viz., Hara Soya and G5P22 exhibited strong antixenosis, 11 genotypes exhibited moderate antixenosis. Whereas, 40 genotypes and 42 genotypes expressed slight antixenosis and preference host respectively.

Keywords: Antixenosis, Common cut worm, Soybean, *Spodoptera litura*

The common cutworm, *Spodoptera litura*, is a major leaf-feeding pest of soybean (Ramakrishnan *et al.*, 1984). It is a serious pest and its incidence is being observed in all the soybean growing areas during *kharif* season. Identification of resistant sources by screening soybean genotypes is useful in development of resistant cultivars. Antixenosis is one of the screening methods for which response exerted by genotypes on defoliating larvae will be assessed based on Preference Index (C).

The experiment was conducted at ICAR-IISR, Indore during *kharif* 2019. About 95 genotypes were screened in 3 replications by antixenosis at laboratory. One pre weighed leaf (or a portion of leaf) of all the genotypes is placed in circular manner in a petri plate having thin thermocol sheet at the base. Ten 3rd instar *S. litura* larvae were released at the centre of Petri plate. After 8 hrs, the left over leaves of all the genotypes were removed, oven dried at 50°C for 15 minutes and weighed. Calculated the weight of leaves eaten by larvae for all the genotypes. Preference Index (C) was calculated given by Kogan and Goeden (1970).

Preference Index, $C = 2A / M+A$, where, A = Dry weight of leaves of test genotypes eaten by larvae and M = Dry weight of leaves of susceptible check eaten by larvae.

The genotypes were classified as per C value (Table 1). The degree of antixenosis resistance was determined using a preference comparison between the test line and a standard variety, JS 335. Out of 95 screened soybean genotypes, 2 genotypes viz., Hara Soya (0.37) and G5P22 (0.44) exhibited strong antixenosis, 11 genotypes exhibited moderate antixenosis (0.61 to 0.74). Whereas, 40 genotypes (0.76 to 0.98) and 42 genotypes (1.00 to 1.56) expressed slight antixenosis and preference host respectively (Nobuhiko Oki *et al.*, 2017). Based on this

classification, genotypes exhibiting strong and moderate antixenosis can be considered as resistant sources. These resistant sources can be further used in breeding programs by hybridization for transferring into agronomically superior cultivars and identify QTL governing resistance with development of mapping populations.

C value	Antixenosis response
0.10 to 0.25	Extreme antixenosis
0.26 to 0.50	Strong antixenosis
0.51 to 0.75	Moderate antixenosis
0.76 to 0.99	Slight antixenosis
1.00 or > 1.00	Preferred host

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Yield reduction and efficacy of antiviral product against yellow mosaic virus disease in soybean

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ABSTRACT

Regression equation $\{Y = 1.634 + X_1(0.729), R^2=0.844\}$, by pooling data of moderately and highly infected plants of seven varieties for two years, reveals that a unit increase in severity of yellow mosaic virus disease (YMV) can cause 0.729 per cent yield reduction in soybean. However, maximum yield reduction was noticed as high as 85.7 per cent on plants which infected severely in earlier stage of crop (50th days). Zillon, an antiviral remedy @ 6 ml/L at 15, 30 and 45 DAS was found to be effective in controlling YMV as well as in increasing the yield.

Keywords: Antiviral, Soybean, Yield, Yellow Mosaic Virus

In central India, yellow mosaic disease caused by Mungbean Yellow Mosaic India Virus is a major constraint in soybean production (Usharani *et al.*, 2004). This is single stranded DNA virus of geminiviridae family and transmitted by white fly (Kumar *et al.*, 2014). Present study reveals yield reduction in soybean crop due to different levels of YMV severity and also evaluate an antiviral product which could reduce insecticidal spray in management of vectors.

In two year (2017 and 2018) study, plants of each seven varieties for highly and moderately infected with YMV were tagged at 50 days and per cent disease index (PDI) for YMV was calculated at 50 and 80 days by using 0-9 scale (Anonymous, 2012). Finally, per cent yield reduction was calculated by using the average yield of healthy and infected plants (Table 1). In another trial during 2018, efficacy of zillon, an antiviral remedy from Phytotron Agro Product (India) Pvt Ltd was evaluated in different concentrations and combinations in the field of AICRP on soybean at JNKVV, Jabalpur on susceptible variety JS 335 in Randomized Block Design with 3 replications (Table 2).

The highest yield reduction of 85.7 per cent was noticed in JS 93-05 on 95.3 per cent severity (80th day) of YMV. However, average yield reduction in seven varieties was 72.8 per cent on 84.8 per cent index of

YMV. While pooling the data of all the varieties of the severely and moderately infected plants before harvesting (80th days), a regression formula was derived $\{Y = 1.634 + x_1(0.729), R^2=0.844\}$ which suggests that a unit increase in YMV severity caused 0.729 per cent yield reduction in soybean. Zillon @ 6 ml/L at 15, 30 and 45 DAS was found to be significantly effective and recorded lowest disease (20.0 %) as compared to untreated (47.3) and also gave higher yield significantly.

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Table 1 Yield loss in different varieties due at various levels of YMV severity during 2017 and 2018 (Average)

Varieties	At high severity of YMV			At moderate severity of YMV		
	50 days (PDI)	80 days (PDI)	% yield reduction	60days (PDI)	80days (PDI)	% yield reduction
JS 335	65.6	82.2	63.3	27.8	48.5	27.8
JS 93-05	76.0	95.3	85.7	32.6	52.2	26.3
JS 72-280	50.8	73.8	62.6	24.7	33.7	21.6
NRC 7	52.2	78.3	63.6	28.6	42.5	22.6
MACS 58	73.4	93.5	84.4	35.7	55.2	27.3
MONETTA	56.6	87.3	80.3	30.5	46.3	26.8
RKS 18	67.5	83.5	69.7	25.8	34.6	22.1
Mean	63.2	84.8	72.8	29.4	44.7	24.9
*Correlation (r)	0.678	0.940**	-	0.711	0.890**	

*Correlation with per cent yield reduction

Table 2 Bio-efficacy of Zillon against yellow mosaic virus disease of soybean during 2018

Treatments	% Incidence	% Disease control	100 seed wt (g)	Yield (kg/ha)	% Yield increased
4 ml/L at 15 & 30 DAS	35.0	26.2	10.70	1196.7	8.3
6 ml/L at 15 and 30 DAS	30.3	35.9	11.27	1228.7	11.2
4 ml/L at 15 and 45 DAS	36.3	23.2	10.55	1185.3	7.3
6 ml/L at 15 and 45 DAS	31.7	33.3	11.08	1212.7	9.7
4 ml/L at 15, 30 and 45 DAS	21.7	54.4	11.80	1281.0	15.9
6 ml/L at 15, 30 and 45 DAS	20.0	57.8	11.90	1289.0	16.7
Triazophas 40 EC @ 1.5 ml/L at 15 and 45 DAS	25.3	46.4	10.88	1218.3	10.3
Untreated control	47.3	-	9.85	1105.0	-
CD (P= 0.05)	2.9	-	0.49	100.5	-

Evaluation of antifungal molecules against *Alternaria helianthi* causing leaf blight in sunflower

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ABSTRACT

In sunflower the yield loss reported due to the major destructive disease, *Alternaria* leaf blight varies from 11.30 to 73.33 per cent. Among the nano particles and fungicides evaluated against *Alternaria helianthi*, Azoxystrobin (98.49) in systemic fungicides, Propiconazole + Difenconazole (91.29) in combi products and silver colloidal particles (52.72) in nano particles were efficient ones in inhibiting the pathogen under *in vitro* assay.

Keywords: *Alternaria helianthi*, Management, Sunflower

Sunflower (*Helianthus annuus* L.) one of the important oilseed crops fails to yield to its full capacity owing to the major biotic stress. *Alternaria* leaf blight occurs with incidence as high as 95-100 per cent due to heavy rains during flowering and grain filling stage of the crop. Despite ill effects of chemical control, it is the still on time and first line of control to tackle destructive plant diseases. *In vitro* evaluation of different combi-products, systemic fungicides and nano particles against *Alternaria helianthi*, necessitates providing useful and preliminary information regarding their efficacy against pathogens within a short period of time and serves as a guide for field testing.

Isolation of the fungus was made from typical leaf spot on infected plants collected from the field in *kharif* sunflower crop. The efficacy of three nano particles and ten fungicides were evaluated against *A. helianthi* at different concentrations on potato dextrose agar medium using poisoned food technique.

Under *in vitro*, azoxystrobin recorded the maximum inhibition of mycelial growth in all the three concentrations of 0.05%, 0.075% and 0.10% (95.81, 97.62 and 98.49, respectively) in systemic fungicides. In combi products maximum inhibition of mycelial growth of 86.07, 88.03 and 91.29 per cent was noticed at all the three concentrations of Propiconazole + Difenconazole (0.10%, 0.15% and 0.20%, respectively). Among the nano particles maximum mean inhibition of 52.72 per

cent mycelial growth was recorded in silver colloidal particles followed by silicon nano particles (46.06%) at higher concentration. Similarly, Karmakar *et al.* (2016) reported that Propiconazole 13.9 per cent + Difenconazole 13.9 per cent (combi product) at 0.2 per cent concentration recorded 100 per cent growth inhibition of *A. padwickii*. Mishra *et al.* (2009) reported that Azoxystrobin at 500 ppm expressed an inhibition of mycelial growth by 91.69 per cent in *Alternaria brassicae* of cauliflower. In conclusion, highest per cent inhibition of *A. helianthi* was observed in Propiconazole + Difenconazole (88.46), Azoxystrobin (97.31) and nano silver colloidal particles (52.72).

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Incidence of sucking insect pests in groundnut

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ABSTRACT

Groundnut crop is damaged by various insect pests, hence monitoring their incidence plays a key role for planning management strategies. Thrips and leafhopper population was found throughout the year, but we observed two significant peaks of thrips population during 6th and 38th Standard week and leafhopper population had three peaks at 7th, 43rd and 45th Standard weeks. Hence suitable management strategies could be planned during these periods to manage these insect pests.

Keywords: Groundnut, Management, Sucking Pests, Seasonal Incidence

A large number of insect pests damage groundnut crop, like thrips, aphids, leafhoppers, tobacco caterpillar, hairy caterpillar, leaf miner and gram pod borer (Sharma *et al.*, 2003). Amongst them sucking pests, cause direct damage to the crop by sucking sap from plant parts but also act as vectors of major viral diseases (Naidu *et al.*, 1998). The leafhoppers can cause up to 22 per cent of yield loss in groundnut (Vyas, 1984), while thrips up to 17 to 40 per cent (Ghewande, 1987).

Occurrence of sucking pests *viz.*, leafhoppers and thrips were studied during the 2017 and 2018 calendar years at DGR farm, Junagadh. The groundnut variety, GJG-22 was sown in the first week of every month in plots of size, 5m length and 2m width. Thus, the crop was made available throughout the year for the experiment. The recommended crop production practices were followed (except crop protection) in order to avoid influence of pest management on the population of leafhoppers and thrips. Observations were recorded at weekly intervals where a modified method of sampling for leafhoppers and thrips was followed (Nandagopal *et al.*, 2007).

Thrips and leafhopper population were recorded throughout the year. Thrips population had two significant peaks, one peak at sixth standard week (11 thrips) and second was during 38th standard week (13 thrips). However, leafhopper population had three peaks

at seventh, 43rd and 45th standard week with 23, 11 and 11 leafhoppers, respectively. Hence suitable management strategies could be planned during these period to manage these insect pests.

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Efficacy of different methods of inoculation for inducing root rot disease in castor caused by *Macrophomina phaseolina*

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ABSTRACT

Soil inoculation and root dip inoculation methods were found more efficient, rapid and effective for identifying castor genotypes against root rot disease for early detection of resistance source. The soil inoculation method

induced maximum (87.7%) root rot disease and was statistically at par with root dip inoculation method (82.7%) after 25 days of inoculation.

Keywords: Castor, Inoculation methods, Root rot disease

Castor crop is affected by several biotic and abiotic stresses of which root rot caused by *Macrophomina phaseolina* (Tassi) Goid, is one of the important diseases. The present study was undertaken to identify suitable screening methods to select resistant genotypes.

Five different inoculation methods (1) soil inoculation (2) blotting paper inoculation (3) tooth pick inoculation (4) stem tape inoculation, and (5) root dip inoculation were tried. Twenty seedlings / plants were maintained in each method. Disease reaction was recorded periodically.

Experimental results revealed that there were significant differences observed in disease incidence and symptoms development under different inoculation methods. The soil inoculation method induced maximum (87.7%) root rot disease and was statistically at par with root dip inoculation method (82.7%) after 25 days of inoculation. In the method of blotting paper inoculation, 67.5% root rot disease was recorded. Least root rot disease (22.38%) was induced by toothpick inoculation method and stem tape inoculation (29.7%) and there was

no significant difference among them to induce root rot disease. Based on the results, it could be concluded that soil inoculation as well as root dip inoculation method would be more efficient, rapid and effective. These methods can be further used to carry out other experiments for standardization of the techniques. Grezes-Bessent *et al.* (1996) also evaluated different methods to induce *M. phaseolina* root rot and reported that soil inoculation method was suitable for evaluation of castor genotypes at early stage.

Average of four replications (5 seedlings or Plants/replication); Means followed by a common letter are not significantly different at the 5 % level by DNMRT.

REFERENCE

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Table 1 Effect of different methods of inoculation on root rot incidence in castor variety 48-1

Methods of inoculation	Total no. of seedlings/plants	Incubation period (Days)	Disease incidence (%) *
Soil inoculation	20	14	69.53 a (87.77)
Blotting paper inoculation	20	2	55.28 b (67.57)
Toothpick inoculation	20	30	31.55 c (22.38)
Stem tape inoculation	20	20	33.05 c (29.75)
Root dip inoculation	20	10	65.47 a (82.76)

Influence of abiotic factors on seasonal abundance of natural enemies on safflower during *rabi* season

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ABSTRACT

An experiment was conducted to observe the influence of abiotic factors on seasonal abundance of natural enemies on safflower at oilseed research station, Latur, Maharashtra during *rabi* 2016-17. The incidence of lady bird beetle was recorded from 45th standard meteorological week (SMW) to 08th SMW. The incidence started at 21 days after germination of safflower crop i.e. 0.1 ladybird beetle/5 cm twig/plant during 48th standard meteorological week and reached to its peak (0.7 beetle/plant) during 2nd Standard meteorological week and recorded peak of 0.7 ladybird beetle/5 cm twig/plant and there after population decreased. The weather parameters *viz.*, low temperature, high humidity showed significant role in multiplication ladybird beetle. The weather parameters during the peak incidence of ladybird beetle were maximum temperature-26.50C, minimum temperature-11.6°C, morning relative humidity of 82% and evening relative humidity of 38%.

Keywords: Abiotic factors, Ladybird beetle, Seasonal incidence

One of the major reasons for the low productivity in safflower is the loss due to insect pests. Among the insect pests that attacks safflower, the aphid, *Uroleucon compositae* Theobald (Hemiptera: Aphididae) is the most destructive and regular pest on which lady bird beetle is found as an voracious predator.

A field trial with seasonal incidence of natural enemies i.e. ladybird beetle in relation to weather parameters was carried out during *rabi* 2016-17 at Oilseeds Research Station, Latur (MS). The observations on population of ladybird beetle were recorded at weekly interval on 10 randomly selected plants from 10 m x 10 m plot size. Lady bird beetle count was taken by observing 5 cm twig of the selected and tagged plant from experimental plot. The weekly data obtained was correlated with weather parameters. The whole plot was kept free from insecticidal application.

Simple correlation of ladybird beetle population with weather parameter was worked out. The correlation coefficient worked out with different weather parameters revealed that, morning relative humidity showed positive significant (0.634) and evening relative humidity was observed negative non-significant (-0.237) where as it was negatively non-significant with maximum temperature (-0.346) and minimum temperature was found to be negatively non-significant (-0.402). Similar results were also observed by Patil and Kamnath (2012) who reported that morning relative humidity showed positive significant and evening relative humidity showed negative non-significant correlation while negative non-significant correlation with rainfall. These finding are in close conformation with present finding and negative non-significant with rainfall (-0.007). The

incidence of ladybird beetle was recorded from 45th standard meteorological week (SMW) to 08th SMW. The incidence started at 21 days after germination of safflower crop i.e. 0.1 ladybird beetle/5 cm twig/plant during 48th standard meteorological week and reached to its peak (0.7 beetle/plant) during 2nd Standard meteorological week and recorded peak of 0.7 ladybird beetle/5 cm twig/plant and there after population decreased. The weather parameters viz., low temperature, high humidity showed significant role in multiplication of ladybird beetle. The weather parameters during the peak incidence of ladybird beetle were maximum temperature of 26.5°C, minimum temperature of 11.6 0C, morning relative humidity of 82% and evening relative humidity of 38%. Patil and Kamnath (2012) found the population was at its peak during third week of January when the temperature was low with high humidity similar to present findings.

The population of predator showed non-significant correlation with maximum temperature, minimum temperature, rainfall and evening relative humidity, while it was positively correlated with morning relative humidity.

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Table 1 Seasonal incidence of LBB on safflower during *rabi* (2017)

SMW	LBB/ 5 cm twig	Temp (°C)		Rainfall (mm)	Rainy days	R.H %	
		Max	Min			I	II
45	0	32.0	18.2	0.0	0.0	29	42
46	0	30.7	16.3	0.0	0.0	43	53
47	0	29.5	17.9	0.0	0.0	28	39
48	0.1	30.0	13.6	0.0	0.0	31	455
49	0.1	28.0	12.1	0.0	0.0	44	54
50	0.2	27.9	11.6	0.0	0.0	43	54
51	0.4	29.1	11.8	0.0	0.0	34	47
52	0.5	28.5	10.9	0.0	0.0	35	42
1	0.6	27.9	12.4	0.0	0.0	72	29
2	0.7	26.5	11.6	0.0	0.0	82	38
3	0.6	27.8	14.1	0.0	0.0	83	37
4	0.5	29.3	15.5	0.0	0.0	76	32
5	0.6	31.0	15.6	0.0	0.0	69	25
6	0.6	31.6	16.5	15.0	1	67	27
7	0.5	31.0	16.9	00	0.0	66	25
8	0.4	34.0	16.9	0.0	0.0	50	17
r-value		-0.346	-0.402		-0.007	0.634**	-0.237

At 5% level of significance at (n-2) d.f. i.e. 14=0.426; 0.574

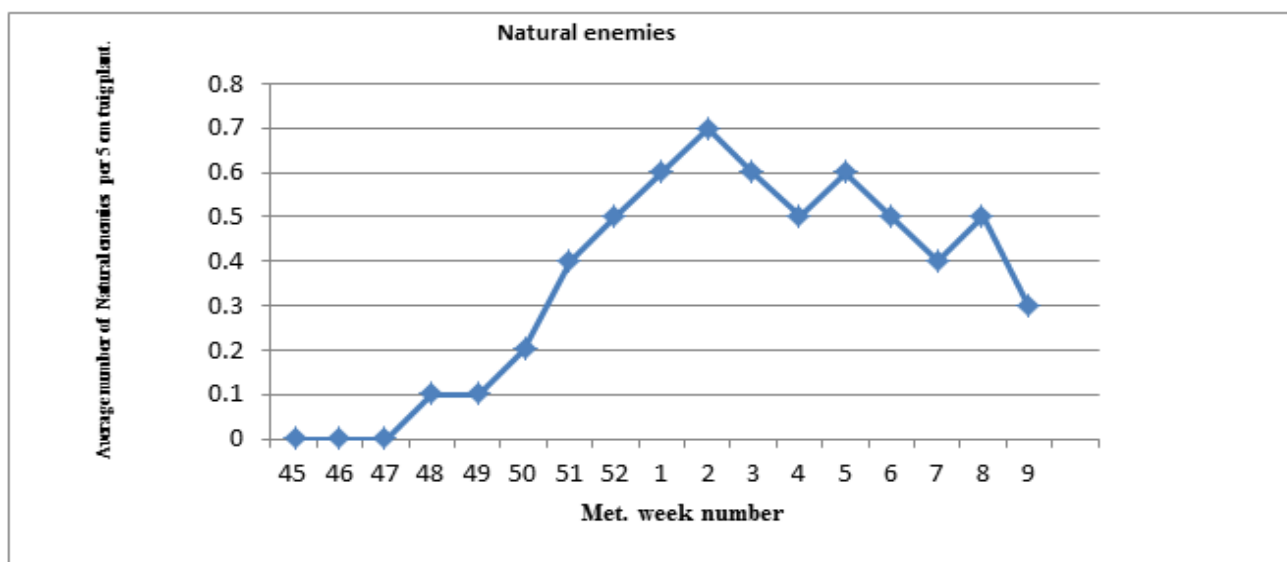


Fig 1 Population dynamics of natural enemies on safflower in relation to weather parameters

Effect of seed bacterial endophytes on stem rot and growth promotion in groundnut

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ABSTRACT

Seven bacterial endophytes from peanut seeds were isolated and tested against *Sclerotium rolfsii* of groundnut under *in vitro*. The endophyte isolate EGN1 showed 47.3% inhibition of the pathogen and biochemical tests were positive for siderophore, protease and phosphate solubilization.

