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Integrated Phosphorus Management in Mustard [*Brassica juncea* (L) Czern and Coss]

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Abstract

A field experiment was conducted during *Rabi,* 2015 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, to study the "Integrated Phosphorus Management in Mustard [*Brassica juncea* (L) Czern and Coss]. Treatments consisted of ten in randomized block design laid out in four replications. The results revealed that an application of 100% RDP + PSB + Biophos should be recommended for securing higher seed yield of mustard and net return in loamy sand of North Gujarat Agro-climatic zone.

Keywords **:** mustard, phosphate solubilising bacteria, recommended dose of phosphorus

Introduction

Oil seed crops play a vital role in Indian agricultural economy occupying 14 percent of the national gross cropped area and contributing 10 percent value of agricultural products. The steep escalation in the price of edible oils during last few years has increased the importance of oil seed cultivation. Oilseeds are among the major crops that are grown in the country apart from cereals. In terms of acreage, production and economic value, these crops are second only to food grains. India is the fifth largest vegetable oil economy in the world, next only to USA, China, Brazil and Argentina. In our country, among the oil seed crops, rapeseed and mustard are the most important and highly promising group of crops under different agro-climatic conditions, because of its wide adaptability and comparatively high production potential. Rapeseed and mustard include several oilseed crops which belong to the family Brassicaceae and genus *Brassica*. Among them, Indian mustard, (*Brassica juncea* (L) Czern and Coss) alone accounts for about 80 percent of the 6.3 m ha area under rapeseed and mustard crops of the country (Singh and Kumar, 2015). It is a crop of *rabi* season and performs well on sandy loam to loamy sand and medium black type of soils in Northen and North-Western regions of India.

Phosphorus solubilizing bacteria can help in reducing the requirement of chemical fertilizers. They are cheaper, pollution free and renewable. The futures of agriculture depend on the use of bio-fertilizers as a potential source of nutrients. Biophos (*Chaetomium globosum*), fungus isolated from arid region, have special ability to solubilize insoluble phosphates in soil. These cultures secrete organic acids and also have some special enzymes which help in solublizing phosphorus. This ability of these cultures is harnessed to improve the P availability of agriculture crops. When applied near the root zone of crops, these microbes solubilise more phosphorus than their own need which becomes available to the plants. Keeping in view the above facts, this trail was conducted to find out the integrated phosphorus management in mustard.

Materials and Methods

A field experiment was conducted during *Rabi,* 2015 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural

University, Sardarkrushinagar. Treatments consisted of ten treatments i.e., T_1:Control, T_2: 75 % RDP, T_3: 100 % RDP, T_4:75 % RDP + Biophos* T_5: 75 % RDP + PSB** T_6: 100 % RDP + Biophos, T_7: 100 % RDP + PSB, T_8: 75 % RDP + PSB + Biophos, T_9: 100 % RDP + PSB + Biophos and T_{10}: PSB + Biophos in randomized block design laid out in four replications. The recommended dose of phosphorus was 50 kg/ha, biophos was given @ 30 g biophos (*Chaetomium globosum*)/kg seed and phosphorus solubilizing bacteria (PSB) was given @30 ml/kg Phosphate solublizing bacteria strain *Bacillus spp.* The soil of experimental plot was loamy sand in texture with low in organic carbon (0.15 %) and available nitrogen (147 kg/ha), medium in available phosphorus (36 kg/ha) and high in potash (271 kg/ha) having pH value of 7.4 and Phosphatic enzyme activity (422.1 ìg/g dwt soil/h).

Mustard (Cv. GDM 4) was sown in rows at 45 cm x 10 cm apart using seed rate 3.50 kg/ha on October 15, 2015. The crop was fertilized with 50 kg N and 50 kg P_2O_5/ha. The crop was harvested on February 22, 2016. For nutrient uptake, the plant samples were collected at the time of harvesting. The analysis of plant samples was carried out as per the standard methods. The economics was worked out on current market price basis.

Results and Discussion

The findings of the present study as well as relevant discussion have been presented under the following heads.