Keywords: Endophyte, Groundnut, Growth promotion, Stem rot

Several factors are responsible for low productivity of groundnut in Tamil Nadu and among which stem rot caused by *Sclerotium rolfsii* Sacc. It causes pod yield losses upto 80% under favourable environment. Eco-friendly disease management strategies using endophytic bacteria from seed are gaining importance. These confer induction of plant defense mechanisms and production of lytic enzymes and antibiotics. The purpose of this study was to isolate and characterize endophyte that naturally colonize the seeds of groundnut and test its effect on stem rot pathogen.

Seeds were surface disinfected in 5% commercial bleach and 0.01% Tween 20 for 10 min and rinsed 10 times with sterile distilled water and used nutrient agar for isolation. In the antagonistic assay, percent inhibition over control was calculated. Phosphate solubilisation assay was carried out by method described by Sarikhani *et al.* (2019), siderophore production was studied using Chrome azulol S (CAS) medium and qualitative

proteolytic activity was determined on Skim Milk agar described by Herrera *et al.* (2016). Thin layer chromatography analysis was carried out for effective isolates.

Tests for antagonistic activity with seven endophytic bacterial isolates obtained from groundnut seeds and along with two bacterial bio-agent standards (TNAU–*Pseudomonas fluorescens* Pf1 & EPC5) was carried out *in vitro*. The highest inhibition zone against the pathogen was obtained with EGN1 (47.3%) compared to other isolates and the same showed 100% inhibition in Triangle method of streaking and culture filtrate assay and 68.2% inhibition in filter paper disc assay (Fig.1). The phytostimulation activity shown in Table 1 indicated that the effective strain EGN1 has the ability to solubilize tricalcium phosphate, siderophore production and also has the ability to produce protease enzyme.

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Table 1 Screening of seed bacterial endophytes for plant growth promotion traits

Isolate	Inhibition (%) in dual culture	Siderophore production	Phosphate solubilization	Protease test
EGN 1	47.30	+++	+	+
EGN 2	25.14	++	-	-
EGN 3	41.10	+++	+	+
EGN 4	45.10	+	-	-
EGN 5	12.20	+	-	+
EGN 6	0.00	++	-	-
EGN 7	46.60	++	-	+
TNAU-Pf1	40.00	+++	+	+
EPC 5	27.80	+	-	-
Control	0.00	-	-	-

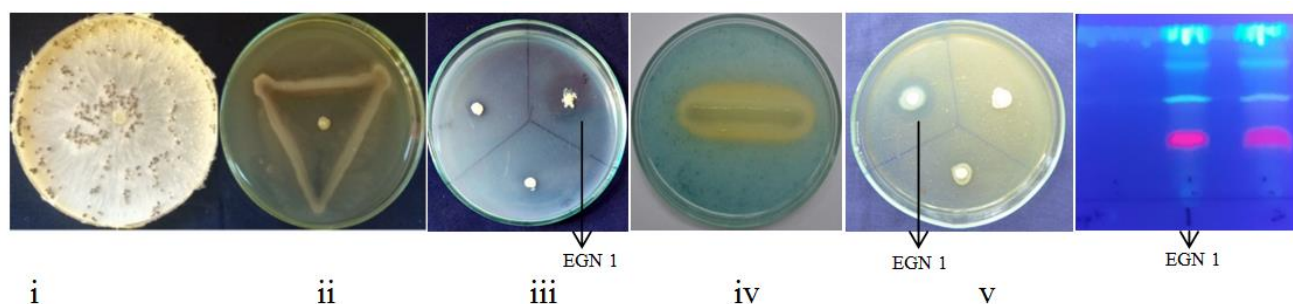


Fig. 1. Antagonistic activity and biochemical assays of bacterial endophyte (EGN1)

i) Antagonistic activity against *Sclerotium rolfisii*, ii) Phosphate solubilisation, iii) Siderophore production iv) Protease assay, and v) TLC analysis

Impact of elevated carbon dioxide on biomass and seed yield of groundnut genotypes (*Arachis hypogaea* L.) under irrigated and moisture stress conditions

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ABSTRACT

Elevated CO₂ (eCO₂) improved biomass, seed yield and its components the two groundnut genotypes viz., Dharani, and K-9 under irrigated and stress conditions, however the magnitude of response differed with genotype as well as moisture level. Impact of moisture stress at flowering stage was high with Dharani for all the parameters under both aCO₂ and eCO₂ conditions as compared with K-9. The response of individual genotype significantly varied to eCO₂ under irrigated and moisture stress conditions.

Keywords: Biomass, Elevated CO₂, HI, Moisture stress, Seed yield

The increasing atmospheric CO₂ concentration and moisture stress cause significant changes in crop productivity. Groundnut (*Arachis hypogaea* L.) is an important edible oil seed crop and moisture stress is one of the major factors which limit the production of groundnut (Shinde *et al.*, 2010).

Two groundnut genotypes - Dharani (TCGS-1043) and Kadiri-9 (K-9) were raised in pots with red soil (Alfisol) having 16% moisture content at field capacity. Two moisture levels - well watered (WW) and water deficit stress (WD) conditions at ambient (aCO₂) and elevated CO₂ (eCO₂) of 550ppm were maintained in a three replications in OTC (open top chamber) facility.

The plants from each treatment were harvested to determine the biomass, seed yield and yield components. Elevated CO₂ (eCO₂) improved biomass, seed yield and its components of both the genotypes under WW and WD conditions, however response magnitude of individual genotype differed. The biomass decreased with WD by 33% and 5.5% in Dharani and K-9 under aCO₂ condition, however with eCO₂ it was 24.5% in Dharani while there was no change with K-9. Similarly the reduction in seed yield with WD was 36.5% of Dharani under aCO₂ and it reduced to 24.5% with eCO₂ condition. The response of K-9 showed a different trend as no impact of moisture stress on seed yield was observed under aCO₂ and 19.9% with eCO₂. Under irrigated condition higher impact of eCO₂ was observed for pod number and test weight with K-9 while it was pod weight and seed yield with Dharani indicating the

impact in improving yield by increasing the number in Dharani while it was size of the seed in K-9. Impact of moisture stress was high with Dharani for all the parameters under both aCO₂ and eCO₂ conditions as compared with K-9. Higher improvement of both biomass and seed yield was observed in Dharani under moisture stress condition as compared with irrigated control, this was not the case with K-9 as higher improvement in vegetative biomass and reduction in seed yield was observed under moisture stress condition.

REFERENCE

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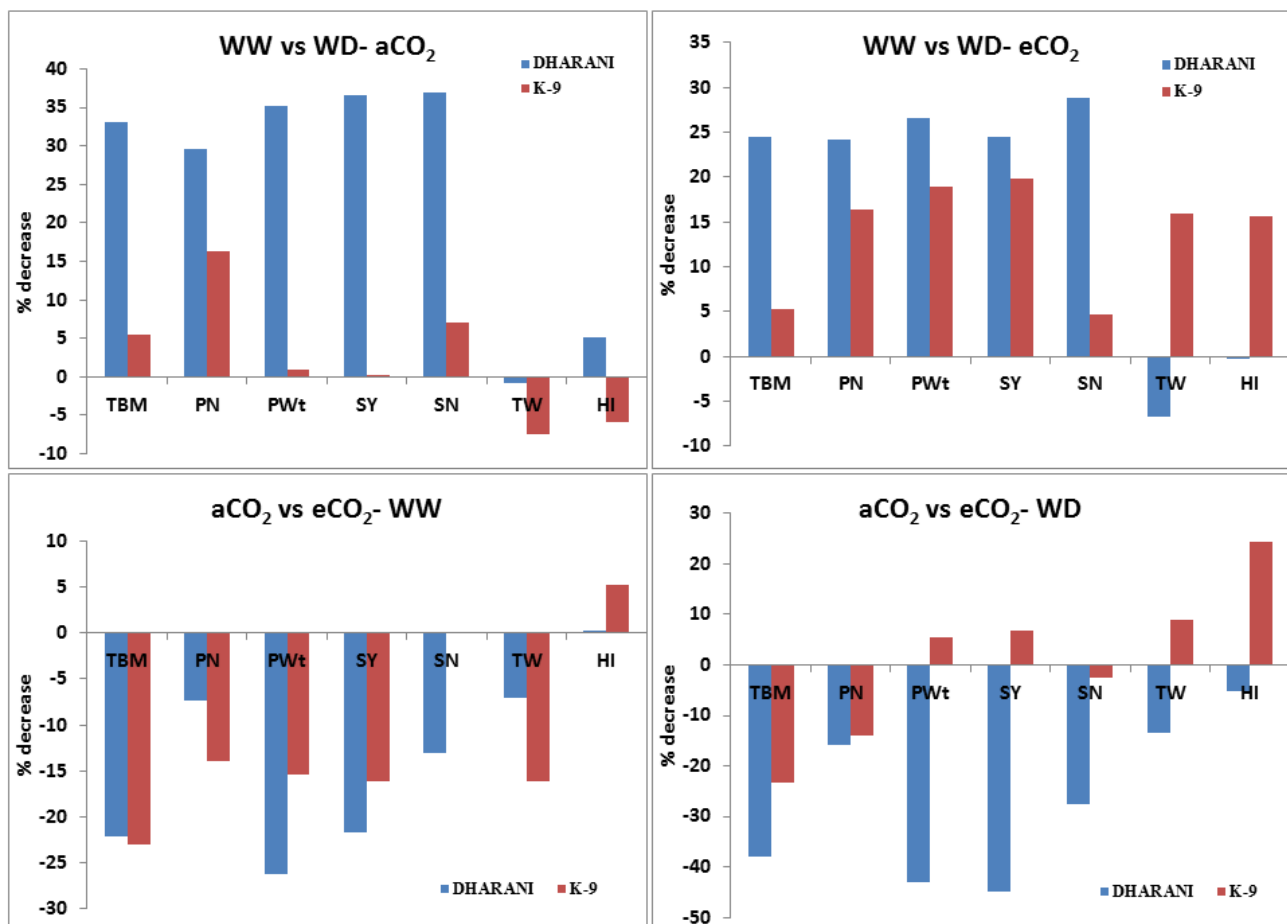


Fig. 1 Impact of elevated CO₂ on biomass and yield components of two groundnut genotypes- Dharani and K-9 under well watered (WW) and water deficit stress (WD) conditions. TBM-Total biomass; PN- Pod number; PWt- Pod weight; SY- Seed yield; SN- Seed number; TW- Test weight (100 seed weight); HI- Harvest index.

Field evaluation of *Trichoderma* and fungicides for the management of castor *Fusarium* wilt disease

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ABSTRACT

Field efficacy of *Trichoderma* and fungicides was tested for castor *Fusarium* wilt management. Among the seven treatments, seed treatment with carboxin 37.5% + Thiram 37.5% @ 3g/kg was found superior. Also the combined seed and soil application of *T. harzianum*, Th4d 1.5% WP was best among *Trichoderma* applications.

Keywords: Castor, *Fusarium* wilt, Management

Castor (*Ricinus communis* L.) is non-edible oilseed crop and affected by several biotic stresses, among them castor wilt (*Fusarium oxysporum* f. sp. *ricini*) is a major constraint. Disease control may be accomplished with the use of biological control agents and fungicide application. The present investigation is carried out to evaluate fungicides and *Trichoderma* against *Fusarium* wilt of castor under field conditions.

Field experiment was carried out to evaluate the effect of biocontrol agents and chemicals for the control of *Fusarium* wilt on castor hybrid YRCH-1 at TCRS, TNAU, Yethapur, Tamil Nadu during *kharif* season 2018. The observation *viz.*, germination, root length, shoot length, wilt incidence and seed yield were recorded.

The results revealed that seed treatment with carboxin 37.5% + thiram 37.5% @ 3g/kg seed recorded germination (96%), root length (9.5 cm), shoot length (17.2 cm), highest seed yield (848 kg/ha) and lowest

disease incidence (36.8%) among all the treatments tested.

Among the *Trichoderma* treatments, combined seed and soil application of *T. harzianum*, Th4d 1.5% WP (T1) was best as it recorded germination (98%), root length (10.1 cm), shoot length (17.2 cm), highest seed yield (746 kg/ha) and disease incidence (44 %) when compared to control (Table 1). Similar results have been reported earlier by Vahunia *et al.* (2017).

REFERENCE

Vahunia B, Singh P, Patel N Y and Rathava A 2017. Management of *Fusarium* wilt of castor (*Ricinus communis* L.) caused by *Fusarium oxysporum* f. sp. *ricini* with antagonist, botanical extract and pot experiment. *International Journal of Current Microbiology and Applied Sciences*, 6(9): 390-395.

Table 1 Efficacy of *Trichoderma* and fungicides against wilt disease of castor

Treatments	Germination (%) [*]	Root length [*]	Shoot length (cm) [*]	Wilt incidence (%) @ 150DAS [*]	Seed yield (kg/ha) [*]
T1-ST – 10 g/kg and SA of <i>T. harzianum</i> , Th4d 1.5% WP (1kg FYM mixed with 100kg FYM incubated for a week and applied while seed dibbling)	98.0	10.1	17.2	44.2	746
T2-ST with <i>T. harzianum</i> Th4d 1.5%WP - 10g/kg and SA of neem cake @ 150kg/h one week before sowing	94.6	9.8	18.1	47.8	714
T3-ST with <i>T. harzianum</i> Th4d 1.5%WP - 10g/kg and SA of vermi compost @ 1t /ha one week before sowing	97.3	9.1	17.7	45.2	710
T4-ST with tebuconazole + trifloxystrobin* 75 WG @ 0.4g/kg	94.6	9.3	16.1	41.5	801
T5-ST with carboxin 37.5% + thiram* 37.5% @ 3g /kg seed	96.0	9.5	17.2	36.8	848
T6-ST with carbendazim @ 2g/kg seed	95.3	10.0	18.5	39.1	808
T7 – Control	94.0	7.9	14.4	82.2	414
CD (p=0.05)	NS	1.3	2.1	6.3	42.6

ST-Seed treatment, SA-Soil Application; *Mean of three replications

Screening of castor (*Ricinus communis* L.) germplasm and inbred lines against Fusarium wilt (*Fusarium oxysporum* f.sp. *ricini*)

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ABSTRACT

Among the 73 entries screened against wilt of castor, 27 were highly resistant (0% wilt), 3 were resistant with < 20% wilt, 10 were moderately resistant (20.1 to 40% wilt), 14 were moderately susceptible (40.1 to 50 %), nine were susceptible and 10 were highly susceptible to Fusarium wilt.

Keywords: Castor, Fusarium, Germplasm, Glasshouse, Inbred, Resistant, Screening

Fusarium wilt of castor causes huge yield losses. Host plant resistance is the major option available for effective management of the wilt. To identify resistance sources against wilt for developing resistant cultivars a study was undertaken to screen germplasm accessions and inbred lines against Fusarium wilt. Identified sources of resistance will be utilized in future breeding programmes aiming at wilt resistance in castor.

Screening experiment was conducted in sick pots by following method suggested Shaw *et al.* (2016). The observations on per cent wilt were recorded at 25, 50 and 75 days after sowing. Cumulative number of wilted plants was considered to calculate percent wilt incidence in each genotypes (Anjani *et al.*, 2014). Reaction of experimental material against wilt (*F. oxysporum* f.sp. *ricini*) was categorized as per the scale given by Mayee and Datar (1986).

Among the 73 test entries, 27 were highly resistant (0% wilt), three were resistant with < 20% wilt, 10 were moderately resistant (20.1 to 40% wilt), 14 were

moderately susceptible (40.1 to 50 %), nine were susceptible and 10 were highly susceptible (Table 1) to Fusarium wilt and this results were in conformity with findings of Anjani and Raof (2014).

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Table 1 Reaction of germplasm and inbred lines to Fusarium infection in sick pot screening

Score	Disease incidence (%)	Reaction against wilt	Number of genotypes	Examples
0	0	Highly resistant	27	HCG-5, HCG-7, HCG-8, HCG-11, HCG-12, HCG-16, K.LOCAL, HCG-20, HCG-35, HCG-36, HCG-37, HCG-38, HCG-43, HCG-45, HCG-48, HCG-50, BCG-1, HCG-6, MI-68, MI-71, MI-73, MI-83, MI-85, MI-86, MI-88, MI-93 and 48-1
1	0.01 to 20	Resistant	03	HCG-81, MI-66 and MI-67
2	20.1 to 40	Moderately Resistant	10	HCG-15, HCG-21, HCG-28, HCG-39, HCG-10, MI-55, MI-59, MI-64, MI-82 and MI-92
3	40.1 to 50	Moderately Susceptible	14	HCG-4, HCG-19, HCG-40, HCG-116, BCG-4, MBWOP, HCG-107, MI-48, MI-51, MI-52, MI-54, MI-76, MI-84 and MI-89
4	50.1 to 75	Susceptible	09	HCG-2, HCG-13, HCG-22, HCG-32, HCG-91, MI-50, MI-53, MI-61 and MI-62
5	>75	Highly Susceptible	10	HCG-1, HCG-25, HCG-26, HCG-31, BCG-2, MI-47, MI-49, MI-69, MI-87 and JI-35
Total			73	

Evaluation and identification of wild species promising for diseases of sesame

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ABSTRACT

Ten wild species accessions of sesame were screened during summer 2016-17 for diseases. All wild accessions were found promising for phytoplasma except IC 0208679, IC 0208660 and IC 208664A. All tested accessions were found promising for powdery mildew except IC 0204206. During *kharif* 2018-19, all lines evaluated have recorded moderately susceptible (IC 0204206, IC 0208660, IC 0208661, IC 0208662, IC 0208663, IC 208679, IC 0208681) to susceptible reaction to *Cercospora* leaf spot. Minimum incidence of phyllody (13.3 %) was observed in IC 208664A and maximum phyllody observed was 42.1% in IC 0204206. All wild accessions were susceptible to bacterial and *Cercospora* leaf spot exhibiting highly consistent reaction over the years.

Keywords: *Cercospora* leaf spot, Disease reaction, Phyllody, Powdery mildew, Sesame, Wild species

The productivity of sesame is low due to its low harvest index, indeterminate growth habit, shattering, susceptibility to pests and diseases (Ashri, 1998). Diseases are the most destructive and causing considerable yield losses in Sesame. Among the diseases, bacterial blight, *Cercospora* leaf spot, powdery mildew *Macrophomina* and phyllody are important yield limiting factors in sesame (Ashri, 1998; Prasad, 2002; Palakshappa *et al.*, 2012) (Fig. 1). To combat the disease and maximize the production, there is an urgent need to manage the diseases of sesame by evaluating wild

species to identify the resistant sources and further use in hybridization programme as male parents.

The experiment was carried out in three different seasons at AICRP centre on Sesame and Niger, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad using ten wild species accessions. The crop was raised using recommended package of practices. Screening for bacterial blight, *Cercospora* leaf spot and powdery mildew in the present study was carried out using 0-5 scale (Anonymous, 2015). The per cent incidence was recorded for phyllody disease.

Table 1 Screening of wild accessions of sesame for major diseases

Wild accessions	Phyllody (% incidence)		<i>Cercospora</i> leaf spot (0-5 scale)		Bacterial blight (0-5 scale)	Powdery mildew (0-5 scale)
	Summer 2016-17	<i>Kharif</i> 2018-19	<i>Kharif</i> 2018-19	<i>Kharif</i> 2019-20	<i>Kharif</i> 2019-20	Summer 2016-17
IC 0204206	0.0	42.1	3	5	3	3
IC 0208657	0.0	15.5	4	5	4	0
IC 208658	0.0	19.5	4	5	3	0
IC 0208660	14.3	19.5	3	5	3	0
IC 0208661	0.0	14.7	3	5	3	0
IC 0208662	0.0	30.4	3	5	3	0
IC 0208663	0.0	21.4	3	5	3	0
IC 208664A	16.7	13.3	4	5	3	0
IC 208679	5.0	17.9	3	5	3	0
IC 0208681	0.0	18.9	3	5	3	0

All the wild accessions were found promising for phytoplasma in summer 2016-17 except IC 0208679 (5% incidence), IC 0208660 (14.3 %), and IC 208664A (16.7%). During *kharif* 2018-19, minimum incidence of phytoplasma was 13.3% (IC 208664A) and maximum phytoplasma observed was 42.1% (IC 0204206). Same

accessions were screened for *Cercospora* leaf spot during *kharif* 2018-19 and all the ten accessions recorded moderately susceptible (IC 0204206, IC 0208660, IC 0208661, IC 0208662, IC 0208663, IC 208679, IC 0208681) to susceptible reaction with a range of 3-4 grade (IC 0208657, IC 208658 and IC 208664A) for *Cercospora* leaf spot. Same accessions

were screened for bacterial blight during *kharif* 2019-20. All wild accessions exhibited disease severity of grade 3 except IC 208657 (grade 4) for bacterial blight indicating moderately susceptible reaction. Stem and root rot of sesame caused by *Macrophomina phaseolina* was noticed during *kharif* 2017-18. All accessions were free from powdery mildew except IC 0204206 with grade 3 during summer 2016-17 (Table 1). From the present study, it was concluded that even wild species of sesame are susceptible to all diseases.

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Bacterial blight



Cercospora leaf spot



Phyllody



Stem and root rot

Fig. 1. Major diseases of sesame

Integrated management of foliar diseases of sesame (*Sesamum indicum* L.)

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ABSTRACT

In sesame, minimum incidence of *Alternaria* leaf spot with severity of 10.6 and 7.8% with higher seed yield of 514 and 612 kg/ha, respectively were recorded in summer, 2018 and 2019 with spray of carbendazim 12% + mancozeb 63% 75WP @ 2 g/l. Low severity of *Cercospora* leaf spot 5 and 6.7% with higher seed yield of 509 and 565 kg/ha, respectively were recorded in summer 2018 and 2019 with spray of myclobutanil 10% WP @ 1 g/l.

Keywords: *Alternaria*, *Cercospora*, Integrated management, Sesame

Sesame (*Sesamum indicum* L.) is one of the most important ancient edible oilseed crop grown in India. Occurrence of *Alternaria* leaf spot and *Cercospora* leaf spot has become a major constraint in recent years for successful and profitable cultivation of sesame. Not much research work was carried out particularly on two fungal leaf spot diseases of sesame in coastal belt of West Bengal. Hence, an attempt was made to assess the effect of integrated disease management with different treatments in respect of disease incidence and yield of sesame.

Two consecutive summer season trials (2017 and 2018) were laid out at Agricultural Experimental Farm, Baruipur, South 24 Parganas, Institute of Agricultural Science, University of Calcutta with eight treatments in integrated manner viz., T1: spray of myclobutanil 10% WP @ 1 g/l; T2: spray of hexaconazole 4% + zineb 68% @ 2 g/l; T3: spray of cymoxanil 8% + mancozeb 64% @ 2g/l; T4: spray of trifloxistrobin 25% + tebuconazole 50% @ 0.4 g/l; T5: spray of hexaconazole 5% + captan 70% @ 2 g/l; T6: spray of *T. viride* @ 0.4%; T7: spray of carbendazim 12% + mancozeb 63% @ 2 g/l and T8: untreated check in randomized block design with three replications using the variety, Savitri. Disease severity of *Alternaria* leaf spot and *Cercospora* leaf spot of sesame was recorded.

Among the different treatments tested in field condition, the minimum severity of *Alternaria* leaf spot

(10.6 and 7.8%) with higher seed yield of 514 and 612 kg/ha, respectively were recorded in summer, 2018 and 2019 with spray of carbendazim 12% + mancozeb 63% 75WP @ 2 g/l. Similar observation on antifungal efficacy of fungicides on *Alternaria* was made by Panwar *et al.* (2013). The reduction of *Alternaria* leaf spot was also directly associated with an increase in seed yield. In case of *Cercospora* leaf spot, the minimum severity of 7.5 and 6.7% with higher yield of 509 and 565 kg/ha, respectively were recorded in summer 2018 and 2019 with spray of myclobutanil 10% WP @ 1 g/l. This was in agreement with the findings of Subrahmanyam *et al.* (1990) who have reported that myclobutanil was very effective on late leaf spot of groundnut.

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Advancement in *Sclerotinia* rot management in Indian mustard (*Brassica juncea* L.)

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ABSTRACT

Sclerotinia sclerotiorum is one of the important a fungal plant pathogens affecting all *Brassica* oilseed species grown in India. Management of the disease by crop rotation has limited success due to the pathogen's wide host range and long-term survival as resting bodies (sclerotia) in the soil. Nine *B. juncea* lines showing low levels of disease have been identified. Two of these lines were crossed with high yielding *B. juncea* varieties and further work on mapping quantitative trait loci (QTL) conferring resistance to *Sclerotinia* using populations of recombinant inbred lines (RIL) derived from the two crosses is under progress.

Keywords: *Brassica juncea*, *Sclerotinia sclerotiorum*, Stem rot management

Sclerotinia sclerotiorum (Lib.) de Bary, the causal organism of stem rot of *Brassica*, with over 500 host plants, infects leaves, stems and pods at different developmental stages, causing seed yield losses of up to 80%, as well as significant reductions in oil content and quality in *Brassicaceae*. Management of *S. sclerotiorum* is difficult, inconsistent and uneconomical due to the presence of wide host range and long-term survival of the resting sclerotia. Since no single method can effectively control *S. sclerotiorum*, one need to go for the integration of various eco-friendly measures. In the light of present day concern about the environment, human health and development of resistance to fungicides, biological control is an attractive alternative for plant disease management. Fungicides have been extensively used for the control of *S. sclerotiorum* in canola. Fungicides are effective in reducing severe yield losses. Seed treatment with carbendazim was also found effective in minimizing the *Sclerotinia* rot incidence. Foliar spray of carbendazim at full bloom stage provided significant disease reduction and highest seed yield among the different treatments over control.

During two consecutive cropping seasons (2016-18) at ICAR-Directorate of Rapeseed-Mustard Research, 5442 *B. juncea* germplasm were field-screened under *Sclerotinia* sick plot to determine their relative levels of resistance to SSR. Mean lesion length following stem inoculation with a highly virulent isolate (ESR 1) of the prevailing *S. sclerotiorum* pathotype ranged from 0 mm in germplasm RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695, IC 511651 to 497 mm in IC 0493022 ($P < 0.001$). Resistant lines have been used in breeding programmes to introgress the disease resistance trait into agronomically superior breeding lines. Already such populations have been developed, and RILs from these crosses have been developed to map the QTLs governing the resistance trait.

Quantitative Trait Locus mapping has proved to be a powerful approach in understanding the genetic basis of quantitative traits. Results from mapping and genetic analysis of *Sclerotinia* resistance show that QTLs in rapeseed would be very useful for marker-assisted selection and breeding for development of durable resistance cultivars.

Physical compatibility of insecticides and fungicides and their phytotoxicity on castor

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ABSTRACT

All 18 combinations of insecticides and fungicides tested were physically compatible. The combinations viz., novaluron + carbendazim, acetamiprid + carbendazim, acetamiprid + carbendazim 12% + mancozeb 63% and buprofezin + carbendazim 12% + mancozeb 63% showed phytotoxic symptoms like vein clearing and scorching on leaves, remaining all other treatment combinations were compatible.

Keywords: Combinations, Compatibility, Castor, Fungicides, Insecticides, Phytotoxicity

If compatibility of commonly used pesticides is known to farmers they will be able to use effective combinations for management of pests and diseases and

spraying costs also can be cut down. The present study was taken up to identify the compatibility among several insecticides and fungicides.

The physical compatibility of 18 combinations involving 6 insecticides (Clothianidin 50 WDG @ 0.1 g/l, Acetamiprid 20 SP@ 0.2 g/l, Flonicamid 50WG@ 0.2 g/l, Buprofezin 25SC @ 1.5 ml/l, Novaluron 10EC @ 1ml/l and Dimethoate 30EC@1.7 ml/l) and 3 fungicides (Propiconazole 25EC @ 1ml/l, Carbendazim 50 WP @ 1g/l and Carbendazim 12% + Mancozeb 63% WP @ 2G/l) were evaluated with jar compatibility test. In this test, initially 5 different sources of water were used (Nagarkurnool pond-8.03 pH, Palem pond-7.76 pH, RARS, Palem farm pond- 6.37 pH, RARS, Palem bore water- 8.38 pH and Kotalgadda village bore water- 8.22 pH) was taken in 1 liter jar to which 1 insecticide and 1 fungicide were added. The volume of insecticide and fungicide mixture was made up to 1 liter with 5 different sources of water, agitated by shaking the jar and left undisturbed for 30 minutes. Observations were recorded after 30 mins and 60 mins with respect to foaming, sedimentation and precipitation.

Pot culture experiment was conducted to study the phytotoxic effects of combinations of treatments (6 insecticides and 3 fungicides) along with untreated control. For each treatment 2 liter of tank mix of insecticide and fungicide were prepared as per the dosages in two replications. The pesticides are sprayed at 45 and 60 DAS on the foliage uniformly. Observations were taken before and after 1, 3, 7, 10 and 14 days after spraying.

All 18 combinations of insecticides and fungicides tested were physically compatible (Kamala et al., 2004 and Kubendran *et al.*, 2009). The pH of water ranged from 6.3 to 8.3. The water obtained from RARS, Palem farm pond was slightly acidic whereas water obtained from other four sources was found slight to moderately alkaline. The pH of insecticides ranged from 5 (Dimethoate 30EC) to 8.2 (Novaluron 10 EC), dimethoate and acetamiprid are moderately acidic (5 and 5.8, respectively), clothianidin was slightly acidic (6.5) whereas, buprofezin and novaluron were moderately

alkaline in nature (8.1 and 8.2, respectively). The pH of different combination of insecticides and fungicides with different sources of water was changed with range of 5.2 (Clothianidin 50 WDG @ 0.1 g/l + Carbendazim 12% + Mancozeb 63% WP @ 2G/l) to 8.5 (Clothianidin 50 WDG @ 0.1 g/l + Propiconazole 25EC @ 1ml/l). The combinations of novaluron 10EC @ 1ml/l + propiconazole 25EC @ 1ml/l (7.1) with Kotalgadda village bore water and combinations of flonicamid 50WG@ 0.2g/l + carbendazim 50WP @ 1g/l (7.0), buprofezin 25SC @ 1.5 ml/l + carbendazim 50WP @ 1g/l (7.2), novaluron 10EC @ 1ml/l + carbendazim 50 WP @ 1g/l (7.1) and clothianidin 50 WDG @ 0.1 g/l + carbendazim 12% + mancozeb 63% WP @ 2 g/l (7.2) with Palem pond water was neutral in nature. Remaining all other treatments were slightly acidic to slightly alkaline in nature with five sources of water.

The treatments Novaluron + Carbendazim 3 days after treatment castor plant showed symptoms like vein clearing and scorching on leaves. In treatments Acetamiprid + Carbendazim, Acetamiprid + Carbendazim 12% + Mancozeb 63% and Buprofezin + Carbendazim 12% + Mancozeb 63% , top most leaves started drying on 10th day and completely dried up on 12th day after treatment. Remaining all other treatment combinations were phytotoxically compatible with phytotoxicity scale ranging from 0-1 scale.

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Development of white rust resistant Indian mustard (*Brassica juncea* L. Czern & Coss) strain, "DRMRIJ 12-40"

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ABSTRACT

White rust caused by *Albugo candida* (Pers. ex Lev.) Kuntze is one of the most devastating diseases of Crucifers and causes severe losses in Indian mustard (*Brassica juncea*). DRMRIJ 12-40 is an inbred line derived from a cross between Zem 2 (exotic germplasm) and JGM 1-11 followed by individual plant selection. Shuttle breeding was followed to advance and screen the segregating generations (F₂ and F₄) at IARI Regional Station, Wellington. This strain has expressed resistant reaction against white rust during multilocation testing under All India Coordinated Research Project on Rapeseed-Mustard.

Keywords: Indian Mustard, Variety, White rust resistance

White rust caused by *Albugo candida* (Pers. ex Lev.) Kuntze is one of the most devastating diseases of Crucifers and causes severe losses in Indian mustard (*Brassica juncea*). Symptoms of the disease may appear at vegetative stage itself and sustain even at flowering stage. Indian germplasm of *Brassica juncea* generally has been reported to have susceptibility against this pathogen. Resistance to white rust has been shown to be governed by a single dominant gene. Wellington at Nilgiris in Tamil Nadu is a hot spot for white rust and also a site for raising Indian mustard during off season (April–July).

DRMRIJ 12-40 is an inbred line derived from a cross between Zem 2 (exotic germplasm) and JGM 1-11 followed by individual plant selection. Cross was attempted during 2004-05 between Zem 2 and JGM 1-11. F₁ generation was raised at Bharatpur during 2005-06. Shuttle breeding was followed by raising F₂ generation at IARI Regional Station Wellington during 2006. Resistant plants were selected and F₃ progeny rows were raised at Bharatpur during 2006-07. Progenies having all resistant plants were selected and again screened at IARI Regional Station Wellington (TN) during 2007 (F₄ generation). Homozygous single plants were selected from homogenous resistant lines. F₅ generation was raised at Bharatpur during 2007-08. Single plants were selfed and advanced from F₆ (2008-09) to F₈ (2010-11) generation. DRMRIJ 12-40 was inducted to AICRP-RM during 2015-16 and had been evaluated continuously for four years during 2015-16, 2016-17, 2017-18 and 2018-19.

White rust reaction on the leaves was recorded at two different stages viz., 75 and 100 days, while stag-

head formation was recorded at flowering stage. DRMRIJ 12 - 40 expressed resistant reaction against white rust at 75 days stage which was at par with resistant check BIO YSR. Disease reaction against white rust on leaves at 100 days stage was recorded at five locations viz., Hisar, Kangra, Kanpur, Pantnagar and Morena, which included three hot spots (Kangra, Pantnagar and Morena, Table 1). On the basis of mean disease index over all five locations for four years, candidate strain DRMRIJ 12-40 expressed 1.9 % disease severity which was better than the resistant check BIO YSR (6.5%) and susceptible check Rohini (34.3%). Resistant reaction against white rust was confirmed with already reported IP markers (Panjabi-Masand *et al.* 2010) and the strain was found to possess both white rust resistance loci. Hence, on the basis of disease reaction at five locations over four years and confirmation of resistance with molecular markers, strain DRMRIJ 12-40 was found resistant against white rust.

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Table 1 Mean disease index of candidate strain DRMRIJ 12-40 and check genotypes against white rust pathogen

Location	White rust reaction at 100 days		
	DRMRIJ 12-40	Bio YSR (Res. Check)	Rohini (Sus. Check)
Hisar	2.25	0.0	34.75
Kangra	1.13	14.2	44.8
Kanpur	0.0	0.0	31.7
Pantnagar	5.5	9.4	29.1
Morena	0.5	8.7	31.2
	1.9	6.5	34.3

Agri-innovations in oilseed crops for enhanced productivity and nutritional security

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ABSTRACT

In order to enhance the productivity and production potential of oilseeds, Ministry of Agriculture and Farmers Welfare, Government of India initiated organization of Cluster frontline demonstrations (CFLDs) on oilseeds. Some institutional support programmes were introduced to attain self-sufficiency in oilseeds production. Agri-innovations aid in enhancing the productivity of oilseeds and in maintaining nutritional security.

Keywords: Agri-Innovations, Enhanced productivity, Oilseed crops, Nutritional security

India is the largest producer, consumer and importer of vegetable/edible oils in the world. At present, about 26.18 million hectares of land is under oilseeds cultivation. Currently India is in the mid-way of self-sustaining in oilseeds production. Major contributor for oilseed economy in the world is soybean followed by rapeseed, mustard, peanut, sunflower and cotton. The most important tropical oilseeds are the coconut, palm kernels and groundnut (Sharma *et al.*, 2012).

Current *per capita* vegetable oil consumption in India is higher than recommended by nutritionists. This suggests implementation of programmes to increase awareness about adequate levels of vegetable oil consumption, especially at a time when domestic supply demand mismatch is affecting national self-sufficiency in edible oil production. In order to enhance the productivity and production potential of oilseeds, Ministry of Agriculture and Farmers' Welfare, Government of India initiated organization of Cluster Frontline Demonstrations (CFLDs) on oilseeds through Krishi Vigyan Kendras (KVKs) under the National Mission on Oilseeds & Oil Palm (NMOOP) in 2015-16 and subsequently supported conduct of CFLDs on oilseeds under the National Food Security Mission (NFSM) during 2018-19 (Malathi *et al.*, 2019).

Productivity has been taken into account due to adoption of modern techniques, good agronomic practices and technological breakthrough which lead to improvement in productivity. To increase production, more value addition is required to oilseeds and oils. Kumar *et al.* (2008) have identified some of the

innovations which can be used in oilseed crops *viz.*, resource-conservation technology, precision farming, crop modelling and simulation, etc. On-farm demonstrations and adoption of improved technologies need to be embraced to get higher recovery of oils through efficient processing methods. The irrigation, nutrient supply, availability of quality seed and the crop-specific production constraints in terms of technology and the institutional infrastructure as the determinants of growth rate, the input-use efficiency and intensity will help to enhance productivity of oilseed crops. Latest scientific and technological innovations in agro-techniques and enhancement in input-use efficiency need to be put to test. The promising technologies among these needs to be promoted to provide a strong technical push for oilseed productivity enhancement.

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Mobile application for safflower technology transfer

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ABSTRACT

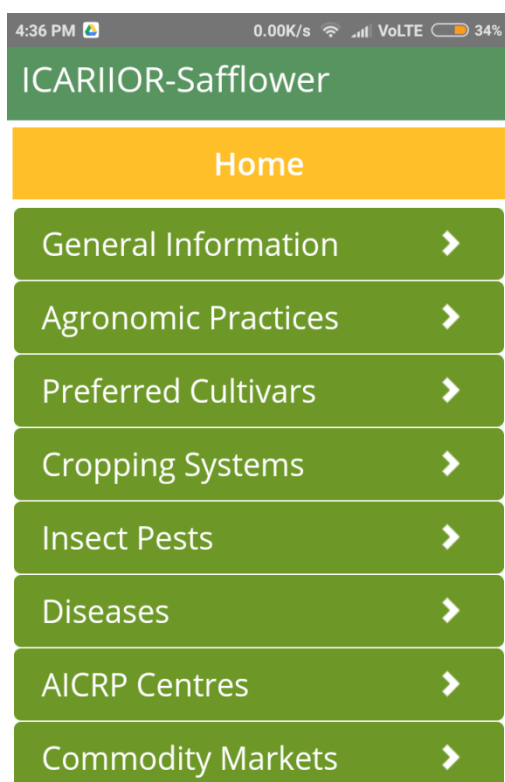
Information and communication technologies brought significant change in agriculture development. Among the ICTs mobile technologies has better access to provide more information to the stakeholders. Towards this

direction for effective technology transfer of safflower, an Android based mobile application “ICARIOR Safflower” mobile APP was developed at ICAR-IIOR to provide information on the safflower technologies to the stake holders. The information on different aspects of safflower *viz.*, General information, Agronomic Practices, Preferred cultivars, Cropping systems, Insect pests, Diseases, AICRP centres and Commodity markets was compiled and categorised into major chapters with sub-topics within each. This APP supports English language and is available in Google play store.

Keywords: Android, ICTs, Mobile APP, Safflower

The information and communication technologies (ICTs) has brought significant changes in agriculture development and transfer information and knowledge through various technologies among farmers and other stake holders. ICTs are integrated with different devices such as computer, internet, mobile phones, television and radio for dissemination of information (Chhachhar *et al.*, 2013). Among the ICTs available Mobile technology provide new approach to the farmers which have the potential to offer better service that can be used to better

access to the information. The mobile phones are multifunctional devices – doing much more than simply send and receive voice calls. Technologies such as voice and SMS platforms, custom made mobile/web applications, social media platforms can offer better services to the farmers. The major benefit of using mobile phones is that they can be used as platform for exchanging the information through calling, accessing the mobile application installed in the mobile (Patel *et al.*, 2016).



India ranks third in area and sixth in production of safflower at the global level (2016-17). It is mainly grown under residual moisture conditions in Maharashtra, Karnataka and in pockets of Andhra Pradesh, Telangana and Madhya Pradesh. Poor crop management under input starved conditions is the most important reason for low productivity. To increase the productivity and to provide the timely information to the

stake holders an initiative was taken by ICAR-IIOR, to develop a mobile app on safflower production technologies.

ICARIOR-Safflower Mobile App is developed using the open source software Android Studio which is a stack of software components which is divided into five sections namely Applications, Application Framework, Libraries, Android Runtime, Linux Kernel

and four main layers. Android Studio uses Java development tools for coding. Once the application is developed, it could be tested using virtual Android device and the functionality of the App is tested before publishing. Once the application is completed and tested, it could be published in the Google play store which facilitates the stake holders to download any time.

ICARIOR-Safflower Mobile APP was developed by ICAR-IOR to provide information on the safflower technologies to the stake holders. The information on different aspects of safflower viz., General information, Agronomic Practices, Preferred cultivars, cropping systems, insect pests, diseases, AICRP centres and commodity markets was compiled and categorised into major chapters with sub-topics within each. The APP is

developed in English and works both online and offline mode. Once the APP is installed in the mobile, the end user can retrieve the information as per the choice and at any point of time.

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Development of decision support system (DSS) for forecasting of gray mold disease of castor (*Ricinus communis* L.) using internet of things (IOTs)

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ABSTRACT

Gray mold disease of castor caused by the fungus *Botryotinia ricini* is responsible for disease epidemics and heavy yield losses in castor growing regions of Telangana. An experiment was conducted in castor growing areas to understand the crop-weather-disease relations using wireless sensors, disease prediction models and Decision Support System (DSS). The DSS uses these weather data along with crop and management information to drive disease forecasting systems and a validated model of the disease to generate location specific management recommendations for fungicide application.

Keywords: DSS, Castor, Gray mold, IOTs

Gray mold caused by *Botryotinia ricini* is one of the most destructive diseases of castor bean in Telangana state of India (Prasad *et al.*, 2016). The occurrence of gray mold is strongly governed by weather conditions (Soares 2012). Fortunately, Internet of things (IOTs) made it possible to observe the changes happening in castor crop in time and space (Koshy *et al.*, 2018). Intensive research efforts lead to establishment a biophysical relationship between the weather parameters and disease incidence so that they could be used for developing weather based disease prediction models and decision support systems.

To collect weather data remotely, Wireless Sensor Networks (WSN) were deployed in farmer's field of Mahabubnagar district, Telangana state. Data on temperature, relative humidity (RH) and capsule wetness hours in hourly intervals were recorded by WSNs and the data received at central servers at IOR through

GPRS system enabled Gateways. Disease severity was recorded at 24-hour interval manually.