Effect of Integrated Phosphorus Management

Remarkable improvement of growth attributes *viz.,* plant population in mustard remained unaffected due to different phosphorus management treatments. Plant height at harvest, 100 % RDP + PSB + Biophos) recorded significantly higher values of all growth attributes. However, it was at par with 100 % RDP + Biophos, 100 % RDP + PSB and 75 % RDP + PSB + Biophos in case of plant height at par with treatments 100 % RDP + Biophos, 100 % RDP + PSB and 75 % RDP + PSB + Biophos. With respect to improvement in yield attributes *viz.,* number of siliquae/plant, number of seed/siliqua, length of siliqua, test weight with application of 100% RDP + PSB + Biophos being at par with treatments (100 % RDP + Biophos, 100 % RDP + PSB and 75 % RDP + PSB + Biophos emerged out the best treatment. Increased value of these yield attributes might to be due to the fact that addition of phosphorus, PSB and Biophos increased availability of nutrients for a longer period which might have

Table 1. Effect of different yield attributes characters on mustard as influenced by different treatments

Treatments	Plant population (per net plot)	Plant height (cm) at harvest	Number of siliquae/ plant	Number of seeds/siliqua	Length of siliqua (cm)	Test weight (g)	Oil content (%)
T_1 : Control	253	146.5	245.0	11.7	3.93	4.76	37.8
T_2 : 75 % RDP	254	166.0	271.6	11.9	4.00	5.01	38.4
T_3 : 100 % RDP	255	168.8	278.7	12.4	4.15	5.18	38.7
T_4 : 75 % RDP + Biophos	252	167.8	276.7	12.2	4.05	5.13	38.4
T_5 : 75 % RDP + PSB	256	163.4	275.7	12.0	4.00	5.05	38.4
T_6 : 100 % RDP + Biophos	257	175.0	287.0	13.3	4.45	5.44	39.0
T_7 : 100 % RDP + PSB	256	174.3	284.9	13.1	4.40	5.28	38.8
T_8 : 75 % RDP + PSB + Biophos	255	174.2	283.7	12.8	4.35	5.21	38.7
T_9 : 100 % RDP + PSB + Biophos	260	184.5	288.7	13.9	4.55	5.54	39.0
T_{10} : PSB + Biophos	251	157.2	260.6	11.7	3.98	4.85	37.9
S.Em. ±	3.0	5.1	3.4	0.5	0.06	0.09	0.5
CD (P = 0.05)	NS	14.7	9.7	1.3	0.20	0.28	NS
CV %	2.35	6.0	2.4	7.3	3.3	3.8	2.42

TABLE 2. Effect of different treatments on yield and benefit : cost ratio

Treatment	Yield (kg/ha)		Gross return (₹//ha)	Cost of cultivation (₹/ha)	Benefit or Profit (₹/ha)	BCR
	Seed	Stover				
T_1	1793	4483	64997	19098	45899	3.40
T_2	2085	5005	75478	20682	54796	3.65
T_3	2224	5782	80731	21210	59521	3.80
T_4	2196	5560	79640	20696	58944	3.85
T_5	2172	5489	78765	20696	58069	3.81
T_6	2423	6543	88077	21224	66853	4.15
T_7	2338	6431	85046	21224	63822	4.01
T_8	2304	6406	83843	20710	63133	5.05
T_9	2554	7150	92965	21238	71727	4.38
T_{10}	1967	4721	71206	19126	52080	3.72
S.Em.±	84	221				
CD (P=0.05)	243	641				
CV%	7.58	7.68				

accelerated crop growth there by enhanced photosynthetic activity, which might have enhanced number of flowers and their fertilization resulted in higher number of siliquae/plant and ultimately seed yield/ plant. This might be also due to effective partitioning of assimilates to the sink, as a result of availability of phosphorus coinciding with physiological needs of the crop. These finding are in agreement with those of Davaria *et al*, (2001) and Meena *et al*, (2002).