Minimum temperature of 21°C, maximum temperature of 28°C, a mean RH of 94 per cent and 14 h of continuous wetness for a period of 4-5 days favoured disease development. Based on the data acquired from WSN, a weather indices based model was developed using temperature, relative humidity, wetness hours and their interactions on disease severity. The model was tested and further improved during 2018-19 incorporating the date of sowing, spike initiation, number of rainy days and continuous wetness as decision rules. Further, model validation in farmer's fields has been taken up during *kharif* 2019-20 and advisories were sent to 4000 castor growers through SMS and Voice alerts in advance to take up disease management interventions. It was observed that timely advisories helped the farmers to protect the crop and minimise the losses. On-farm demonstrations were

conducted to showcase effectiveness of prophylactic spray of propiconazole fungicide in management of gray mold.

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Correlation studies of sunflower *Alternaria* leaf blight with weather parameters

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ABSTRACT

To assess the impact of weather conditions on the progress of *Alternaria* leaf blight in two cultivars KBHS-44 and Morden of sunflower, an experiment was conducted during *kharif* 2013-14 and 2014-15. It was recorded that per cent disease index (PDI) was positively correlated with relative humidity during morning (RH1), relative humidity during evening (RH2), and with crop age for two cultivars. These correlations were found to be significant under protected and unprotected conditions. PDI was negatively correlated with temperature maximum significantly and also with rainy days, sunshine hours and wind velocity. But the effect of temperature minimum was not significant.

Keywords: *Alternaria* leaf blight, Correlation, Humidity, Weather parameters

Sunflower is one of the major oilseed crops grown in India and world. *Alternaria* leaf blight is one of the major diseases caused by *Alternaria helianthi* and seed yield losses were reported upto 80% (Shanker Goud *et al.*, 2006). The symptoms appeared on all plant parts and it is seed and air borne. This disease is affected by different weather conditions. To study the relation between the disease (PDI) and weather factors an experiment was carried out with two genotypes of sunflower at RARS, Nandyal.

The experiment was done for two years i.e., 2013-14 and 2014-15 with four different dates of sowing i.e., July 2nd fortnight, August 1st fortnight, August 2nd fortnight and September 1st fortnight with two cultivars KBSH-44 and Morden under both protected (maintained by spraying propiconazole @1 ml/litre for two sprays at the time of disease initiation and second at 15 days after first spray) and unprotected conditions. Spore load was calculated by erecting spore trap in the field. For every week since the starting of appearance of disease, disease severity score based on 0 to 9 scale was recorded and PDI was calculated. Correlations were computed between disease severity and crop age, *Alternaria* spore load with different corresponding weekly mean weather parameters.

Among four different dates of sowings, more disease severity was found in third and fourth dates of sowing and it reached up to 95.47%, 83.12% and 84.4%, 73.4% on morden and KBSH-44 respectively

during 2013-14 and 2014-15 years. From the pooled data, it was observed that PDI of *Alternaria* leaf blight was positively correlated significantly with crop age, RH1 and RH2 for two cultivars (Table 1). Other parameter, temperature maximum showed negative correlation significantly with PDI. Spore load and sunshine hours had positive significant correlation with PDI while temperature minimum and temperature maximum, rainfall, rainy days had negative correlation with PDI. Spore load was positively correlated but non-significant with RH1, RH2. These results are supported by observations made by Amaresh *et al.* (2003) who recorded negative correlation between *Alternaria* leaf blight, mean maximum temperature, yield and positive correlation with rainfall and relative humidity. PDI had negative correlation with sunshine hours, wind velocity, temperature minimum, rainy days, only for KBSH-44 with temperature minimum under unprotected conditions. Suresh *et al.* (2013) conducted similar type of experiments in safflower crop and found that PDI was negatively correlated with RH1, RH2, temperature minimum and positively correlation with crop age.

The research results showed that the disease progress of *Alternaria* leaf blight was positively correlated with spore load, crop age and relative humidity.

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Table 1 Correlation of Percent Disease Index (PDI), spore load of *Alternaria* leaf blight with weather parameters

PDI	Weather parameters (mean)								
	Temp. Min (°C)	Temp. Max (°C)	R.H 1 (%)	R.H 2 (%)	Crop age	R.F(mm)	Rain days	Sunshine Hrs.	Wind velocity (km/hr)
Morden (P)	-0.191	-0.328	0.407	0.431	0.48	-0.108	-0.065	-0.183	-0.042
Morden (UP)	-0.239	-0.302	0.392	0.386	0.57	-0.157	-0.116	-0.122	-0.044
KBSH-44 (P)	-0.248	-0.342	0.387	0.417	0.49	-0.104	-0.080	-0.164	-0.083
KBSH-44 (UP)	-0.377	-0.416	0.402	0.413	0.55	-0.158	-0.111	-0.142	-0.066
Spore load	-0.362	-0.031	0.228	0.046	0.36	-0.410	-0.555	0.316	-0.159

P-Protected, UP-Unprotected. Correlation coefficient (r) = 0.29.

On-farm demonstrations on management of gray mold disease of castor

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ABSTRACT

Gray mold of castor is one of the major destructive diseases causing huge yield loss. In on-farm demonstrations on fungicidal management of gray mold conducted during *kharif* 2017 and 2019 at different locations in Mahabubnagar Dist. and IIOR farm fields revealed that two sprays of propiconazole @0.1% recorded least percent disease severity and significantly increased the seed yield.

Keywords: Castor, Gray mold disease, Management

Gray mold caused by *Botryotinia ricini* is one of the very important diseases of castor inflicting huge yield losses to farmers in Telangana state (Prasad *et al.*, 2016). Use of chemical fungicides have shown efficacy of propiconazole against gray mold under experimental field conditions (Anonymous, 2018). Large scale on-farm demonstrations was taken up under farmers' fields in Mahabubnagar Dist. to showcase potential of the fungicide propiconazole management of gray mold disease.

On-farm demonstrations on management of gray mold of castor using chemical fungicide propiconazole 0.1% were taken up in 10 farmer's fields in 3 mandals of Mahabubnagar district of Telangana State and IIOR farm fields during *kharif* 2017 and 2019. Prophylactic sprays of propiconazole fungicide 0.1% was given based on the alerts given by the decision support system (DSS) for gray mold developed at IIOR based on weather data obtained from Wireless Sensors Networks (WSN)

deployed in farmer's fields. Observations on disease severity and seed yield were recorded.

During the year 2017, gray mold disease severity of castor ranged from 22 to 30% and a seed yield between 750 and 850 kg/ha was obtained in fields where one spray of fungicides was taken up (Table 1). Disease severity of 10% was recorded in fields where fungicide was sprayed two times with a seed yield of 1105 kg/ha. Disease severity ranging from 65 to 78% and seed yield between 450 and 570 was recorded in unsprayed fields. During 2019, gray mold severity ranged from 18 to 28 % and a seed yield recorded was between 700 and 980 kg/ha in fields where one spray of fungicides was taken up. In two fields where fungicide was sprayed twice, a disease severity of 7.9 and 12% was recorded with 1075 and 1310 kg/ha seed yield. Disease severity ranging from 65.9 to 83.4% and seed yield between 200 and 517 kg/ha was recorded in unsprayed fields. The demonstrations on fungicidal management thus showed potential of the timely spray of fungicide propiconazole

in management of gray mold, realizing high seed yield and economic benefit to castor growers.

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Table 1 Efficacy of propiconazole on gray mold of castor in on-farm demonstrations (Mahabubnagar and IIOR, Hyderabad)

Cropping season	Location	Farmer's field	Disease severity (%)		Seed yield (Kg/ha)	
			Sprayed	Unsprayed	Sprayed	Unsprayed
2017	Mahabubnagar	1	25.0	65.0	750	545
		2	22.0	78.0	850	450
		3	10.0	72.0	1105*	570
	IIOR	1	25.0	90.0	850	230
		2	30.0	85.0	800	150
		3	12.0	69.3	1075*	441
2019	Mahabubnagar	1	28.0	83.4	700	200
		2	24.0	77.5	820	427
		3	12.0	69.3	1075*	441
	IIOR	1	18.0	79.1	980	404
		2	7.9	65.9	1310*	517
		3	10.0	72.0	1105*	570

*Two sprays of propiconazole

Software aiding in selection of promising germplasm for oil palm improvement trials

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ABSTRACT

Oil palm germplasm of exotic sources collected from different parts of country is conserved in gene bank of ICAR-Indian Institute of Oil Palm Research (ICAR-IIOPR). Data recorded on morphological and yield parameters over a period of time needs to be evaluated to identify promising ones with required characteristics. Software was developed providing data entry screens for recorded observations, data analysis and generating reports which help in selection of germplasm with required traits.

Keywords: Calculations, Database, Data entry, Oil palm, Reports

Oil palm germplasm collected from different parts of country is conserved in gene bank of ICAR-IIOPR for evaluation and identifying promising ones for further utilization in breeding programmes. Data recorded periodically on morphological and yield parameters for this purpose becomes cumbersome for evaluation over a period of time. Germplasm evaluation and characterization is very important by multivariate analysis of oil palm germplasm as it helps to get elite genotype for further breeding programme (Bhagya, 2019). Change in technology and new requirements in analyzing germplasm data paved way for development of a software which helps scientists in the decision making process of selection of germplasm. At the same time, in long duration plantation crops like oil palm, this software helps in maintaining individual palm-wise data over the years which can be analyzed and utilized as and when needed.

Requirement specification of the software was done by collecting information about various observations

recorded periodically in oil palm germplasm conserved in the field of the research institute. Details of calculations performed on these recorded data were also collected to design the data entry screens and design the database. The software was developed in php 5.6.4, HTML 5, CSS with database in MySQL 5.0.11. Validations for all input data in the data entry screens are performed. The software is installed on the data server of the institute and can be accessed from any system in the local area network (Mary Rani, 2004).

The software is menu driven and is user friendly. To use the software the user is required to login with the username and password. Successful login displays homepage of the software with the options of Observations, Calculations and Reports as main menu. Options of Harvesting, Quarterly, Annual and Bunch Analysis Observations are available under dropdown menu Observations. Each of these sub menus has the options for data Insert, View, Modify and Delete. While data on morphological observations recorded quarterly

and annually, harvesting and bunch analysis data recorded regularly can be stored using corresponding "Insert Screen", the stored data can be viewed using View option. Any correction of data entry done can be edited using the Modify screen. The 'Calculations' menu presents two options Palm-wise calculations and Accession-wise means as dropdown menus. Based on the observations recorded, calculations of parameters like sex ratio, height increment, bunch index etc. are calculated. The Reports menu provides reports on Accession-wise growth and yield, palms that are high yielding, palms with low height increment, palms having

high bunch index value. These reports help in selection of germplasm for required traits.

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Frontline demonstrations on whole package in oilseeds: impact in enhancing productivity and profitability

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ABSTRACT

Frontline demonstration is one of the useful tools for transfer of technology as it is based on the pedagogy principle of seeing is believing. The demonstrations on whole package in oilseeds crops were conducted on farmer's fields in different agro-ecological situations during 2014-15 to 2018-19 to show the productivity potential and profitability of improved technologies (IT). The results showed 24.53 per cent increase in average yield with IT (1513 kg/ha) as compared to farmers practice (1215 kg/ha). The additional net returns accrued with IT was ₹ 10, 227/ha. FLDs proved a positive impact on adoption of improved technology on oilseed crops. The priority should be given to extension agencies to organize FLDs for increasing productivity potential of oilseed crops.

Keywords: ANR, Extension agencies, FLDs, Whole package, Yield gap

Frontline demonstrations on nine oilseeds crops were conducted by various AICRP oilseeds during 2014-15 to 2018-19 to show the productivity potential and profitability of improved technologies (IT). A total of 24,035 demonstrations were conducted on whole package which included recommended cultivar, optimum seed rate and spacing, fertilizer management and need based plant protection as compared to farmers' practices (FP) (Afzal, 2013). Data from IT plots and FP plots were analyzed and percent improvement in yield, cost of cultivation, gross monetary returns (GMR) was worked and the exploitable yield gap was estimated.

The results showed that the average mean yield of FLDs in all oilseeds was higher with IT than the farmers practice. The cost of cultivation (CoC) of IT was ₹24,441/ha as compared to FP of ₹22,084/ha, 10.72 % increase in CoC of IT as compared to FP but GMR of IT was ₹58,672/ha, whereas FP was ₹46,072/ha. The GMR increased by 27.33 % over FP, the additional net returns increased to ₹10227/ha over FP. The Benefit cost ratio was 2.40 in IT and 2.09 in FP. Over all, the gross monetary returns and additional net returns of IT are higher in all nine oilseeds crops as compared to the FP. The average yield of FLD plots was 1513 kg/ha, which was higher in IT than the national average yield of 1151

kg/ha. It was estimated that the yield gap between National yield and FLDs yield is 31.45%. The total oilseed production in the country can be enhanced to 38.64 mt from 29.39 mt by bridging the yield gap even without increasing the area under oilseeds (Kumar, 2014).

It is recommended that extension agencies engaged in transfer and application of agricultural technologies on farmers' field should give priority to organize frontline demonstrations (FLDs) on large scale by adopting cluster approach for harnessing the productivity potential of oilseed crops and to ensure rapid spread of flagship technologies developed by National Agricultural Research and Education System (NARES).

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Table 1. Economic returns due to whole package in oilseeds during 2014-15 to 2018-19

Crop	No. of demos	Mean seed yield (kg/ha)		Increase in seed yield (%)	CoC (Rs./ha)		Increase over FP (%)	GMR (₹/ha)		Increase over FP (%)	ANR (₹/ha)	B:C ratio	
		IT	FP		IT	FP		IT	FP			IT	FP
Total oilseeds mean	24035	1513	1215	24.53	24451	22084	10.72	58672	46078	27.33	10227	2.40	2.09

IT=Improved Technology; FP=Farmers Practice; CoC=Cost of Cultivation; GMR=Gross monetary returns; ANR=Additional Net Returns; B:C ratio= Benefit cost ratio

Temporal performance of castor *vis-à-vis* competing crops in Gujarat - A Markov chain analysis

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ABSTRACT

Temporal performance of castor cultivation in Gujarat for the last five decades was studied. The study divided in to five periods and transition probabilities were calculated for castor and its competing crops with respect to area and production. Results indicated that over all share of castor was very high with respect to area (84.8) and production (74.2). Castor share in area during Decade IV and V were low compared to previous periods. However, there was three-fold increase in production contribution in Decade V compared to the earlier period. This increase in production contribution despite of reduction of area retention can be attributed to the release of high yielding public sector hybrids, associated technologies and its large scale adoption by NARES during the last two decades.

Keywords: Castor, Cropping pattern, Crop substitution, Transition probability matrix

Castor is an important industrial oilseed crop grown all over the world. India is the global leader in terms of area, production and productivity and Gujarat occupies first rank in area, production and yield among the states. Cropping pattern in any region is mainly determined by preference of farmers, prices and demand apart from the agro-climatic conditions. In the present context the study analyses the probability of retention of castor cultivation area in future *vis-à-vis* its competing crops.

Area and production of castor and other major competing crops *viz.*, groundnut, rice, wheat, bajra, maize, cotton, gram, tur and others (area under rest of crops) was collected from Directorate of Economics and Statistics, Ministry of Agriculture, GOI for last 50 years (1966 - 2016).

Markov chain analysis is adopted in the present study to know the contribution of area and production by castor and other crops. Markov chain analysis develops a transitional probability matrix (TPM) 'P', whose elements P_{ij} indicate the probability (share) of crop group switching from the i^{th} crop group to the j^{th} crop group over time. Transitional probability matrix which denotes the transition probabilities for every pair of state ($i, j= 1,2,..r$) and has the following properties. (i) $0 \leq P_{ij} \leq 1$ (ii) $\sum P_{ij} = 1$ for $i = 1, 2,..r$. Its diagonal elements represent retention share of respective crop group in terms of area/production under crops. The stability of the

share of crop and their direction of change over a period of time was captured by TPM. As the diagonal elements approaches zero, the crops become less and less stable and as they approach one, they become more and more stable over a period of time (Rao, 2005; Basavaraj *et al.*, 2016).

Temporal data considered for the study was divided in to five periods (decades). Transition probabilities were computed for each decade to study the performance of castor crop over five periods and overall performance of castor also computed by considering the entire study period. The probabilities were converted to per cent values and were presented in Table 1. The results suggested that contribution of castor towards area (84.8) and production (74.2) over five decades is very high compared to other crops.

The individual decadal analyses indicate that castor share was highest in Decade II (62.2) and Decade IV (29.7) was lowest. From Decade III on wards the castor lost its major area to cotton (24.7, 57.8 and 68.9). The reason being during these periods Bt cotton released and become popular globally as well as in India. A perusal of Table 1 shows that castor area slightly gained its share in Decade V but major share was gone to cotton. However, gain in production was more than threefold and cotton lost its contribution in terms of production. This increase in production contribution despite reduction of area

retention can be attributed to the release of high yielding public sector hybrids, associated technologies and its large scale adoption by NARES during the last two decades.

This in-depth analyses reveals that the performance of castor is remarkable and to retain the status of castor in Gujarat focused technology assemblage in low productivity regions of Gujarat could improve yield and thereby increase in production contribution. Taking policy measures such as fixing MSP, establishing linkage between farmer and industry for output marketing or direct buy back by government leads to

reduction in supply chain and fetching more profit would attract the farmers for cultivating the castor.

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Table 1 Transition probabilities for Castor and competing crops

Period	Over all (1966-16)	Decade I (1966-75)	Decade II (1976-85)	Decade III (1986-95)	Decade IV (1996-2005)	Decade V (2006-16)
	Area					
Castor acreage /Retention of previous year (%)	84.8	36.8	62.2	57.8	29.7	31.1
Crop Substitution (%)	Rice (8.7) Maize(4.0) Tur (2.5)	Maize (1.6) Tur (59.6) Wheat (2)	Rice (37.8)	Cotton (24.7) Rice(17.5)	Rice(18.1) Cotton (57.8)	Cotton (68.9)
	Production					
Castor production contribution of previous year (%)	74.2	35.0	56.3	23.6	13.9	43.1
Crop Substitution (%)	Rice (25.7) Gram (0.1)	Wheat (36.0) Maize(19.0) Gram(10.0)	Rice(13.0) Maize (19.0)	Cotton (21.3) Rice(21.8) Maize(29.0) Gram(4.2)	Rice(30.8) Maize(40.2) Bajra(15.1)	Groundnut(1.1) Rice(25.1) Maize(12.3) Cotton(28.3) Tur(5.5)

Performance of oilseeds in India: A temporal study

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ABSTRACT

In India, oilseeds are cultivated on an area of 26 million ha with a production of 29.65 million tonnes primarily under rainfed conditions. Oilseeds production could not keep pace with the growing demands due to changing life style, increasing population and rising per capita income resulting to dependency on imports. The CAGR revealed that across different periods, despite fluctuations in the rate of growth in area, yield contributed to change in production thus suggesting the power of technologies operational at the farm. Multi-pronged strategy through institutional refurbishments for technology assemblage, favourable tariff policy and public private partnerships on seed production, output marketing and value chains needs strengthening for enhancing the domestic production and productivity.

Keywords: Area, Oilseeds, Population, Production

In India, oilseeds are cultivated on an area of 26 million ha with a production of 29.65 million tonnes (Quinquennium ending 2017-18). Although progress has been achieved in production of oilseeds in India, the pace in production is not commensurate to meet the rising demand of consumption and hence heavy dependency on imports has been evidenced in the country post globalization.

An attempt has been made in this paper to examine the performance of oilseeds from 1966-67 to 2017-2018. The study is divided into five periods. Compound Annual Growth Rate (CAGR) for area, production, productivity, cumulative exports earnings and imports were computed to examine performance of each period.

During Period I, the CAGR was 0.47, 3.24 and 2.76 per cent for area, production and productivity

respectively. An additional area of 0.65 million ha for TE 1965-66 over 1966-67 led to production increase of 2.09 million tonnes and yield increase by 108 kg/ha. The *per capita* availability (PCA) increased from 2.6 to 3.5 kg/annum. The cumulative export earnings (CEE) from oilseed products was ₹928.91 crore while cumulative import (CI) imports was ₹288.6 crore.

During period II, CAGR of area, production and yield was 1.50, 3.77 and 2.23 per cent, respectively. The additional area and production evidenced for TE 1985-86 over TE 1976-77 was 2.16 million ha and 2.69 million tonnes with incremental yield of 78 kg/ha. The PCA increased from 3.5 to 5 kg/annum. The CEE earned from oilseed products was ₹1,687.07 crores while the CI resulted to ₹5,722.4 crores. The increase in imports resulted in establishing the TMOP with the objective of achieving self-sufficiency.

Table 1 Compound Annual Growth Rates of area, production and yield of oilseeds (1966-67 to 2017-18)

Period	Area	Production	Yield
1966-67 to 1975-76	0.47	3.24	2.76
1976-77 to 1985-86	1.50	3.77	2.23
1986-87 to 1995-96	3.70	6.97	3.15
1996-97 to 2005-06	0.01	1.08	1.07
2006-07 to 2017-18	-0.49	1.13	1.62
Overall Period	1.23	3.19	1.93

The period III evidenced 3.70, 6.97 and 3.15 per cent CAGR in area, production and yield respectively. An additional area and production of 5.84 million ha and 7.66 million tonnes was evident (TE 1995-96 over 1986-87). The PCA increased from 5 to 7 kg/annum. The CEE was ₹10,863 crores and CI was ₹6,275 crores. The advent of GATT/WTO led to the spurt in the imports especially during 1995-96 (₹ 2,260 crores).

During period IV, the CAGR in area was 0.01, in production and yield was 1.08 and 1.07 per cent respectively suggesting the stagnancy in area. The area increased by 0.15 million ha but production increased by

2.71 million tonnes (TE 2005-06 over 1996-97) suggesting the power of technology at the field level. This period evidenced increase in the PCA from 7 to 10.6 kg/annum growing at a CAGR of 3.89 per cent. The gains in production growth could not offset the increase in PCA and hence imports began to flow in. The CI during this period was ₹74, 325 crores while CEE was ₹27,983 crores.

In period V, CAGR of -0.49, 1.13 and 1.62 per cent in area, production and yield was evidenced. The area reduced by 1.33 million ha while production increased by 2.07 million tonnes (TE 2017-18 over 2006-07). This is a testimony that technologies generated in oilseeds across the NARES have paved way for increase in production. The PCA increased from 10.6 to 19.5 kg/annum and had widened the gap in the demand supply balance forcing increasing imports ably complimented by a favourable import policy. The CI during this period was Rs.537456 crores while CEE was ₹159822 crores.

The country needs to evolve institutional refurbishments for technology assemblage and transfer on AESR basis for enhancing the domestic productivity and production. Suitable import policy on tariff needs to be evolved to favour increase in area under oilseeds. Implementation of MSP could be a driving force to rejuvenate the oilseed farming community. Appropriate public private partnerships needs to be evolved for seed production output marketing and value chains

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Trends in consumption of vegetable edible oils in India: A temporal analysis

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ABSTRACT

Though India is one of the largest producers of oilseeds in the world, it is the biggest vegetable oil importer to meet the supply demand imbalance thus causing a huge loss to the exchequer of the nation. The present per capita consumption is 18.2 kg/annum. The growth analysis suggested that during the TMO period, highest rate of growth of area, production was evidenced. Population growth rate, domestic oil availability and out of home consumption, are observed to be the main factors for higher imports of edible oils. Appropriate policy on import duty of edible oils and increase in MSP for oilseeds and its implementation may encourage domestic production of edible oils thereby reducing the import bill.

Keywords: Consumption, Edible oils, TMO - Technology Mission on Oilseeds

Vegetable oils are essential for nutrition, energy and economy of the country and in global commodity supplies. Edible vegetable oils are derived from oilseed crops *viz.*, groundnut, sesame, rapeseed and mustard, sunflower, soybean and safflower. In addition, substantial quantities of vegetable oils from secondary sources are derived from cotton seed, rice bran, oil palm and corn.

A temporal study was formulated with the objectives of finding the status of oilseed crops, imports, domestic availability, per capita consumption of edible vegetable oils and population growth rate in the country. The required data was collected from different secondary sources and classified into four periods such as Pre-Technology Mission on Oilseeds period (TMOP) (1975-76 to 1985-86), TMOP period (1986-87 to 1994-95), WTO period (1995-96 to 2000-01) and post-WTO period (2001-02 to till date). Log linear functional form was used to compute CAGR in the present study.

During Pre-TMO period, India witnessed a CAGR of area 1.50, production 2.85 and yield 1.33 per cent while the rate of imports was 16.83 %. This increased import rate led to implementation of TMO by the GoI in 1986 and later, due to technology interventions and transfers, the aforesaid period (1986-87 to 1994-95) has accounted for the highest CAGR (4.26, 7.74 and 3.3 % in area, production and yield respectively). Although, the domestic area, production and yield of nine oilseed crops grew at a notable CAGR of 1.13, 3.11 and 1.96 % for the whole period (1975-76 till date), there has been a negative CAGR -1.39, -0.71, 0.69 % for the same was observed during the WTO period because of new trade

regime due to establishment of WTO. This affected the imports with an increased CAGR of 36.68 per cent (Cumulative imports: 10.7 million tonnes) during the same period. Though the domestic availability of edible oil has been increasing over the years (2.7 mt in 1975-76 to 10.5 mt in 2018-19), the total demand (domestic availability plus imports) also grew at an increasing rate (2.8 mt in 1975-76 to 25.5 mt in 2018-19) due to which, the country is still continuing with higher imports.

The *per capita* consumption of edible oils has changed over the years and now the country is witnessing the CAGR of 4.16 per cent with 19.5 kg/annum. Rise in population growth rate, increasing out of home consumption, increasing domestic demand (domestic availability plus imports) and insufficient domestic availability of edible oils (including secondary sources) are considered to be some of the reasons for higher imports. Policy on import duty of edible oils and increase in MSP for oilseeds may encourage domestic production of edible oils thereby reducing the imports.

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CAGR for area, production, yield of oilseeds, domestic availability, *per capita* consumption and imports of edible oils in India (1975-76 to 2018-19)

Periods	Area (m. ha)	Production (m. tonnes)	Yield (kg/ha)	Domestic availability of edible oil (m. tonnes)	<i>Per capita</i> consumption (kg/annum)	Imports of edible oil (m. tonnes)
Period I (1975-76 to 1985-86)	1.50	2.85	1.33	4.21	4.90	16.83
Period II (1986-87 to 1994-95)	4.26	7.71	3.30	7.70	2.15	-27.10
Period III (1995-96 to 2000-01)	-1.39	-0.71	0.69	-1.73	5.79	36.68
Period IV (2001-02 to 2018-19)	0.57	2.80	2.22	3.51	5.33	8.94
Overall period (1975-2018)	1.13	3.11	1.96	3.39	4.16	9.56

Source: Various reports from Department of Sugar & Vegetable Oils; DG, CI & S, Dept. of Commerce, Kolkata and Economic Survey of GoI.

Storage stability of kernels and oil of normal and oleic acid rich groundnut Varieties

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ABSTRACT

The oleic acid rich groundnut variety (Dh 245) and normal groundnut variety (GPBD 4) were kept for storage in the form of kernels as well as oil for six months to study the storage stability. Peroxide value and free fatty acids increased at lower rate in Dh 245 compared to GPBD 4 variety in both kernels and oil. In case of fatty acid composition, the per cent decrease in the linoleic acid content and U/S ratio was lower in Dh 245 variety compared to GPBD 4 variety in both kernels and oil. This indicated that Dh 245 variety has good storage stability than GPBD 4 variety. Oxidation rate of kernels was lower than oil during storage.

Keywords: Groundnut, Oxidative parameters, Peroxide value

Groundnuts have good amount of proteins (25-28%) and lipids (50-55%). Due to their high oil content, they are susceptible to developing rancidity and off-flavors through lipid oxidation. Groundnut oil contains linoleic and oleic acid at different ratios. Normal groundnuts have 40-50 per cent oleic acid and 30-40 per cent of linoleic acid. Groundnuts with high oleic to linoleic acid ratio (O/L) have been released for better oil stability and nutritional quality. In the present study, the oleic acid rich groundnut and normal groundnut were investigated and compared for storage stability.

The oleic acid rich groundnut variety (Dh 245) and normal groundnut variety (GPBD 4) which were procured and shells were removed using manual groundnut decorticator. Oil was extracted from selected varieties using table top hot oil expeller. The kernels and oil of both the varieties were stored at ambient conditions in suitable packaging material. The fatty acid composition of the samples was analysed once in a month and other oxidative parameters were determined at every 15 days by AOCS methods (Anon, 1993) for a period of six months. The statistical analysis was carried out by SPSS software (version 23).

The peroxide value and free fatty acid increased in all the samples, which may due to auto oxidation of fats and/or due to enzymatic oxidation (Smouse, 1994). The

peroxide value crossed unacceptable limit of 15 meqO²/kg in GPBD 4 oil, whereas the oil of Dh 245 variety and seeds of both the varieties the peroxide values were found within the acceptable limit at the end of the storage period. The per cent increase in the free fatty acids was found lower in Dh 245 variety in both seeds and oil. In case of fatty acid composition, the unsaturated fatty acids decreased and saturated fatty acids increased in the composition during storage, which confirms the earlier results (Li *et al.*, 2014). The per cent decrease in the linoleic acid content was observed lower in seeds and oil of Dh 245 variety (13% &17%) compared to seeds and oil of GPBD 4 variety (20% & 27%).

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Decomposition analysis of safflower production in India

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ABSTRACT

The present study was an attempt to analyze the growth performance of total oilseeds in India and relative contribution of area and yield on production of safflower in particular using secondary data. The results indicated that during the study period (2005-06 to 2017-18) area under almost all the crops except soybean had declined whereas production declined only in case of sunflower (-13.40 %), safflower (-7.41 %) and niger seed (-2.85 %). Further, a detailed district wise analysis of safflower revealed that the area was the major contributor (56.94 %) for the decline in production of safflower in Belgaum district. The contribution of productivity was remarkable in Bidar district (572 %). In Period-I, productivity effect was high in the case of Osmanabad (114 %) and Parbhani (110 %) districts and in Period- II, interaction effect was high in the case of Hingoli district (566.20 %).

Keywords: Contribution of area, Decomposition, Safflower

Despite many dietary benefits and its uses, safflower remained as a minor oilseed crop in India. Of late, the area of safflower is coming down in the country. Keeping in view the importance of safflower, an attempt has been made to study the growth of total oilseeds in India, safflower in particular and to know the contribution of area and productivity towards production of safflower. An attempt has been made earlier to analyse the growth performance of oilseed crops in India

(Gaddi *et al.*, 1999) and in the present study we have taken up a decomposition analysis of the oilseed situation in the country since 2000.

To analyse the growth rates, time series data on area, production and productivity of important oilseed crops grown in India from 2005-06 to 2017-18 were collected from DES, GOI. In order to analyse the effect of area and productivity on production, potential safflower growing districts were identified from

Karnataka and Maharashtra states which contribute to more than 90% of safflower production in India. Belgaum, Bidar, Dharwad and Gulbarga districts of Karnataka, Osmanabad, Parbhani and Hingoli districts from Maharashtra were identified for which secondary data on area, production and productivity were collected from the concerned state agricultural departments based on the availability of the data i.e. for a period from 2007-08 to 2015-16 in Karnataka and from 2000-01 to 2018-19 in Maharashtra. To analyse the growth performance of oilseeds in India, Average Annual Growth Rates (AAGR) have been worked out. To measure the contribution of area and productivity towards production of safflower decomposition analysis was used.

The crop wise growth rates indicate that area under almost all the crops except soybean had declined in India. Annually, the area under groundnut which is a leading oilseed crop declined by 2%, sunflower by 15.30%, safflower 10.27%, sesame 0.41%, rapeseed and mustard by 1.02%, linseed by 1.91% and niger seed by 4.70%, whereas the area under soybean and castor increased annually by 2.63 % and 2.32 % respectively. Highest decline in area was seen in the case of sesame and rapeseed and mustard. With respect to the production, negative trend was recorded in sunflower (-13.40%), safflower (-7.41%) and niger seed (-2.85%). Productivity of all the crops increased during the study period which might be the reason for increase in production of some crops even though area declined annually. There are similar analysis reported earlier also (Gaddi *et al.*, 1999). This may be attributed to the technological advances made in these crops with respect to cultivation.

The results of decomposition analysis (Table 1) indicate that, area was the major contributor (56.94%) in production of safflower in the case of Belgaum district followed by Dharwad (37.03%) and Bidar (20.52%)

districts. While in the case of Gulbarga, the contribution of area and productivity was negative. The contribution of productivity was remarkable in the case of Bidar (572%). Both the area and productivity influenced the production in the case of Belgaum (409.06%), Dharwad (1004.97%) and Gulbarga (461.90%) districts.

In the case of Maharashtra, during Period-I, productivity effect (114%) was most responsible for increase in production of safflower in Osmanabad district, whereas area effect was negative (-47.00%). Productivity was a driving force in Parbhani district with an effect of 110%. The interaction effect was highest in the case of Hingoli district (72%). In Period-II, area and productivity effect was negative in all the districts. However the interaction effect was again high in the case of Hingoli (766.20%).

From the above analysis, it is revealed that despite several programs and schemes in the form of “Technology Mission on Oilseeds,” the area and production have witnessed negative growth for most of the oilseed crops except soybean and castor. Though, safflower and sunflower are minor oilseeds, they assume importance in dietary pattern and hence, efforts should be made to promote these oilseeds, keeping in view of increasing demand in the international market. Promoting the latest technologies of oilseed processing such as cold press and extraction of virgin oil will go a long way in boosting production of safflower and sunflower which in turn substantially increases their share in export market.

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Table 1 Contribution of area and productivity on production of safflower in Karnataka and Maharashtra

State	District	Area Effect	Productivity Effect	Interaction Effect
Karnataka	Belgaum	56.94	-366.00	409.06
	Bidar	20.52	572.00	-492.52
	Dharwad	37.03	-942.00	1004.97
	Gulbarga	-68.90	-293.00	461.9
Maharashtra				
Period – I (2000-01 to 2009-10)	Osmanabad	-47.00	114.00	33.00
	Parbhani	55.00	110.00	-65.00
	Hingoli	-8.00	36.00	72.00
Period – II (2010-11 to 2018-19)	Osmanabad	-206.70	-228.00	534.70
	Parbhani	-358.60	-115.00	573.60
	Hingoli	-262.20	-404.00	766.20

ICT outreach for farmers and other stakeholders to enhance productivity of oilseeds

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ABSTRACT

Oilseeds are very important next to food-grains in India, in terms of acreage, production and value. Edible oil plays an important role in nutrition since, it acts as a carrier for fat soluble vitamins in the body as well as other physiological functions in the body. Therefore, there is an urgent need to increase the productivity of oilseeds in order to meet the daily requirements. Information and communication technology (ICT) could be a possible solution which can share timely and accurate information on weather, inputs, markets, and prices, by feeding information into research and development initiatives, by disseminating knowledge to farmers, by connecting producers and consumers, and through many other avenues. The research efforts of schemes and mobile apps on oilseeds under ICAR has resulted in widespread network in development of high yielding varieties/hybrids coupled with the location-specific crop production and protection technologies. This paper deals with importance of ICT outreach for farmers and other stakeholders that increases production of oilseed crops and reduction of oil imports.

Keywords: ICT, Oilseeds, Production

Oilseeds are very important in India, next to food-grains in terms of acreage, production and value. Considering the importance of oilseeds Government has implemented various schemes for increasing the production of oilseeds. These are Intensive Oilseed Development Programme (1974–84); National Oilseeds Development Project Fresh Fruit Bunches of Oil Palm (1984-90), Oilseeds Production Thrust Project (1987-91), Oilseeds Production Programme (1991-2004) and Oil Palm Development Programme (1991-2004) under Technology Mission on Oilseeds and Integrated Scheme of Oilseeds, Oil Palm and Maize (ISOPOM) in 2004-14. Seed hub of oilseeds have been included under NFSM-Oilseeds & Oil palm from 2018-19. There are several production technologies developed in the NARES (Anonymous 2014) that will be useful for farmers and these need to reach the farmers.

Various websites and Mobile apps for improving status of oilseeds:

Some of the websites which are useful for improving oilseeds production are:

- ICAR, New Delhi (www.icar.org.in) – Oilseed Research.
- ICAR-IIOR (<http://www.icar-iior.org.in>)–Safflower, Sunflower, Linseed, Sesame, Niger, Castor.
- APEDA (www.apeda.com) – Oilseed export.
- ICRISAT, Hyderabad (<http://icrisat.org>) – Groundnut.
- NMOOP (www.nmoop.gov.in)-Oil Seeds development schemes/Guidelines/Circulars etc.
- AGMARKNET <http://agmarknet.nic.in> - Market arrivals and prices.

ICAR-Indian Institute of Oilseed Research (ICAR-IIOR), Hyderabad broadcasts regularly voice SMSs to farmers' mobile phones on various production technologies related to oilseed crops. And mobile applications used like Kisan Savidha, Plantix, IIFCO Kisan Agriculture, IIOR-Mobile app and AgMarknet.

ICT has become an important aspect for the growth of Oilseed production and socio economic development in business sectors. Farmers always searched for technological options and practices which brought them higher returns and readily responded to various economic incentives. ICT can do so, by collecting and sharing timely and accurate information on weather, inputs, markets, and prices, by feeding information into research and development initiatives, by disseminating knowledge to farmers, by connecting producers and consumers. The use of mobile applications providing price information to farmers can reduce market distortions and help farmers plan production processes.

Growing import is depressing domestic market and production. The Nutritional requirement of vegetable oil is about 12-13 kg per annum per person while in India we consume more than 19 kg per annum *per capita*. The excess consumption can be reduced by educating the consumers through mobile apps, electronic print media, wide publicity/advertisement and nutritional camps. By reducing oil consumption to 15 kg, we can reduce 5.00 million tons of import costing around Rs.25000/-crores per year.

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Analysis on export competitiveness of oilseeds with BRICS countries

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ABSTRACT

The paper attempts to assess India's trade intensity as well as the revealed comparative advantage (RCA) of the oilseeds with respect to trade with BRICS (Brazil, Russia, India, China and South Africa) disaggregate levels. The study assesses the structure of the comparative advantage from 2001 to 2018. The study found that TI (Trade Intensity) with the BRICS group was more in comparison to ROW (Rest of world). EEI (Export Intensity Index) for BRICS countries was also more intense in comparison to ROW whereas III (Import Intensity Index) showed less intense in comparison to ROW. Relative comparative advantage for groundnut, sesame and mustard was observed with the BRICS group.

Keywords: Export intensity index, Import intensity index, Oilseeds, Trade intensity

India is the largest producer of oilseeds in the world and oilseed sector occupies an important position in the agricultural economy of the country. India is the fifth largest vegetable oil economy in the world, next to USA, China, Brazil and Argentina, and has an annual turnover of about ₹80000 crores (Jha *et al.*, 2012). All the BRICS countries are leading in the production.

Data from International Trade Centre (ITC) based on Harmonized System Codes (HS Code 2017(HS6)): for the period of 2001-2018 were collected.

EII between India and BRICS= $[X_{ij}/X_i]/\{[M_j-M_{ji}]/[M_w-M_i]\}$
EII= Export Intensity Index. M_j = Total imports of country j and M_{ji} = Imports of country j from country i.

III between India and BRICS= $[M_{ij}/M_i]/\{[X_j-X_{ji}]/[X_w-X_i]\}$
III = Import Intensity Index. X_j = Total export of country j and. X_{ji} = Export of country j to country i.

Revealed Symmetric Comparative Advantage: In RCA index calculation, the problem of asymmetry arises and to make it symmetric, the methodology suggested by Dalum *et al.* (1998) was followed and the new index is

called 'Revealed Symmetric Comparative Advantage' (RSCA). Mathematically, it can be expressed as follows, $RSCA = (RCA - 1) / (RCA + 1)$.

Trading index with BRICS group for the year 2002 and 2007 showed more than ROW. Export intensity index more intense in 2005, whereas import intensity index showed less intense with BRICS group. Groundnut, sesame and mustard registered more comparative advantage whereas soybean, sunflower and other oilseeds had less comparative advantage.

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Year	RSCA						TI	EII	III
	Groundnut	Soybean	Sunflower	Sesame	Mustard	Major Oilseeds			
2001	0.511	-0.992	-0.995	0.991	0.787	-0.087	0.914	0.795	0.118
2002	0.393	-0.997	-0.220	0.990	0.978	-0.228	1.009	0.863	0.132
2003	0.564	-0.963	-0.709	0.956	0.957	-0.107	0.918	0.852	0.108
2004	0.728	-0.622	-0.453	0.954	0.982	0.120	0.922	0.898	0.105
2005	0.806	-0.976	-0.271	0.960	0.976	0.278	0.994	1.051	0.125
2006	0.907	-0.966	-0.122	0.954	0.982	0.479	0.954	0.974	0.125
2007	0.686	-0.989	-0.702	0.911	0.963	-0.050	1.008	0.880	0.142
2008	0.728	-0.987	-0.678	0.916	0.984	-0.066	0.905	0.760	0.147
2009	0.798	-0.984	-0.424	0.851	0.980	-0.128	0.925	0.650	0.169
2010	0.769	-0.990	-0.580	0.839	0.972	-0.042	0.929	0.802	0.150
2011	0.785	-0.997	0.020	0.843	0.988	-0.028	0.824	0.596	0.151
2012	0.793	-0.997	-0.259	0.839	0.983	-0.048	0.781	0.596	0.141
2013	0.813	-0.963	-0.245	0.836	0.990	-0.132	0.715	0.551	0.120
2014	0.809	-0.984	-0.255	0.789	0.980	-0.116	0.775	0.550	0.133
2015	0.819	-0.989	-0.437	0.722	0.963	-0.153	0.851	0.443	0.159
2016	0.819	-0.993	-0.620	0.708	0.925	-0.141	0.903	0.422	0.174
2017	0.830	-0.991	-0.607	0.810	0.961	-0.178	0.922	0.463	0.184
2018	0.836	-0.989	-0.432	0.831	0.974	-0.200	0.831	0.498	0.157

Growth and decomposition of major oilseeds in Madhya Pradesh (2000-01 to 2017-18)

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ABSTRACT

Madhya Pradesh occupies 27 and 24 per cent of India's oilseeds area and production (TE 2017-18). The CAGR for area was positive for soybean, rapeseed-mustard, sesame and groundnut while area decelerated in linseed and niger. The positive CAGR for production and yield across all oilseed crops indicates sustained production due to area expansion and technology implementation. Decomposition analysis revealed that area effect had more pronounced contribution for change in production across all crops while technology (yield effect) played a crucial role for change in production of sesame, rapeseed-mustard and soybean. Technology assemblage and its large scale expansion can enable increase in the productivity of oilseed crops in Madhya Pradesh.