Significant enhancement in seed and stover yields was achieved by an application of 100 % RDP + PSB + Biophos. However, it was at par with 100 % RDP + Biophos, 100 % RDP + PSB and 75 % RDP + PSB + Biophos. combined effect of phosphorus, PSB and Biophos that provided balanced nutrition and favourable soil environment for better plant growth resulted in maximum seed, stover and biological yield. It is obvious that phosphate solubilizing bacteria produced higher quantity of organic acids which dissolved mineral phosphate and made it available to plants. These acids associate with metals and increase the concentration of soluble phosphate. They also synthesize growth promoting substances and produce vitamins which augment the plant growth. The results supported by the findings of Wagadre *et al.* (2010), Nawange *et al.* (2011) and Kumawat *et al.* (2013).

Oil content (%) and in mustard seed remained unaffected due to different phosphorus management treatments. On the basis of economics, treatment 100% RDP + PSB + Biophos realized the highest net return of ₹71727/ha with BCR of 4.38.

Conclusion :

In light of the results obtained from present investigation, it is concluded that for obtaining higher seed yield of mustard and net returns in loamy sand. Crop should be fertilized with 100% RDP + seed treated with PSB and Biophos at the 30 g/kg seed each.

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Studies on Some Physico-Chemical Properties of Dhandhing Guri Watershed at Coochbehar-II Block of Coochbehar District, West Bengal

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Abstract

A study was conducted on various physico-chemical properties of soil such as soil texture, Bulk density, water holding capacity, pH, EC, organic carbon, available nitrogen, available P, K, S and CEC of different land situation in a watershed in Dhandhinguri, Coochbehar district, which is located at the northern part of West Bengal. The investigation reveals that the mean changes in pH and Bulk density increases with increase in depth. The bulk density of the watershed from 1.11 to 1.42 gm/cc irrespective of land situation. The pH of the soils ranges between from 4.45 to 7.86. The lower cation exchange capacity found in the soil layer of 30 - 45 cm in the watershed, The CEC decreases with increase in depth of soil profile. The CEC of the soils varies from 5.97 to 16.33 (cmol(p+)/kg).

The result further reveals that the mean changes in organic carbon, available N, P_2O_5, K and S content decreases with increase depth of soil layer of the watershed under study. The avg. organic carbon content of watershed was 0.50 %. The Available P range is 88.36 irrespective land situation and soil layers. The average available k value was 85.63 kg/ha i.e. the soil was deficient in potassium. Irrespective of land situation water holding capacity decreased with increase in depth.

Keywords **:** physico-chemical properties, Watershed,

Introduction

At present there is a talk of the second Green Revolution. The first Green Revolution had its own share of prosperity and problems. In the food security Atlas by the M.S. Swaminathan Research Foundation (MSSRF), Chennai, it was pointed out, "The Punjab which is India's granary today will become food insecure in 15-20 years from now, if the present unstable land and water use practice continue". The Second Green Revolution is a change in agricultural production widely thought necessary to feed and sustain the growing population on Earth. These calls have precipitated in part, as a response to rising food commodity prices, and fears of peak oil price among other factors. It includes Assam, Bihar, Jharkhand, Eastern UP, Chhattisgarh, Odisha and West Bengal. The development project (WDP) is a step in this direction. The significance of developing the watershed in these regions is unavoidable. In the present situation the ground water layer decline due to excessive use in crop production without proper management. So Watershed Management is an evolving concept in India basically associated with the proper storage and harvesting of rain water which are lost by run off by appropriate management of natural and manmade Watershed.

Watershed in India:

A watershed, also called a drainage basin or catchment area, is de1ned as an area in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa.

Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people (Wani *et al.* 2008).

The rain-fed agriculture contributes 58 per cent to world's food basket from 80 per cent agriculture lands (Raju *et al.* 2008). As a consequence of global population increase, water for food production is becoming an increasingly scarce resource, and the situation is further aggravated by climate change (Molden, 2007)

Out of the total geographical area of 329 m ha, India has already 16.5 m ha with problem soil. In the year 1976, the National Commission on Agriculture (NCA) has estimated that inundation of lands and thereby degradation of land was occurring at an approximate rate of 5-8 mha per annum, mainly by water erosion considering this, the Govt. of India launched a pilot project on "Watershed Planning" in 1976. During 1983, ICAR under the guidance of DARE (Department of Agricultural Research and Education, Ministry of Agriculture, India) launched 47 Operational Research Projects (ORP) on integrated watershed management in different agro-climatic zones which emphasized on a multidisciplinary approach to "dry land farming". Observing the marvellous performance of such ORPs, the Ministry of Agriculture, Government of India devised a systematic scheme for implementation of such project during 7th five-year plan as NWDPRA (National Watershed Development Project for Rainfed Areas) in 26 states having obtuse scope for dry land agriculture.

The present investigation was undertaken to evaluate the soil Physico-chemical properties i.e. fertility status of this watershed in different land situation with following objectives

i) To access the status of organic carbon and pH of soils

ii) To evaluate fertility status of soil with respect to Nitrogen, Phosphorus, potassium and Sulphur.

iii) To determine soil texture, bulk density, water holding capacity, porosity of soil.

iv) To determine the cation exchange capacity and electrical conductivity of soil.

v) To correlate the nutrient levels with various physical and chemical properties of soil.

Study Area:

The Dhandhing Guri watershed is rainy area having less undulation but sloppy land where run-off loss is severe and cultivation depends on the rain water i.e. rain-fed agriculture. There are no options for storage as well as conservation of water.

LOCATION:

Cooch Behar district is located on the northern region of West Bengal. Cooch Behar lies between $25^0$57'47" to $26^0$36'2" North latitude and between $89^0$54'35" to $88^0$47'44" East longitude. The Dhangdhingguri watershed was identified at Cooch Behar-II block (Pundibari, near N.H.-31) of the district which is under the Terai region of West Bengal. The Dhangdhingguri watershed, which is under the Gopalpur watershed, is a micro-watershed. Gopalpur watershed (fig-1) lies between $26^0$23'35" to $26^0$25'31" North latitude and between $89^0$22'54" to $89^0$26'34" East longitude and total area of the watershed is 1165.27 ha whereas the Dhandhingguri watershed lies between $26^0$23'07" to $26^0$28'42" North latitude and between $89^0$21'36" to $89^0$29'11" East longitude and total area of the watershed is 317.53 ha. The major villages in the study area are Dhangdhingguri, Chhotorangros, Angarkata and Holongerkuthi.

Physiography, Releif and Drainage:

The study area forms a part of Terai region and represents a slopy plain. The general elevation in the area ranges from 42m to 53m above MSL with a general gradient to North-West to South-East. This area drained by River Torsa. The river is not seasonal because the streams are enriched with ice-melted water and the flow is almost according to the gradient.

Collection of Samples:

The soil samples were collected from three different land situations. The soils were collected from

three different layers as well. The soils were collected from the above mentioned villages i.e. 0-15cm, 15-30cm and 30-45cm depth of the soils. The collected soil samples were air dried and grinded in a wooden mortar sieved through nylon sieve (80 mesh) and carefully preserved in the laboratory to avoid any contamination. Then soil samples were analyzed for different relevant physicochemical properties by using the standard methods (Jackson 1973). The characteristics of the soils are given in the Table 1.

Results and Discussion

In the present investigation, various physico-chemical properties of soil such as soil texture, Bulk density, water holding capacity, pH, EC, organic carbon, available nitrogen, available P, K, S and CEC were studied. The parameters were determined for various soils of Dhandhingguri watershed situated at Coochbehar-II block in Coochbehar district of West Bengal.

The different physico-chemical properties determined in laboratory showed variation within the land situation as well as among the soil layers under study. Highlights of the salient information generated from results of the study were furnished here under.

It has been found that the pH medium land soils were more acidic than upland and low land. The pH values of the watershed vary from 4.45 to 7.86 and the average pH value of these soils was 5.87 which are slightly acidic. The pH was increase with increase depth in all land situations. E.C values were relatively low and less than 1 dsm1 except some samples from upper layers so, the soils were normal for crop growth. The variance of E.C value is 0.89 dsm^{-1}.