Keywords: CAGR, Decomposition analysis, Madhya Pradesh

In India, annual oilseeds are cultivated on 24.51 million ha with a production of 31.46 million tonnes (2017-18). Madhya Pradesh ranks first in area and production (6.98 million ha and 7.11 million tonnes) contributing to 27 and 24 per cent of the nation's oilseeds area and production. Soybean (5.01 m ha and 5.32 million tonnes), Rapeseed-mustard (0.75 m ha and 0.98 million tonnes), sesame (0.42 m ha and 0.19 million tonnes), groundnut (0.22 m ha and 0.35 million tonnes), linseed (0.16 m ha and 0.09 million tonnes) and niger (0.06 m ha and 0.02 million tonnes) are the most important oilseeds cultivated in Madhya Pradesh.

The present study attempts to examine the performance of oilseeds in Madhya Pradesh during the period 2000-01 to 2017-18. The data obtained from Department of Economics and Statistics, GoI was analysed for examining the compound annual growth rates (CAGR) and estimating the effect of area, productivity and interaction on total oilseeds production by using log linear growth model and decomposition approach respectively.

Across oilseed crops in Madhya Pradesh, highest CAGR in area was observed in sesame followed by rapeseed-mustard, soybean and groundnut while linseed and niger evidenced deceleration in area (-1.31 and -3.43 per cent respectively). The CAGR in production was maximum in sesame followed by rapeseed-mustard, groundnut, soybean, linseed and niger. For yield, the CAGR was maximum in niger, followed by sesame, groundnut, linseed rapeseed-mustard and soybean. Positive and accelerated growth rate in yield and area were attributed to production growth of oilseeds in Madhya Pradesh.

Estimation of the effect of area, productivity and their interaction on change in production of oilseeds was worked for the triennium averages (TE) of the respective base and current years (TE 2002-03 and TE 2017-18 respectively). The results revealed that in soybean, 54 per cent of change in production was attributed to area effect and 33 per cent due to yield effect (technology) while in rapeseed-mustard, yield effect and area effect attributed to 39 and 38 per cent respectively to the change in production. In sesame, change in production was primarily due to yield effect (50 per cent) and only 17 per cent due to area effect. In groundnut, area effect (75 per cent) contributed to change in production while 15 per cent was due to yield effect. In case of niger and linseed, area effect solely contributed to change in production. Development of newer varieties / hybrids and related technologies in oilseed crops and their large scale expansion can enable increasing the oilseeds production from Madhya Pradesh. Similar studies have been done in different oilseed crops (Rambabu *et al.*, 2014; Uttam Singh *et al.*, 2015).

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Table 1 Average area, production, yield and Compound Annual Growth Rate of oilseeds (2000-01 to 2017-18)

Crop	Average (2000-01 to 2017-18)			Compound Annual Growth Rate (%)		
	Area (lakh ha)	Production (lakh tonnes)	Yield (kg/ha)	Area	Production	Yield
Soybean	50.99	52.49	1029	1.99	3.82	1.79
Rapeseed & Mustard	6.65	7.06	1062	2.82	5.30	2.41
Sesame	2.42	1.06	439	7.72	11.57	3.58
Groundnut	2.13	2.70	1268	0.56	4.10	3.53
Linseed	1.29	0.55	425	-1.31	1.21	2.55
Niger	0.97	0.24	243	-3.43	0.40	3.97

Table 2 Decomposition Analysis of oilseeds in Madhya Pradesh (TE 2017-18 vis-à-vis TE 2002-03)

Crops	Change in			Area Effect (%)	Yield Effect (%)	Interaction Effect (%)
	Area (lakh ha)	Production (lakh tonnes)	Yield (kg/ha)			
Soybean	10.67	23.45	293	54	33	13
Rapeseed & Mustard	2.60	5.13	451	38	39	23
Sesame	2.55	1.40	182	17	50	33
Groundnut	0.25	1.52	545	76	15	9
Linseed	-0.23	0.13	154	195	-66	-29
Niger	-0.35	0.04	146	403	-169	-133

Transforming production technologies for more productivity and profitability towards doubling the farmers Income: success stories of large scale linseed cultivation at farmers field

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ABSTRACT

The objectives of the study to assess the yield performance and economics of linseed varieties under best agronomic management *viz.*, weed, irrigation, nutrition and mechanization for high productivity and profitability in large scale technology and mechanization demonstrations at cultivators field of Sagar, Hoshangabad and Mandasaur district of Madhya Pradesh. Results revealed that the linseed crop is more profitable as compared to major *rabi* crops under limited water availability and sustainable use of natural resources and best possible agronomic management and mechanization.

Keywords: Cultivation, Low input cost, Mechanisation, Technology

The objectives of the study were to assess the yield performance & economics of linseed varieties under best agronomic management for high productivity and profitability on large scale with low input cost based production technology and mechanization demonstrations at cultivators field in Sagar, Hoshangabad and Mandasaur district of Madhya Pradesh.

Demonstration 1: Linseed varieties JLS 27 & JLS 66 were sown during *rabi* 2016-17 and JLS 66 during 2017-18 at the cultivator field of Shri Alambir Singh

Randhava, Village Bhapson, Block, Khurai, District Sagar in 7.50 and 25 ha, respectively. The soil was treated with *Trichoderma viride* @ 5.0 kg/ha. Seed treated with fungicide (Carboxin + thairum) @ 2.0 g/kg of seed followed by biofertilizer (*Azotobactor* and PSB) @ 0.5 g/kg each. Recommended dose of NPKS: 80:40:20:20 kg/ha, respectively was applied by fertilizer applicator based on soil test report. 0.5% bentonite sulphur was sprayed before flowering.

Demonstration 2: Five linseed varieties namely JLS 9, JLS 66, JLS 27, JLS 67 and PKDL 41 were sown during *rabi* 2017-18 & JLS 66 and JLS 73 during 2018-19 at the cultivator field of Shri Dinesh Maheshwari, Village Godrai, Block, Bankhedi, District Hoshangabad in area of 2.00, 6.00, 1.50, 1.00 and 2.00 ha, respectively and 40.00 and 20.00 ha during 2018-19. Seed was treated with Imidacloprid 48% FS@ 1.25 ml/kg seed. Recommended dose of NPKS: 80:40:20:20 kg/ha, respectively was applied by fertilizer applicator based on soil test report. The first irrigation was given at 30-35 days after sowing and second at 60-65 days. Liquid fertilizers NPK: 19:19:19, with fungicide thiophenate methyl 1.0 kg/ha and Imidacloprid 17.6 SL was also applied before flowering to the crop.

Demonstration 3: To assess the performance, productivity and profitability of linseed varieties under organic cultivation at cultivator field. Three linseed varieties JLS 27, JLS 66 and JLS 67 were sown during *rabi* 2017-18 and JLS 66 and JLS 67 during 2018-19 in the field of Shri Arjun Patidar, Village Gurdiya pratap, Block, Suwasra, District Mandasour in 1.00, 2.00 and 1.50, 2.00 and 2.00 ha respectively. Green manuring of Dhancha (*Susbania strata*) was practiced after *kharif* season to fulfill the nutritional requirement of *rabi* crop. Seed was treated with *Trichoderma viridae* @ 10g/ kg. Dry sowing was done followed by come up irrigation. One hand hoeing was done manually to improve aeration and plant growth by disturbing the soil texture and weed management. Two irrigation at 30-35 and 55-60 days was applied to raise healthy crop. To fulfill the nutrients requirement of the crop jeevamrit was sprayed before flowering. Harvesting was done by manually and trampling was done by tractor.

The results revealed that the farmer harvested 24.80 q/ha with JLS 27 which earned ₹ 90100/ha as NMR with

4.19 IB:C ratio. In the next year i.e., 2017-18, 18.25 q/ha grain yield was recorded for variety JLS 66 with NMR of ₹61325/ha showing 2.95 IB:C ratio as mentioned in demonstration 1 indicated JLS 27 is better performing as compared to JLS 66 (Table 1).

In demonstration 2, all the improved varieties were tested with same treatment and results revealed that the linseed variety JLS 66 recorded highest yield, under similar treatments which earned ₹88200/ha as NMR with 4.45 IB:C ratio. Under the similar package & practices of cultivation during 2018-19 linseed variety JLS 66 was sown in area 40 ha, the productivity of 19.50. The results of demonstration 3 farmer was harvested 22.10 q/ha linseed yield with JLS 27 which earned ₹180000/ha as NMR with 9.52 IB:C ratio followed by 21.20 q/ha in JLS 66 fetching an NMR of ₹171900/ha showed 9.10 IB:C ratio.

During the year 2018-19 the farmers harvested 22.20 q/ha yield with NMR of 179050 and IBC ratio of 8.63 in variety JLS 66 indicated the potential performance and response of linseed varieties under organic cultivation. The high NMR and IBC ratio indicated the suitability and response of the crop under organic method of cultivation as compared to conventional method. This is most appropriate crop due to its low production cost, high net profit and nutritional value suitable for doubling the farmer's income.

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Table 1 Details of varietal performance and economics of linseed cultivation at cultivators field

Name of Farmer & District	Year	Varieties	Area (ha)	Production (q)	Cost of cultivation/ha	Gross monetary returns (₹/ha)	Net monetary return (₹/ha)	Incremental B:C ratio
Alambir Singh Randhava Sagar	2016-17	JLS 27	7.50	24.80	21500	111600	90100	4.19
		JLS 66	25.00	18.50	21500	83250	61750	2.87
Dinesh Maheshwari Hoshangabad	2017-18	JLS 66	25.00	18.25	20800	82125	61325	2.95
		JLS 9	2.00	23.00	19800	103500	83700	4.23
		JLS 66	6.00	24.00	19800	108000	88200	4.45
		JLS 73	1.50	21.40	19800	96300	76500	3.86
	2018-19	JLS 67	1.00	20.80	19800	93600	73800	3.73
		PKDL 41	2.00	21.00	19800	94500	74700	3.77
		JLS 66	40.00	19.50	21500	87750	66250	3.08
Arjun Patidar Mandasaur	2017-18	JLS 73	25.00	18.80	21500	84600	63100	2.93
		JLS 27	1.00	22.10	18900	198900	180000	9.52
		JLS 66	2.00	21.20	18900	190800	171900	9.10
	2018-19	JLS 67	1.00	18.50	18900	166500	147600	7.81
		JLS 66	2.00	22.20	20750	199800	179050	8.63
		JLS 67	2.00	18.20	20750	163800	143050	6.89

*The seed price as ₹ 4500 and 9000/q were for conventional and organic produce, respectively

On-farm validation of management technology for seed and soil borne safflower diseases

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ABSTRACT

On farm validation for seed and soil borne safflower disease management technology was conducted at Parbhani to evaluate the *Trichoderma* strain (Th4d) as seed dresser compared with farmers' practice. The seed treatments, *Trichoderma harzianum* Th4d SC @ 2 ml/kg and *Trichoderma harzianum* Th4d WP @ 10 g/kg were most effective with significantly least incidence of 5.3% of seed/soil borne disease as compared to farmers' practice where the disease incidence was 11.3%. The treatment *Trichoderma harzianum* Th4d SC @ 2 ml/kg and *Trichoderma harzianum* Th4d WP @ 10 g/kg also recorded highest seed yield (1034 and 1055 kg/ha) followed by Carbendazim+Mancozeb (SAFF) @ 0.2% (977 kg/ha). The cost-benefit analysis showed that the seed treatment with *Trichoderma harzianum* Th4d WP @ 10 g/kg recorded the highest net monetary returns of ₹16,700/-.

Keywords: Safflower, Seed and soil borne, Technology, *Trichoderma*

The wilt of safflower caused by *Fusarium oxysporum* f.sp. *carthami* is an important disease of safflower leading to yield losses as high as 80% (Prashanthi *et al.*, 2000; Pawar *et al.*, 2013). The disease is reported to be seed transmitted to a tune of 10-40 per cent and the fungus perpetuates as mycelium and spores on the seed and seed coat or as chlamydo spores in plant debris in soil. The soil borne, *Macrophomina* sp. cause root rot in safflower leading to considerable yield losses (Gholve *et al.*, 2017). Damping off and seedling blight of safflower is caused by Phytophthora in the event of continuous rains during seed germination and seedling stage. The disease has been reported to cause seed yield losses to the tune of 25 to 93 per cent. Incidence of the disease is known to be high during cloudy days when the temperature falls below 25°C. High level of humidity is known to favour rapid spread of the disease and losses amounting to over 75 per cent, sometimes up to as high as 90 to 95 per cent.

The experiment for on-farm validation technology for management of seed/soil borne disease of safflower by chemical and biological agent's seed treatment was conducted during *rabi* 2018 at Parbhani, Maharashtra to study the efficacy of fungicide and bioagents as seed dressers for the management of seed/soil borne diseases of safflower like *Fusarium* wilt and *Phytophthora* damping-off and seedling blight. The experiment was conducted at two demonstrations (Farmers' field and research farm) and the safflower variety PBNS-12 was sown on 08.11.2018 with the spacing 45x20 cm and recommended dry land safflower cultivation practices were followed. The plot size of each treatment was 1000 m² and 50:25 kg N and P₂O₅ were applied at the time of sowing as basal dose. There were four treatments as presented in Table 1.

The data on the incidence/intensity of seed/soil borne diseases of safflower, seed yield and economics as influenced by chemical and biological agents' seed treatment are presented in Table 1. The average of two demonstrations indicated that seed treatments, *Trichoderma harzianum* Th4d SC @ 2 ml/kg and *Trichoderma harzianum* Th4d WP @ 10 g/kg were most effective with significantly least incidence (5.3%) of seed/soil borne disease (*Fusarium* & *Rhizotonia*) as compared to farmers' practice where the disease incidence was 11.3%. The treatment *Trichoderma harzianum* Th4d SC @ 2 ml/kg and *Trichoderma harzianum* Th4d WP @ 10 g/kg also recorded highest seed yield (1034 and 1055 kg/ha) followed by Carbendazim + Mancozeb (SAFF) @ 0.2% (977 kg/ha) whereas farmers' practice recorded low yield (815 kg/ha). The cost -benefit analysis showed that the seed treatment with *Trichoderma harzianum* Th4d WP @ 10 g/kg recorded the highest net monetary returns of ₹16,700/-, B:C ratio of 1.60) and carbendazim + mancozeb @ 0.2% (₹14,080/-, B:C ratio of 1.60). On the other hand, the farmer' practice recorded the least net monetary returns of ₹ 8,600/-and B:C ratio of 1.40. Cost of cultivation of farmers' practice was ₹ 22000/- per ha. Safflower selling rate was ₹ 4000/q. The result revealed that the most effective and economical management of the seed/soil borne diseases of safflower like *Macrophomina* root rot, *Fusarium* wilt and *Phytophthora* seedling blight and higher seed yield was by treating the safflower seed before sowing with *Trichoderma harzianum* Th4d SC @ 2 ml/kg seed or *Trichoderma harzianum* Th4d WP @ 10 g/kg seed or Carbendazim 12% + Mancozeb 63% @ 0.2%.

From the above study, it could be concluded that for effective and economical management of the seed/soil borne diseases of safflower like *Fusarium* wilt,

Macrophomina root rot and Phytophthora seedling blight and getting higher seed yield, it is recommended to treat the safflower seed before sowing with *Trichoderma harzianum* Th4d WP @ 10 g/kg or *Trichoderma harzianum* Th4d SC @ 2 ml/kg or carbendazim+mancozeb @ 2 g/kg seed.

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Prashanthi S K, Srikant Kulkarni, Anahosur K H and Kulkarni S 2000. Management of safflower root rot caused by *Rhizoctonia bataticola* by antagonistic microorganisms. *Research in Plant Diseases*, **15**: 146-150.

Table 1 On-farm validation for management of seed/soil borne disease of safflower by chemical and biological agents seed treatment (Parbhani, 2018-19)

Treatment	Soil borne disease incidence (%)			Disease control (%)	Seed yield (kg/ha)			Gross returns (₹/ha)	Cost of cultivation (₹/ha)	B:C Ratio
	Farmer's field	Research Farm	Mean		Farmer's field	Research Farm	Mean			
Carbendazim+Mancozeb @ 0.2% <i>Trichoderma harzianum</i> Th4d SC @ 2 ml/kg	6.3	7.3	6.8	42.3	954	1000	977	39080	25600	1.5
<i>Trichoderma harzianum</i> Th4d WP @ 10 g/kg	5.6	5.1	5.35	55.0	1100	968	1034	41360	25400	1.6
Farmer's practice	11.3	12.3	11.8	---	880	750	815	32600	24000	1.4

Effect of technology transfer through frontline demonstrations on yield and economics of safflower in scarcity area of Western Maharashtra

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ABSTRACT

A total of 790 frontline demonstrations were conducted on farmers' field during last three decades (1987-88 to 2018-19) in scarcity zone of Maharashtra state. The components viz., whole package, thinning, improved variety, recommended dose of fertilizers, plant protection measures and intercropping were tested with local package of practices. The intercropping of gram and safflower (6:3) and use of RDF under rain fed conditions were the most economical component which increased monetary returns by 46 and 40 per cent over local practice. The results also revealed that awareness in respect of use of improved varieties, balanced fertilization, IPM module adoption and precise use of component technologies brought a significant change in their livelihood through additional income.

Keywords: B:C ratio, Component technology, Whole package

The reports of several surveys have identified the factors responsible for lower production of the safflower producing areas. Lack of adoption of improved technology of safflower cultivation was one of the thrust area where the effective work was expected (Damodaran and Hegde, 2008; Anonymous, 2018). In response to this, the AICRP on Safflower, Solapur under MPKV, Rahuri, more than 700 demonstrations were successfully conducted on farmers' fields.

Seven different components, as presented in Table 1, were demonstrated in comparison with the farmers' practice. Under whole package, all production technologies were demonstrated. For demonstrations on various components, all the practices and inputs were

kept constant and only the component was changed to get the effect of that particular component in question over the local practice. In the cycocel demonstrations, a recommended plant growth retardant was used for reducing the vegetative growth under limited moisture conditions. The demonstrations on RDF v/s Farmers practice and need based plant protection measures were carried with a view to demonstrate the importance of optimum quantity and time of use the inputs to the farmers. All the demonstrations were conducted on 0.40 ha each for improved vs. local practice in Solapur district.

The component wise average data on yield and economics of total 790 are presented in Table 1. The

average data on seed yield showed an increase of 29.4 percent over local package of practices. An additional income of ₹ 3260/ha was anticipated under improved package of practices. It was observed from data that use of certified seed of improved SSF-708 and Phule Chandrabhaga varieties recorded 26.8 per cent higher seed yield (1083 kg/ha) over local cultivars (854 kg/ha). The B:C ratio of 2.06 was noticed under use of improved variety component.

The adoption of need based plant protection measures for effective control of safflower aphids and Alternaria leaf spot, one need-based spray of NSKE 5% immediately after notice of aphids on border rows followed by dimethoate 0.05 % 15 days first spray and one or two need-based sprays of Mancozeb (Dithane M-45) under rainfed conditions increased the productivity by 34.3 percent thereby providing additional net returns to the extent of ₹3186/ha over the farmers' practice with the B:C ratio of 1.88 as compared to farmers' practice (1.50).

To create the awareness about the effect of application of balanced nutrition on yield of safflower, 47 frontline demonstrations were conducted. It was observed that the use of recommended dose of fertilizer (50:25:0 NPK kg/ha) under rain fed conditions showed increasing productivity by 35 per cent with an additional net returns of ₹2853/ha and a B:C ratio of 1.76 in RDF applied plots against the B:C ratio of 1.55 in farmers' practice.

In order to realize the importance of plant density and geometry, about 34 FLDs were conducted on farmers' field. It was observed that, higher yield of 916 kg/ha was obtained in thinned plot and it was 19.7 per

cent higher than non-thinned plots. An additional income of ₹ 2039/ha was received from the thinned plot.

The productivity was increased by 14.2 percent under rain fed conditions with cycocel application. This resulted in additional net returns of ₹1728/ha over farmers' practice. The B:C ratio of 2.12 was noticed under improved practice, while it was 1.77 under farmers' practice, respectively.

The adoption of whole package of practices was found effective mainly in terms of proportionate increase in yield owing to improved technology over prevailing farmers' practices. The improved technologies proved to increase in yield to the tune of 35.7 per cent over their corresponding prevailing farmers' practices during this period.

About sixty nine demonstrations were conducted in traditional safflower growing area on intercropping of Safflower + chickpea (3:6). The safflower equivalent yield of 1309 kg/ha was recorded in intercropping system which was 46.4 per cent higher over sole cropping of safflower. An additional income of ₹5603/- was noticed from intercropping of Safflower + chickpea over sole crop of safflower. The B: C ratio of 2.24 was observed over the local practice (1.69).