The range and mean of organic carbon content indicated a decreasing trend with increase in depth from surface to subsurface layer sols belonging to the three land situation under investigation. A significantly positive correlation between available nitrogen, phosphorus, potassium with organic carbon was found. The average organic carbon content in the watershed was 0.50%. From the value of available nitrogen (%), it has been found that the available nitrogen content was decrease with increase in depth of soil. The medium and low land situation has high organic carbon as well as available nitrogen than other land situation.

The available phosphorus content decreased with increase depth in all land situations except sample no. 2 in upland situation. The average available phosphorus content was 45.64 kg/ha. So, the available phosphorus content was low in the watershed soils under study. The Available P range is 88.36 irrespective land situation and soil layers.

The values of CEC in different soil profile under different land situation were presented in Table-3. The cation exchange capacity decreases with increase in depth of soil profile. The CEC of soil is related to the clay content of soil. Due to increase the clay content with increase depth, to the CEC in increase. The clay content was high in the low land situation as the CEC also highest in low land situation of the watershed. The lower CEC found in the soil layer of 30 - 45 cm in the watershed.

The changes of available sulphur in soils collected from the different soil profile under different land situation were showed in Table-3. The results revealed that the surface layer of this area have high amount of available sulphur than lower horizon i.e. the available 'S' content decrease with increase depth of soil layer.

Bulk densities of soil collected from different soil profiles under different land situation were showed in Table-4. The results revealed that the highest as well as lowest bulk density was recorded in Upland soil. The bulk density was increased with increase in depth. The change in bulk density of soil was controlled by particle size fraction. In upland situation, sample no. 4, the texture is dominated by sand particles so the comparatively high bulk density was recorded. But in the contrary sample no. 3, texture was less dominated by sand particles. Decrease in sand content bulk density of soil decreased with the elevation of land. It is also revealed that irrespective of land situation bulk density of soil increase with increase depth due to decrease in clay content and compaction in lower horizons.

Water holding capacities of different soil profiles under different land situation were tabulated

Table 1. pH, EC (dS/m) and organic carbon (%) content in three layers under three land situations in Dhandhingguri Watershed

		Depth (cm)								
LAND SITUATION	SAMPLE	0-15			15-30			30-45		
		pH	EC(dS/m)	Org. C (%)	pH	EC(dS/m)	Org. C (%)	pH	EC(dS/m)	Org. C (%)
Upland	1	5.02	2.50	0.78	6.07	1.26	0.45	5.85	0.0101	0.15
	2	5.6	.0087	0.405	6.07	0.0037	0.3	6.34	0.0033	0.15
	3	5.41	1.36	0.495	5.79	0.0087	0.78	6.01	0.0073	0.315
	4	4.95	0.0082	0.84	5.2	0.0042	0.3	5.49	0.0035	0.285
	Mean	5.24	0.96	0.63	5.78	0.319	0.457	5.9	0.006	0.225
Medium land	1	4.72	2.87	1.08	5.53	1.04	0.6	5.55	1.37	0.255
	2	4.52	1.56	0.645	5.71	0.0054	0.465	5.8	0.0064	0.345
	3	5.63	1.78	0.9	5.87	1.25	0.555	5.95	0.0052	0.6
	4	4.45	1.87	0.96	4.41	1.67	0.33	4.81	1.33	0024
	Mean	4.83	2.02	0.896	5.38	0.99	0.48	5.52	0.677	0.36
Low Land	1	4.83	1.45	0.945	5.47	0.0098	0.3	5.71	0.0104	0.225
	2	7.86	2.4	0.675	7.83	1.46	0.375	7.9	0.0122	0.255
	3	6.31	2.16	0.855	6.47	1.22	0.48	6.69	0.013	0.3
	4	6.62	2.36	0.93	7.42	0.0061	0.195	7.63	0.0034	0.075
	Mean	6.405	2.09	0.851	6.79	0.67	0.33	6.98	0.0099	0.213

Table 2. Available nitrogen (%), available P and available K (kg/ha) content in three layers under three in Dhandhingguri Watershed.