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Table 1 Summary of frontline demonstration conducted by AICRP on Safflower Solapur (1987-88 to 2017-2018)

Component	No of demos conducted	Seed yield (kg/ha)		% increase in yield	Additional income (₹/ha)	Gross returns (₹/ha)		B:C Ratio		Cost of Cultivation (₹/ha)	
		IP	FP			IP	LP	IP	LP	IT	LP
Improved variety V/S Local variety	130	1083	854	26.8	3092	14621	11529	2.06	1.68	7100	6860
Need based Plant protection Vs Farmer's practice	73	924	688	34.3	3186	12474	9288	1.88	1.50	6618	6212
Recommended dose of fertilizer Vs Farmer's practice	47	1032	801	28.8	3119	13932	10814	1.75	1.50	7950	7215
Thinning Vs no thinning	34	916	765	19.7	2039	12366	10328	1.81	1.60	6833	6443
Spraying of cycocel v/s farmers practice.	36	1032	904	14.2	1728	13932	12204	2.12	2.01	6558	6071
Whole package of practices Vs farmer's practice	351	1141	841	35.7	4050	15404	11354	2.14	1.77	7182	6415
Intercropping Gram + saff (6:3) v/s Farmers Practices	69	1309*	894	46.4	5603	17672	12069	2.24	1.69	7884	7125
	790	1062	821	29.4	3260	14343	11084	2.00	1.68	7161	6620

(* Safflower Equivalent yield)

Formulation and development of soy okara cookies by blending with different levels of black scented rice flour

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ABSTRACT

Protein malnutrition is widely recognized as a major health problem. Cookies are widely consumed and generally, they are rich in carbohydrates, fats and calories, but low in fibre, vitamins and minerals. Okara, the pulpy by-product generated during the manufacturing process of soymilk and tofu, is considered as a waste product and is either disposed off. A possible use for okara is in baked foods as it has a large amount of fibre and protein. Composite flour was prepared by substituting the wheat flour in the ratio of 10:10:80, 15:10:75, 20:10:70, 25:10:65 and 0:0:100 (control) of okara: black rice flour: wheat flour. The objective of the present study was to prepare nutritious cookies and to study the effect of different combination of okara powder on the nutritional and sensory quality of the developed cookies. In nutrient estimation of cookies, protein content increased from 5.15 % to 7.85 % with increased addition of okara powder. Treatment T4 gave the highest protein content (7.85%) as compared with the control sample T5 (3.26%). The overall acceptability scores for treatment T1, T2, T3 and T4 remains the same. So fortification of cookies can be done by replacing wheat flour with okara powder upto 10-25% without adversely affecting the sensory parameters.

Keywords: Black scented rice, Cookies, Composite flour, Protein, Soy okara

The objective of the present study was to prepare nutritious cookies to deliver a nutritious and healthy product and study the effect of different combination of okara powder on the nutritional and sensory quality of the developed cookies.

The seed of JS-335 soybean variety were procured from Andro Research Farm, Central Agricultural University (CAU), Imphal. The seeds were cleaned manually, dried in sun and stored in plastic containers for further use. Composite flour is prepared by substituting the wheat flour with okara and black rice flour in the ratio of 10:10:80, 15:10:75, 20:10:70, 25:10:65 and 0:0:100 (control) of okara: black rice flour: wheat flour. Soy fortified biscuits samples were analyzed in triplicates for protein using standard method of analysis. The protein content was determined by Kjeldahl method. Sensory attributes were evaluated by 10 members panel who had some previous experience in sensory evaluation of bakery products using 9-point Hedonic Score System. The observed data was analyzed using ANOVA.

The results for moisture, crude protein, crude fat and crude fibre are given in Table 1. The moisture content was not significantly affected by the partial replacement of wheat flour with okara powder and black rice flour. The results revealed that the moisture content decreased from 5.70 to 3.97 % with the increase in okara powder. This may be due to the greater amount of total dry solids in okara powder with high emulsifying properties compared to wheat flour (Banureka *et al.*, 2009). As expected, the protein content increased with the level of substitution of okara powder. The results revealed that

the protein content varied significantly among different samples. Results showed that the protein content gradually increased from 5.15% to 7.85% with increased addition of okara powder. In general, treatment T4 gave the highest protein content (7.85%) followed by treatment T3 (6.80%) as compared with the control sample T5 (3.26%) (Banureka *et al.*, 2009). Appraisal of data in table 1 revealed that the replacement of wheat flour with okara powder and black rice flour caused an increase in fat content from 21.40% to 21.59%. There was no significant difference in the fat content of okara fortified cookies. The fibre content of the cookies increased from 0.48% to 2.82% with the increase in okara (fresh) portion. The highest fibre content (2.82%) was found in treatment T4 and lowest (0.12%) was recorded for control (T5) cookies. The increase in fibre content could be due to the increase in soy okara (fresh) portion during preparation of cookies.

It is evident from the experiment that cookies can be made by replacing wheat flour with soy okara powder (10-25%) and black scented rice flour without adversely affecting the sensory characteristics of cookies.

Sensory evaluation: According to the total sensory scores, the samples exhibited great acceptable sensory characteristics among consumer panel members as shown in Table 2. The overall acceptability scores for treatment T1, T2, T3 and T4 remained the same. So fortification of cookies can be done by replacing wheat flour with okara powder up to 25%.

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Table 1 Proximate composition of cookies prepared from different levels of okara powder, black rice and wheat flour

Treatments	Parameters			
	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)
T1	5.41	5.15	21.40	0.48
T2	5.02	5.67	21.42	1.02
T3	4.50	6.80	21.53	2.20
T4	3.97	7.85	21.59	2.82
T5	5.70	3.26	12.51	0.12
S.Ed (+)	0.80	0.26	0.56	0.12
C.D	1.79	0.59	1.25	0.26

Where, T1= Okara powder: Black rice flour: Wheat flour (10:10:80); T2= Okara powder: Black rice flour: Wheat flour (15:10:75); T3= Okara powder: Black rice flour: Wheat flour (20:10:70); T4= Okara powder: Black rice flour: Wheat flour (25:10:65) ;T5= Control (0:0:100)

Table 2 Average score for sensory evaluation of cookies from different levels of okara powder, black scented rice and wheat flour

Treatments	Parameters				
	Colour	Taste	Texture	Flavour	Overall acceptability
T1	6.75	7.00	6.60	7.75	7.40
T2	7.25	6.50	6.90	7.50	7.40
T3	6.88	7.80	7.30	7.75	7.40
T4	7.50	7.10	7.40	7.88	7.40
T5	7.11	7.11	7.00	7.82	7.07
S.Ed(+)	0.29	0.51	0.34	2.35	0.43
CD	0.65	1.14	0.77	5.24	0.97

Where, T1= Okara powder: Black rice flour: Wheat flour (10:10:80); T2= Okara powder: Black rice flour: Wheat flour (15:10:75); T3= Okara powder: Black rice flour: Wheat flour (20:10:70); T4= Okara powder: Black rice flour: Wheat flour (25:10:65)

Cost and returns of groundnut crop in Andhra Pradesh

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ABSTRACT

The cost of cultivation data of Groundnut at Triennium Ending 2016-17 in Andhra Pradesh state reveals that the value of main product (₹51003) of groundnut is lesser than the total cost of cultivation (₹58588). Operational costs are 69% and fixed costs are 31% in total cost, among which human labour cost is highest (28.53%) followed by seed cost (17.21%), net returns are ₹15690 at cost A2, and negative (₹-7585) at cost C2, which reveals that the farmers income is negative by considering own labour costs. Replacing human labour with low cost machines, development of some more HYV by the researchers, adoption of best management practices by the farmers, raise of MSP by the Government to meet the total expenditure are the suggestions that arise from the study.

Keywords: Cost of cultivation, Cost of production, Groundnut

The latest and accurate information on profitability of any crop is crucial for policy formulation; the information on costs and returns is useful for farmers in efficient allocation of scarce resources and also useful to organizations closely related to agricultural sector. This

study is aimed at exploring cost and profitability of Groundnut crop in Andhra Pradesh state.

Cost of cultivation data of Groundnut crop was taken from the reports of Directorate of Economics and Statistics, GoI for three years i.e. from 2014-15 to 2016-

17 where the data was analysed by using cost concepts method. The average cost of cultivation at Triennium Ending (TE) 2016-17 was calculated by using simple statistical techniques.

Cost of production of Groundnut at different levels is given in Table 1, from which it is revealed that Cost C2 (₹4561) is more than the market price (₹4484) at TE 2016-17, average yield is 11.7 q/ha, farmers get a marginal income of ₹5225/ha from by-product of groundnut which is used as a feed to the cattle. Value of main product (₹51003) is less than total cost of cultivation (₹58588). Table 2 revealed that the operational costs are 69% and fixed costs are 31% in total cost, among which human labour cost accounts for the highest percentage (28.53%) followed by seed cost (17.21%), all other costs are less than 10% only. fixed costs include rental value of own land, rental value of leased in land, land revenue, depreciation on farm buildings and implements and interest on fixed capital. Net returns are ₹15690 at cost A2, and net returns are negative (₹-7585) at cost C2, that means farmers are obtaining a negative income if own labour costs are considered. However, minimum support price of 2019-

20 ₹ 5090/q which is not remunerative to meet the total expenditure at the average yield.

More human labour can be reduced by replacing with machinery which are to be granted in subsidies by the government (Kamala Bai, 2019), some more High Yielding Varieties are to be developed on research front and best management practices are to be adopted by farmers to reach the average yield as countries like Israel (59.8 q/ha) and USA (45.6 q/ha). MSP has to be raised by the Government to meet the total expenditure on crop.

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Table 1 Cost of production of groundnut at TE 2016-17 in Andhra Pradesh (₹/q)

Cost item	Values (₹/q)
Cost A1	2584.88
Cost A2	2633.89
Cost B1	2732.88
Cost B2	4048.55
Cost C1	3245.88
Cost C2	4561.55
Average market price (₹/q)	4484.89
Value of main product (₹/ha)	51003.41
Value of by-product (₹/ha)	5225.29
Average yield (q/ha)	11.70

Table 2 Item wise breakup of cost of cultivation (₹/ha) at TE 2016-17 in Andhra Pradesh state

Item	Cost	Percentage to the total
Operational cost	40435	69.02
Total human labour	16712.53	28.53
Total animal labour	1894.26	3.23
Total machine labour	3314.52	5.66
Seed	10084.02	17.21
Fertilizer and manure	5752.69	9.82
Insecticides	775.61	1.32
Irrigation charges	806.87	1.38
Miscellaneous	56.87	0.10
Interest on working capital	1037.61	1.77
Fixed costs	18153.63	30.98
Total cost	58588.63	100.00
Net returns at cost A2	15690	
Net returns at cost C2	-7585	

Technology interventions for enhancing the productivity and profitability of small holder agriculture in Vikarabad district of Telanagana

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ABSTRACT

The present study is based on technology interventions implemented under the Farmers FIRST Programme (FFP) on small holder agriculture in Vikarabad district of Telangana. Data from 30 households through random sampling was analysed for working out the profitability and B:C ratios for the interventions in oilseeds and pulses. The results suggest that the interventions led to increasing profitability through reduced cost of cultivation and increased productivity indicating higher B:C ratios due to technology interventions.

Keywords: B:C ratio, Profitability, Small holder agriculture, Technology interventions

Under the Farmers FIRST programme (FFP), technology interventions were carried out for enhancing the productivity/profitability across crops on whole village concept in small holder agriculture in Vikarabad district of Telanagana. Primary data was collected from 30 respondents for castor, groundnut and redgram through random sampling and analyzed for accrual of additional net returns over operational costs and Benefit Cost ratios (B:C ratio).

The technology interventions targeted on primarily enhancing the productivity / profitability of small holder agriculture by reducing the cost of cultivation and critical input management for increasing the productivity with the objective of striving towards doubling of farmers' income. The results indicate that the per ha cost of cultivation reduced by ₹854 and 1683 in groundnut and redgram respectively through a combination of interventions viz., contour cultivation, spacing, seed treatment, integrated nutrient management including use of gypsum in groundnut, application of Rhizobium, P solubilizing bacteria and inter-cultural operations. In castor, technology assemblage led to reducing the cost of cultivation by ₹1860/ha in *kharif vis-à-vis* redgram and ₹13691/ha against groundnut (*rabi*). Interventions in castor under *rabi* were initiated considering the wild boar menace on groundnut crop. The overall additional

net returns due to technology assemblage/interventions resulted in enhancing the per ha additional net returns ranging from ₹868 in redgram to ₹33763 in groundnut. In castor, the additional net returns accrued/ha were ₹1518 (*kharif* rainfed) and ₹7566 (Late *kharif/rabi* irrigated). The B:C ratios were higher on the farms with technology intervention *vis-à-vis* local practice. Similar analysis have been done in other crops (Choudhary *et al.*, 2017; Priyanka *et al.*, 2018)

It can be concluded that technology interventions and technology assemblage play a greater role in increasing the productivity and profitability of small holder agriculture. Such interventions when replicated on large scale can enable enhancing the domestic production of vegetable oils in the country.

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Table 1 Productivity and economics of technology interventions

Crop	Yield (q/ha)		Cost of cultivation (₹/ha)		Gross returns (₹/ha)		Net returns (₹/ha)		Change in cost of cultivation (₹/ha)	Addl net returns (₹/ha)	BC ratio	
	IT	FP	IT	FP	IT	FP	IT	FP			IT	FP
Groundnut	19.25	13.75	33988	34842	94729	61820	60741	26978	-854	33763	2.79	1.77
Castor (<i>Kharif</i>)	3.25	3.34*	12352	14212	15275	15617	2923	1405	-1860	1518	1.24	1.10
Castor (<i>Rabi</i>)	11.85	13.15**	18821	32512	55695	61820	36874	29308	-13691	7566	2.96	1.90
Redgram	8.92	9.1	13167	14850	41737	42552	28570	27702	-1683	868	3.17	2.87

*-redgram in castor equivalent; **-groundnut in castor equivalent; IT- Improved technology; FP-Farmers' practice

Performance of DRMRIJ-31 (Giriraj) variety of mustard in cluster front line demonstration under arid climate condition

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ABSTRACT

In the Rajasthan, the average productivity is low as compared to other mustard growing area due to use of traditional method without improved variety. KVK Jodhpur had conducted cluster frontline demonstrations on mustard variety Giriraj at various villages of Jodhpur during *rabi* season (2016-17, 2017-18 and 2018-19). The results revealed that yield increases from 21 to 40 per cent and additional return up to ₹8741/ha in demonstration field compared to farmers' practice. An extension gap ranging from 339 to 571 kg/ha was observed in the CFLD and farmers practice respectively.

Keywords: Extension gap, Giriraj variety, Mustard

The average productivity of mustard is 1558 kg/ha, in Rajasthan, which is low as compared to other mustard growing area. (Anonymous, 2018). It is essential to demonstrate the high yielding varieties such as DRMRIJ-31(Giriraj) which is resistant to biotic and abiotic stresses with recommended production technologies to farmers to improve the productivity. Cluster front line demonstrations (CFLD) on mustard were conducted at farmers' field in district Jodhpur (Rajasthan) during *rabi* 2016-17, 2017-18 and 2018-19 by KVK, Jodhpur to exhibit the performance of recommended high yielding Mustard variety with recommended package of practices for harvesting higher crop yields. Each demonstration were of one acre area and using recommended package of practices(N,P,K) and the farmers were provided quality seed of Mustard variety Giriraj during all the years of the study. The sowing was done during mid-October to last week of October under assured irrigated conditions and harvested during first fortnight of March. The demonstrations on farmers' fields were regularly monitored by Krishi Vigyan Kendra, Jodhpur scientists' right from sowing to harvesting. The grain yield of demonstration crop was recorded and analyzed. Different parameters as suggested by Yadav *et al.* (2004) were used for calculating gap analysis, costs and returns. The detail of different parameters is as follows:

Extension gap=Demonstration yield-Farmers practice yield

The grain yields of mustard observed under demonstration were 21.0 to 40.69 per cent than farmers' local practices. 27.66 per cent average yield advantage was recorded under demonstrations conducted out with

improved cultivation technologies as compared to farmers' practices of mustard.

An Extension gap of 329-571 kg per hectare was found between demonstrated technology and farmers practices during different three years and on average basis the extension gap was 442.0 kg/ha (Table 1). The extension gap was lowest (329 kg/ha) during 2018-19 and was highest (571 kg/ha) during 2016-17. Such gap might be attributed to adoption improved technologies in demonstrations which resulted in higher grain yield than the practices.

Cluster Front Line Demonstration was effective in changing attitude, skill and knowledge of improved recommended practice of mustard cultivation. This also improved relationship between farmers and scientists and built confidence between them. The demonstration farmers acted as primary source of information on the improved practice of mustard cultivation and also acted as source of good quality seeds in farmer categories including progressive farmers for speedy and wider dissemination of recommended practices to other members of farming community.

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Table 1 Effect of cluster front demonstration on yield, extension gap, technology gap and technology index of mustard

Year	No. of Demonstrations	Demonstration yield (kg/ha)	Farmers practice yield (kg/ha)	% increase	Extension gap (kg/ha)	Technology gap (kg/ha)	Technology index (%)
2016-17	30	19.74	14.03	40.69	571	226	10.27
2017-18	100	19.78	15.50	27.61	428	222	10.09
2018-19	28	19.47	16.08	21.08	329	253	11.50

Castor (*Ricinus communis* L.) based cropping system for higher income in South-Western Haryana

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ABSTRACT

In Sirsa, Hisar and Rewari districts (Haryana) comparison of castor with traditional main cropping patterns *viz.*, cotton-wheat, cotton-mustard, pearl millet-wheat, pearl millet-mustard, cluster bean-wheat and cluster bean-mustard were compared with castor (sole) and castor with intercrops of cluster bean and mung bean. Sole castor recorded higher net returns (₹46341/ha) than all the traditional cropping patterns though highest gross returns were in cotton-wheat cropping pattern (₹95450 /ha). Highest net return (₹54960/ha) and B:C (1.52) were recorded under castor based inter cropping systems

Keywords: Castor, Castor based intercropping, Cropping pattern, Net returns

Castor is mainly grown in Hisar, Sirsa, Fatehabad and Rewari districts of Haryana (Anonymous, 2018). Cultivation of castor had started as rainfed crop on marginal and poor fertility soils of Hisar and Sirsa districts. Cotton farmers suffered heavy losses in their returns due to severe incidence of white fly. They have been looking for alternate to this crop under assured irrigation. Full package of castor cultivation under irrigated conditions has already been developed and under the present investigation efforts were made to compare the suitability of castor as an alternate to cotton crop.

A study was conducted in 60 farmers' fields (and this included the frontline demonstrations that were undertaken) to compare the six traditional cropping patterns being followed in the region *vis-à-vis* castor based cropping pattern. Six main cropping patterns *viz.*, cotton-wheat, cotton-mustard, pearl millet-wheat, pearl millet-mustard, cluster bean-wheat and cluster bean-mustard mostly followed by the farmers of this part of the state were compared with castor (sole) and castor based cropping systems mainly with cluster bean and mung bean as intercrops. Cost of cultivation, gross returns and net returns were computed and compared. In demonstrations DCH 177 castor hybrid was supplied to the farmers and advised to adopt recommended production technology.

Sole castor recorded higher net returns (₹ 46341/ha) than all the traditional cropping patterns though highest gross returns were in cotton-wheat cropping pattern (₹195450 /ha). Highest net return (₹54960/ha) and B:C (1.52) were recorded under castor based inter cropping systems. Castor hybrid DCH 177 was most preferred by the farmers.

Castor crop should be promoted in South-Western parts of Haryana according to suitability of soil type under irrigated conditions as it has been found remunerative and has given maximum net returns. Farmers should be motivated to grow kharif crops as intercrops because it is beneficial in castor which is a wider row spaced crop. Efforts should be made to transfer quality seed and the recommended technology to maximum number of farmers. Thus, there is a need to adopt multipronged strategy that involves enhancing castor production through area expansion and productivity improvements through better adoption of improved technology and drip irrigation.

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Table 1 Comparative cost and returns of various cropping pattern in South-West Haryana

Cropping pattern	Gross returns (₹/ha)	Total cost (₹/ha)	Net returns (₹/ha)	B:C ratio
Bajra-wheat	144860	122750	22110	1.18
Bajra-mustard	108500	92313	16187	1.18
Cotton-wheat	195450	162300	33150	1.20
Cotton-mustard	161700	128430	33270	1.26
Clusterbean-wheat	147480	121550	25930	1.21
Clusterbean-mustard	110680	90350	20330	1.23
Sole castor	143743	97412	46331	1.48
Castor +intercrop	161460	106500	54960	1.52

Impact of front line demonstration on yield and economics of sunflower (*Helianthus annuus L.*) in Bihar

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ABSTRACT

The frontline demonstrations were carried out in 102 farmer fields to demonstrate the impact of improved technology on yield of sunflower during the Spring, 2017. Each frontline demonstration was laid out on 1 acre area, and its adjacent one acre was considered as control (farmer's practice). The frontline demonstration comprised of two hybrids namely, KBSH-44 and KBSH-53. KBSH-53 gave higher yield than KBSH-44. The result indicated that productivity of sunflower gained under improved demonstrated technology (17.10 q/ha) was higher as compared to farmer's practices (13.14 q/ha). The study showed that improved technology gave 30.15% higher grain yield over farmers' practices.