		Depth (cm)								
LAND SITUATION	SAMPLE	0-15			15-30			30-45		
		Available N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Available N (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Available N (%)	Available P_2O_5	Available K_2O (kg/ha)
Upland	1		80.46	143.36	0.009	72.08	82.88	0.007	55.43	86.24
	2	0.010	26.93	71.68	0.008	25.65	68.32	0.007	28.21	73.92
	3	0.002	65.31	80.64	0.008	56.42	48.16	0.001	43.60	54.88
	4	0.002	42.31	92.96	0.016	35.90	77.28	0.009	17.95	60.48
	Mean	0.008	53.75	97.16	0.010	47.51	69.16	0.006	36.29	68.88
Medium	1	0.006	60.87	140.00	0.005	46.17	54.88	0.003	25.65	62.72
	land									
	2	0.013	64.15	100.80	0.012	23.08	114.28	0.011	10.26	108.64
	3	0.025	69.24	72.80	0.016	51.29	58.24	0.012	43.60	54.88
	4	0.009	52.57	144.80	0.006	41.03	87.36	0.004	21.80	70.56
	Mean	0.013	61.71	114.60	0.010	40.39	78.69	0.008	25.32	74.2
Low Land	1	0.013	55.25	106.40	0.012	35.96	66.08	0.008	22.88	63.88
	2	0.008	75.66	106.40	0.004	11.03	87.36	0.004	6.54	81.76
	3	0.10	94.89	116.48	0.003	75.66	88.48	0.002	55.14	89.6
	4	0.015	73.09	99.68	0.013	46.16	84	0.012	30.77	81.84
	Mean	0.011	74.72	107.24	0.008	42.20	81.48	0.006	28.83	79.27

Table 3. Available 'S' (mg/kg) and CEC (cmol (p+)/kg) changes in three layers under three different land situations

		Depth (cm)					
LAND SITUATION	SAMPLE	0-15		15-30		30-45	
UP LAND		Available S(mg/kg)	CEC (cmol(p+)/kg)	Available S(mg/kg)	CEC (cmol(p+)/kg)	Available S(mg/kg)	CEC (cmol(p+)/kg)
	1	9.2	10.99	8.3	9.76	8	9.15
	2	9.5	12.35	9.1	10.01	8.7	9.37
	3	12.9	14.29	12.2	11.65	10.8	8.13
	4	7.9	13.67	7.3	10.23	5	5.97
	MEAN	9.87	12.82	9.22	10.41	8.12	8.15
MEDIUM LAND	1	9.7	10.28	9.3	9.66	8.2	8.99
	2	9.9	13	9.7	10.59	9.1	9.83
	3	14.3	14.94	13.7	12.23	11.4	9.47
	4	8.4	16.33	8.3	13.86	6.2	9.11
	MEAN	10.57	13.64	10.25	11.58	8.73	9.35
LOW LAND	1	10.3	9.87	9.5	9.53	8.9	8.72
	2	10.4	11.7	10	7.36	9.6	6.58
	3	16.8	13.44	15.5	12.09	14.8	10.18
	4	6.7	15.66	6.1	12.07	4.4	9.53
	MEAN	11.05	12.67	10.27	10.26	9.42	8.75

Table 4. Maximum Water Holding capacity (%), Bulk Density (g/cc) and Porosity (%) changes in three layers under three different land situations

		Depth (cm)								
LAND SITUATION	SAMPLE	0-15			15-30			30-45		
		MWHC	B.D.	POROSITY	MWHC	B.D.	POROSITY	MWHC	B.D.	POROSITY
Upland	1	55.1	1.17	49.13	46.63	1.21	52.73	43.47	1.29	52.40
	2	49.5	1.23	53.58	48.98	1.29	52.75	44.69	1.33	53.33
	3	52.47	1.26	48.78	51.23	1.27	49.80	51.03	1.28	51.33
	4	49.26	1.15	42.50	50.73	1.26	47.06	43.99	1.45	42.00
	Mean	51.582	1.2025	48.498	49.3925	1.257	50.585	45.795	1.337	49.765
Medium land	1	62.28	1.11	46.63	64.53	1.14	56.65	52.6	1.17	51.85
	2	51.11	1.25	48.98	48.33	1.32	46.99	46.77	1.36	45.60
	3	60.9	1.14	43.00	61.13	1.16	46.54	59.29	1.19	48.93
	4	61.73	1.28	41.82	77.05	1.33	47.43	62.56	1.35	54.55
	Mean	59.005	1.195	45.108	62.76	1.237	49.404	55305	1.267	50.231
Low Land	1	38	1.24	40.95	63	1.27	39.81	40.14	1.29	41.36
	2	55.14	1.25	43.95	54.37	1.31	45.42	53.01	1.36	46.88
	3	62.55	1.21	45.00	61.74	1.25	44.93	60.21	1.29	52.40
	4	43.23	1.34	41.74	46.07	1.35	49.44	36.12	1.42	46.82
	Mean	49.73	1.26	42.909	56.295	1.295	44.899	47.37	1.34	46.863

TABLE 5. Correlation coefficient (r) between different physico-chemical properties in Dhandhingguri watershed (whole land situation)

	pH	EC	OC	Av_N	Av_P	Av_K	MWHC	BD	PD	POROSITY	SAND	SILT	CLAY	CEC	Av_S
pH	1.000														
EC	-.195	1.000													
OC	-.350*	.666**	1.000												
Av_N	-0.193	0.088	.381*	1.000											
Av_P	-0.112	.627**	.627**	0.204	1.000										
Av_K	-0.169	.575**	.518**	0.161	.374*	1.000									
MWHC	-0.272	.407*	0.241	-0.164	0.236	0.072	1.000								
BD	.354*	-.430**	-.591**	-.207	-.499**	-0.108	-.392*	1.000							
PD	0.219	-0.440	-.694**	-.488**	-.398	-.344*	-0.172	.537**	1.000						
POROSITY	0.016	-0.198	-.387*	-.428**	-0.098	-0.316	0.083	-0.097	.784**	1.000					
SAND	-0.105	-0.305	-.490**	-0.096	-.474**	-0.151	-0.354*	0279	0.32	0.16	1.000				
SILT	0.051	0.127	.338*	0.027	.362*	-0.007	.344*	-0.327	-0.172	0.044	-.883**	1.000			
CLAY	0.138	.428**	.485**	0.155	.414*	0.319	0.196	-0.069	-.391*	-.396*	-.691**	0.271	1.000		
CEC	-0.293	.465**	.591**	.359*	.607**	.375*	0.292	-0.311	-.387*	.235	-.327	0.153	.436**	1.000	
Av_S	0.055	0.221	.357*	-0.106	.497**	0.024	.444**	-.479**	-.341*	-0.044	-.683**	.698**	0.325	0.284	1.000

*. Correlation is significant at the 0.05 level (2tailed).

**. Correlation is significant at the 0.01 level (2tailed).

in Table-4. The result showed that highest water holding capacity of soil recorded under low land situation due to high clay content and organic matter content. The organic matter content as well as clay content is lower in surface soil. So irrespective of organic matter the water holding capacity of soils profile decreases with increase in depth. But it was observed that as we come down to the elevation the water holding capacity was increased as compared to each depth. Except low land situation, the water holding capacity of other land situation was more than 50%, whereas the water holding capacity of low land situation should be higher. The reason behind such results may be due intensive agriculture which may lead to the breaking down of soil structure.

Conclusions

Irrespective of land situation, the available K content increase with increasing depth of soil. But in some samples irregularities was observed in between 15-30 cm and 30-45 cm depth. The average available k value was 85.63 kg/ha i.e. the soil was deficient in potassium.

From the value of available sulphur, irrespective of land situation, it has been found that the available sulphur content decrease with increase in depth. The surface soil has high available sulphur than subsurface layer. The average available S content was 9.73 mg/ kg which was lower, than 10 mg/kg (critical limit). These results indicate that there may be deficiency of sulphur in near future in the watershed.

The CEC of the soils varies from 5.97 to 16.33. The CEC values indicated a decreasing trend with increasing depth. The medium land situation has the highest CEC as compared to other land situation.