Keywords: Economics, Farmer's practice, Improved technology, Sunflower, Yield

A wide gap exists in sunflower production with the use of available techniques and its actual application by the farmers that leads to further reduction in yield, reflected through poor yield of sunflower crop on farmer's field. There is a tremendous opportunity for increasing the productivity of sunflower crop by adopting the improved technologies. To demonstrate the scientific cultivation of sunflower, front line demonstrations had been laid out at farmer's field.

The 102 Front Line demonstrations under AICRP on Sunflower was carried out in 102 farmer's field to demonstrate the impact of improved technology on yield and economics of sunflower during the Spring, 2017. Each frontline demonstration was laid out on 1 acre area, adjacent 1 acre was considered as control (farmer's

practice). The frontline demonstration comprised of two varieties, namely, KBSH-44 and KBSH-53.

The data (presented in Table 1) revealed that improved technological interventions gave higher grain yield, gross return and net return as compared to Farmer's practices. Simultaneously, improved technology provides additional income of ₹10178/ha more over farmers practices.

The above findings inferred that the usage of recommended package of practices leads to increased productivity of sunflower in Bihar. To reduce the technological gap and to reverse the trend of extension gap, emphasis must be to conduct more number of demonstrations to bring awareness among farmers regarding the recent technologies and production practices.

Table 1 Impact of front line demonstration on yield and economics of sunflower in Bihar

Particulars	IT	FP	Additional Income in IT over FP (₹/ha)
Grain yield (q/ha)	17.10	13.14	-
Cost of cultivation (₹/ha)	25711	22548	-
Gross returns (₹/ha)	57344	44004	-
Net returns (₹/ha)	31633	21455	10178

IT- Improved Technology, *FP- Farmer's Practices

Studies on phenotypic stability in sesame (*Sesamum indicum* L.)

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ABSTRACT

Sixty genotypes of sesame were studied for phenotypic stability over three seasons. Genotypes \times season interaction was significant for all the traits except plant height at maturity. Maximum phenotypic expression for plant height, number of branches, no. of capsules, seed length, seed breadth and oil content was observed in SI. For days to maturity, number of flowers, 1000 seed weight, 1000 seed volume, seed yield and harvest index the maximum expression was observed in SIII, capsule volume, number of seeds/capsule, seed density and total dry matter production displayed maximum expression. Genotype \times seasonal interaction was significant for all the traits except plant height at maturity indicating that different genotypes responded differently to changes in the season. The genotype \times season interaction component was predominant for 100 seed weight, seed breadth, capsule volume, number of seeds per capsule, number of branches, harvest index, total dry matter production, oil content, seed yield, days to maturity, number of flowers and number of capsules. For plant height and 1000 seed volume, genotypic component of variation (σ^2_g) was greater than the genotype \times season component (σ^2_{g1}) indicating that these two characters were least sensitive of seasonal changes compared to other characters. A major portion of the variance attributed to genotype \times season interaction was accounted for by the linear component (variance due to regression) for all the traits excepting capsule volume and total dry matter production. For capsule volume the linear and non-linear component was almost equal. For total dry matter production, linear component was less than the non-linear component. Preponderance of linear portion over non-linear portion was suggestive of possibilities of prediction of the performance of the genotypes across the seasons. 1000 seed volume followed by plant height, days to maturity and 1000 seed weight were the most predictable one.

Keywords: Phenotype, Sesamum, Stability

Indian castor oil exports concentration- a perspective

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ABSTRACT

India is the global leader and ranks first in production with almost 87 percent of world's share as well as in exports of castor oil with a share of 86.8 percent of world's trade (2018-19) and the export is valued at ₹ 5658 crores. Geographic concentration was analyzed using Herfindahl-Hirschman Index (HHI). It showed that the exports are highly concentrated ranging from 2032 to 2584 for the last eight years except for the year 2014-15 when it was 1668 (moderate concentration). The analysis revealed that the castor oil export destinations are highly concentrated to only 10 countries. However, diversification of markets is always desirable

Keywords: Diversification, geographic concentration, Herfindahl-Hirschman Index

India is the global leader and ranks first in production with almost 87 percent in world share and with 86.8 percent of world's exports share for castor oil exports (2018-19). Apart from castor oil other castor products exported were castor seeds, Hydrogenated castor oil, oil cake and meal. The major quantity is exported in the form of castor oil and its fractions (HScode: 151530) to various countries. In the present study, we explored whether castor oil and its export fractions are concentrated to few countries or diversified

over years. The present study considered the last eight years (2011-12 to 2018-19) time series data, obtained from DGCIS, GoI, on castor oil exports to different countries. Geographic concentration was computed by using Herfindahl-Hirschman Index (HHI). It is defined as the sum of the squares of the countries share to the total exports from India. The HHI can be calculated as $HHI = \sum (S_i \times 100)^2$, where S_i denotes the share of castor oil and its fractions to the i^{th} country (2016). The more the index value the more the concentration. For un-

concentrated or diversified markets/countries HHI<1500; Moderately concentrated HHI >1500 and <2500 ; Highly concentrated HHI>2500. From the table 1 it can be observed that during 2011-12 the exports were made to 92 countries and it increased to 108 countries during 2018-19. Even though the number of exporting countries had increased the total exports were concentrated to only a few countries .Top 10 destination countries were contributing 92.3 percent in 2018-19. China imported about 36.3 percent in 2011-12 and 46.4 per cent in 2018-19. China (first) and Netherlands (second) maintained their positions as top importers of Indian castor oil. However, France was in third position till 2017-18 but went to fourth position in 2018-19. HHI showed that the exports are moderately concentrated from 2011-12 to 2017-18 with the lowest value in the year 2014-15(1668) and highest value in 2012-13 (2494). In 2018-19, it is highly concentrated with a value of 2584.The analysis revealed that the castor oil exports destinations are highly concentrated, eventhough

diversification of markets is always desirable for sustained export. Nearly 48 per cent of the Chinese import goes to the Sebacic acid (a derivative of the castor oil) plants of the country (Jianfeng, 2016). Thus, in India also diverting of castor oil for manufacturing and exporting of second and higher order derivatives would fetch more exchequer rather than the exporting castor oil per se.

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Table 1 Top ten countries importing Indian Castor oil and its fractions (Per cent share to total exports)

Country	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
China	36.3	44.4	42.6	31.1	43.8	42.8	44.5	46.4
Netherlands	18.2	13.9	15.7	15.9	12.8	12.4	14.2	14.5
U S A	10.7	11.2	9.9	11.7	9.4	10.6	10.1	10.5
France	15.1	13.0	13.2	13.3	11.9	13.4	11.3	8.3
Thailand	3.8	3.9	4.5	4.1	3.5	3.0	4.4	4.0
Japan	3.3	3.1	2.7	3.2	3.1	2.9	2.9	3.0
U K	1.7	1.4	1.5	1.5	1.6	1.6	1.3	1.8
Korea	1.3	1.1	1.4	1.4	1.3	1.5	1.4	1.6
Italy	0.3	0.3	0.5	0.6	1.1	1.6	1.3	1.1
Turkey	0.9	0.8	1.0	1.1	1.0	0.9	1.0	1.0
Others	8.3	6.9	7.0	16.0	10.4	9.3	7.6	7.7
Total countries	92	90	90	89	99	97	107	108
Total Quantity (lakh tonnes)	4.55	5.27	5.05	5.06	5.43	5.55	6.51	5.74
Total Value (Crores)	4156	3967	3995	4304	4214	4136	6235	5658
HHI	2032	2494	2369	1668	2358	2313	2453	2584

Trend analysis of weather parameters in relation to castor yield

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ABSTRACT

The present study examined the trend analysis of weather parameters temperature, rainfall and with relation to castor yield. Long-term weather data of 47 years from 1970-71 to 2017-18 was been collected from IMD and castor yield data was collected from DES, 2018. Mann Kendall nonparametric test for identification of trend indicated that annual as well as seasonal (June-Sept) monsoon rainfall over India showed significant decreasing trend. Annual mean, maximum and minimum temperatures averaged over India showed significant warming trend. There was significant increase in total no of consecutive dry days of more than 5 days. Maximum and minimum temperature and rain fall showed significant positive correlation with yield.

Keywords: Castor yield, Mann Kendall and correlation, Trend analysis, Weather parameters

Changes in climatic variables may affect the crop yield (Smith *et al.*, 2000; Chandrappa *et al.*, 2011) and these changes may lead to occurrence of new pests and diseases. Climate researchers have used trends for single location and extrapolated these trends for a larger area (Pielke *et al.*, 2000). Therefore, there is a need to relate the trends of climatic parameters with castor yield. Mann Kendall nonparametric test (M-K test) was used for identification of trend. For M-K test, the null hypothesis (H0) was of no trend i.e., the observations of series are randomly distributed in time, against the alternative hypothesis (H1), where there is an increasing or decreasing monotonic trend. To determine the relationship between yield and climatic parameters, correlation analysis was carried out.

The time series of annual maximum temperature in India showed significant increasing trend of 0.16, 0.11 and 0.14°C per decade since 1981. Maximum warming trend is seen during post monsoon season. Total no of consecutive dry days with spell length more than 5 days has increased significantly. The time series of the annual minimum temperature in India showed significant increasing trend. Annual mean, maximum and minimum temperatures averaged over India showed significant warming trend. India receives 75 % of Annual rainfall

from June till September through summer monsoon season. Annual as well as seasonal (June-September) monsoon rainfall over India showed significant decreasing trend. Time series of castor yield in India showed increasing trend which is an indication of improving yield over time. Gujarat covers 60 percent of castor area. Yield increased from 1.988 t to 2.072 t/ha.

This scatter diagrams (Fig.1) show how castor yields varied with weather variables. Yield has increased over most recent years despite increasing climatic variability. Yield was significantly and positively correlated ($r=0.796$) with maximum temperature, minimum temperature (0.617) and rain fall (0.314).

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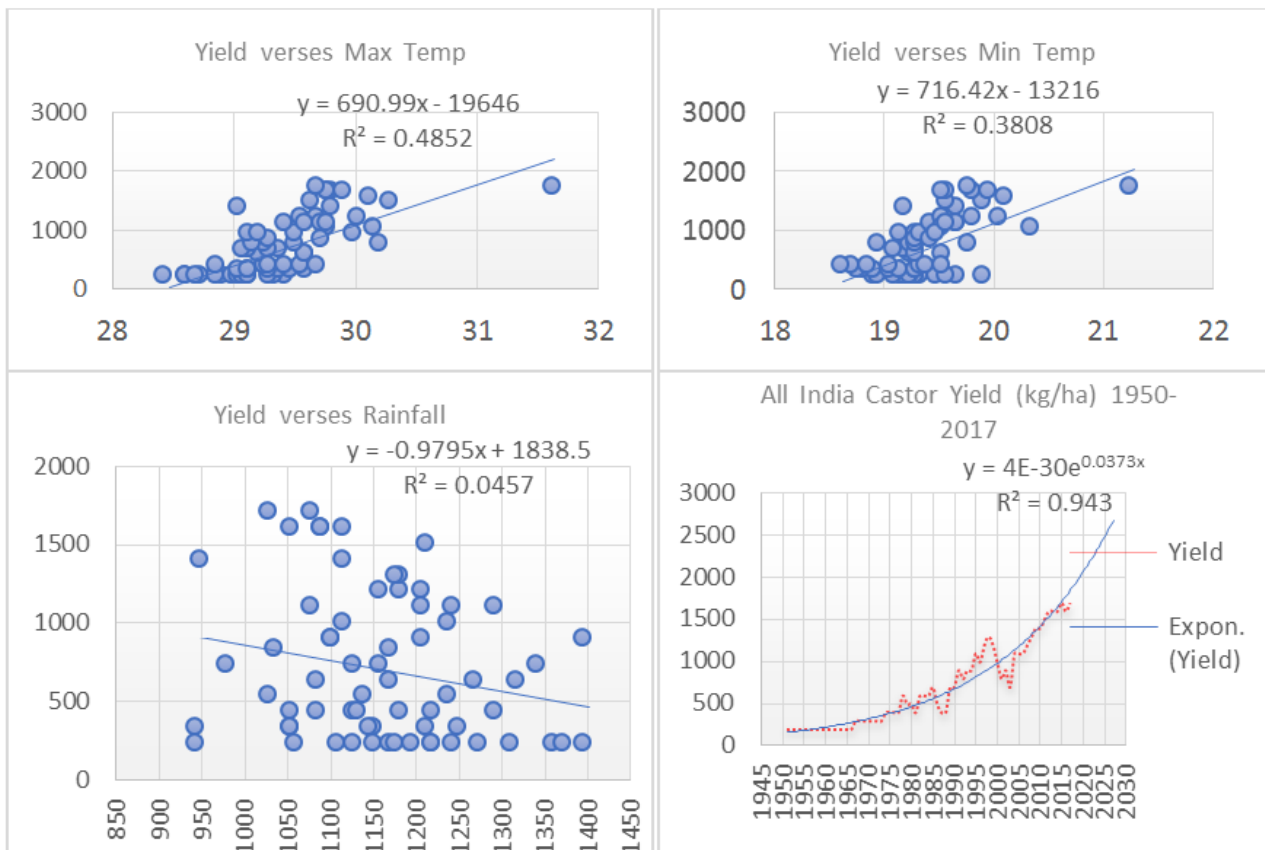


Fig. 1. Scatter diagram showing castor yield with relation to weather parameters

Evaluation, multiplication and deposition of sunflower germplasm accessions in medium term storage

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ABSTRACT

During the year 2018-2019 a total of 700 germplasm lines were multiplied and evaluated during kharif 2018. All the accessions were sown in augmented block design and compared with three checks. Promising accessions were identified with high seed yield and medium oil content. The range for oil content was between 24 and 37%. The germplasm accessions identified for high seed yield and medium oil content were GMU-125, GMU-169, GMU-251, GMU-272, GMU-396, GMU-928, and GMU-1102. The five accessions identified with 37.0% of oil content included GMU-466, GMU-663, GMU-1091, GMU-1106 and GMU-1140. After complete drying of the seeds, the cleaned seeds from each accession were deposited in the medium term storage (MTS) of IIOR with proper labeling. Out of total harvested seeds approximately 50.0 g of the seeds was packed in airtight aluminium package suitable for medium term storage and remaining seeds were stored as working germplasm.

Molecular and biotechnical approaches for oil quality improvement in *Brassica* species

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ABSTRACT

Crop *Brassicaceae* encompass many diverse types of plants, which are grown as vegetables, fodder or sources of oils and condiments. Rapeseed-mustard comprising eight different species *viz.*, Indian mustard, *toria*, yellow sarson, brown sarson, gobhi sarson, karanrai, black mustard and taramira. The oleiferous *Brassica* species, commonly known as rapeseed-mustard is the major group among the oil seed production in the world and it constitutes the world's third important source of edible oil. High amount of erucic acid; C22:1 (40-57%), presence of high level of glucosinolates and other phenolic compounds lower its utility as edible oil. The quality improvement emphasis is to reduce/eliminate these compounds. The conversion of erucic to oleic acid is done by fatty acid elongase (FAE1) coding for β ketoacyl-CoA synthase (KCS). Omics and GWAS help in dissecting the desired QTLs. Molecular evidence has revealed that two-base-pair deletion of AA at the 1,422–1,423 base sites (eC2) for the FAE1 gene resulted in the low erucic acid (LEA) phenotypes. The C-QTL's *viz.*, OIL-C-A8-1, OIL-C-A10-1, OIL-C-B1-1, OIL-C-B2-1, OIL-C-B3-1, OIL-C-B4-1, OIL-C-B7-1 contributed for high oil content. CYP79F1 is involved in regulating the synthesis of 3C Glucosinolates in *B. juncea*. The RNAi method is the powerful technique in suppressing the activity of FAE1 and helps in down regulating the production of erucic acid and thus contributing for the development of the zero erucic acid lines. There is meager research work in the elimination/reduction of other anti-nutritional factors which has to be improved by the breeding efforts.

Keywords: Erucic acid, glucosinolates, FAE1, KCS, LEA, RNAi

Evaluation of soybean [*Glycine max* (L.) Merrill] germplasm for seed yield and earliness

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ABSTRACT

500 germplasm accessions of soybean received from Indian Institute of Soybean Research, Indore were evaluated for plant height, seed yield, days to 50% flowering, plant height, number of pods/plant and 100-grain weight along with checks *rabi* 2018 in a augmented design. Among the 500 accessions evaluated, Soy93 recorded significantly higher seed yield (5211 kg/ha) over the checks KBS23 (4750 kg/ha.) and JS335 (4638 kg/ha) followed by Soy214 (4791kg/ha.). The accession Soy56 recorded 38 days for days to 50% flowering followed by Soy346, Soy347 and Soy485 (40 days) and Soy181 (41 days). Plant height ranged from 15.8 cm (Soy56) to 112.4cm (Soy493). Two accessions *viz.*, Soy267 and Soy200 (111) recorded highest number of pods/plant followed by Soy222 (106), Soy214 (105) and Soy323 (102). Hundred seed weight ranged from 7 g (Soy103, Soy209) to 27.6 g (Soy125). Two accessions, Soy222 and Soy214 were found to be superior for seed yield as well as number of pods/plant. These genotypes can be used in the hybridization programme for the development of early maturing and high yielding varieties.

Polymorphism in FAE1 gene paralogs of *Brassica juncea* associated with erucic acid content

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ABSTRACT

Breeding for low erucic acid is a major objective to improve the edible oil quality in *Brassica juncea*. FAE1, the intron-less, 1521-bp gene encoding fatty acid elongase, genetically control the biosynthesis of erucic acid in oilseed Brassicas. The *Brassica juncea* being an amphidiploid, contains two paralogs of this gene (FAE1.1 and FAE1.2). Allelic variations in the gene such as SNPs and InDels are predominantly responsible for variability in erucic acid content in the seed, among the Brassica genotypes. The coding sequence of FAE1 gene paralogs were sequenced from low (LEA) and high (HEA) erucic acid genotypes which had a few SNPs that differentiated LAE and HEA genotypes. Two SNPs in FAE1.1 at position 591 and 1265 and one in FAE1.2 at 237, which led to a change in the recognition site of Hpy99I, BglII and MnlI restriction enzymes, respectively, converted into CAPS markers to differentiate LEA and HEA genotypes. The efficacy of these CAPS markers was found 100 per cent when validated in *Brassica juncea*, *B. rapa* and *B. nigra* genotypes and used in back-cross breeding. However, owing to functional complexity of CAPS in routine analysis; nucleotide sequence variability in the promoter region of FAE1 gene paralogs were expedited to develop simple PCR based markers. The upstream regions of FAE were sequenced from LEA cultivar Pusa Mustard-30 and HEA cultivar Pusa Bold. A28-bp deletion in the promoter of FAE1.1 and a 340-bp insertion of a transposon-like element in the FAE1.2 gene promoter was discovered in LEA genotype in comparison to HEA. Markers based on these sequence variabilities in the promoter regions of FAE1.1 and FAE1.2 were found to completely co-segregate with the seed erucic acid content. These markers would be effectively used in marker assisted selection for development of low erucic acid cultivars in *B. juncea*.

Keywords: *Brassica juncea*, CAPS, Erucic acid, FAE1, MAS, Molecular marker, Promoter, SNP

Enhancing water use efficiency in rainfed Indian-mustard (*Brassica juncea* L.)

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ABSTRACT

Mustard is the second most important edible oilseed crop of India. It accounts for more than 25 per cent of the total oilseed products in the country. A field experiment of Indian mustard was conducted during *rabi* 2018-19 at Oilseed Research Farm, Kalyanpur, Kanpur (U.P.) using different doses of hydrogel and salicylic acid @ 2.5 and 5.0 kg and 100 ppm, 200 ppm/ha respectively, using in Indian mustard variety Varuna. The results indicated that the doses of 5.00 kg/ha hydrogel and 200 ppm salicylic acid spray at flowering stage and siliqua formation stage was better. It gave more than 19.98 per cent higher grain yield in comparison to control.

Keywords: Hydrogel, Indian mustard, Salicylic acid, Water use efficiency

Estimates of variability, heritability and genetic advance for yield components in linseed (*Linum usitatissimum* L.) genotypes

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ABSTRACT

Linseed (*Linum usitatissimum* L.) yield can be increased with knowledge of the relationship among yield components is essential for the formulation of breeding programmes. Sixteen genotypes of linseed were evaluated for genetic variability, heritability and genetic advance for yield and yield components. Phenotypic and genotypic coefficients of variation (PCV and GCV) were highest (41.57 and 40.28) for seed yield/acre followed by that for number of capsules/plant (33.75 and 23.11). On the other hand parameters such as plant stand/plot and oil content showed minimal phenotypic and genotypic coefficient of variation. Estimates of heritability was highest for days to 50% flowering (97.44), days to maturity (98.54) and yield/ acre (93.86) and minimum for plant stand/acre and oil content. Similarly, genetic advance was highest for yield per acre and lowest for oil content percentage. The highest heritability for the traits like days to maturity, days to 50% percent flowering and yield/ acre will give a positive response to the selection. Traits having high h^2 and high GA are supposed to be under the control of additive genes; hence, these can be improved by selection based on phenotypic performance. Invariably higher PCV as compared to GCV indicated the role of environment in the expression of the traits.

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