It has been found that sand particles percentage increase with increase in depth in all land situation i.e. the surface soils have lowest sand content among the layers. The clay percentage was more in upland situation. The clay percentage was migrated due to the effect of water from high land to low land.

The bulk density of the watershed from 1.11 to 1.42 gm/cc irrespective of land situation, the bulk density was increase with increase in depth. The highest bulk density found in low land situation. The highest bulk density was because of high content of clay in lower layer and compaction with compact structure.

Irrespective of land situation water holding capacity decreased with increase in depth. The water holding capacity was higher in medium land and low land situation. In medium land situation, the water holding capacity was more than 50%. But average WHC is 52.63% and range of 40.93.

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Changes in Quality of Litchi (Cv. Bombai) as Influenced by Different Post Harvest Treatments Under Ambient Storage Condition

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Abstract

Litchi is one of the subtropical fruit which is preferred for its sweetness and unique flavour. Though the fruit is non-climacteric the deterioration of the fruit is very quick after harvest and shelf life is very short. Thus the postharvest treatment can reduce such deterioration by maintaining the pericarp colour and other biochemical parameters. Present investigation was undertaken to find out the suitable post harvest treatment which can reduce the moisture loss and degradation of fruit quality of litchi in terms of taste and colour under ambient storage condition. The result of the investigation revealed that out of different treatments ($CaCl_2$ @ 0.5% & 1.0%, $AgNO_3$ @ 50 ppm & 100ppm, Ascorbic Acid @1000 ppm & 2000ppm and distilled water as control). $CaCl_2$ @ 1.0% treatment was most effective for lowering physiological losses in weight. Fruits treated with $AgNO_3$ @ 50ppm solution scored highest TSS and low acidity during the storage life under ambient environment. Ascorbic acid @ 2000 ppm was recorded best in preserving pericarp colour of litchi fruits during storage and maximum reducing sugar content at the end.

Keywords **:** Litchi, post harvest treatments, quality

Introduction

The litchi (*Litchi chinensis* Sonn) is one of the most important subtropical juicy fruit and popular throughout the world for its excellent fragrant juicy and delicious aril, relished for its sweet taste. The aril contains considerable amount of sugar, calcium, ascorbic acid, thiamin etc. (Maity and Mitra, 2001). Besides the wide table use, litchi is also processed into flavoured squash, preserves, dried litchi etc. As it is a non-climacteric fruit litchi does not improve in quality after harvest and thus harvested only after proper ripening on the tree. But the deterioration of edible quality of litchi is very quick after harvest (Chang, 1983) when stored in ambient condition. Reduction in the post harvest storage life and acceptance of fruits to the consumers within 2-4 days after harvest is mainly due to the dehydration due to the physiological losses in weight, brown discoloration of pericarp and reduction in quality of aril with respect to sweetness and flavor. Pericarp browning of litchi fruits is mainly causes by rapidly degradation of phenols as a result of quick moisture loss and rapid catabolic activity of tissues which leads to ultimate reduction of quality of aril (Jiang and Fu, 1999).

The shelf life of fresh litchi under ambient condition is less than 72 hours (Macfie,1954). Being considered as one of the highly commercial valued fruits in the national and global market, its highly perishable nature limits its transport in long distance domestic markets as well as export markets due to lack of appropriate post-harvest technologies. As a result a major share of total production of Indian litchi is being marketed only in the short distance domestic markets and little amount is being exported from India.

Various methods of controlling pericarp browning and shelf life extension have been reported by different scientists. Use of SO_2 and sulphites (Fuchs etal.1993), acidification of flesh (Zauberman, *et al*., 1989; Underhill *et al*., 1992), high humidity, low temperature, fungicide treatment, growth regulators and modified atmosphere packaging (Ray, 1998) are some such recommendations. Treatment with litchi fruits with SO_2 fumigation is commercially practiced to control pericarp browning (Normand and Bouffin, 1995). SO_2 treatment is a well known inhibitor of polyphenol oxidase by reacting with anthocyanin pigments to form a stable complex (Markakis, 1982). SO_2 fumigation is used to lower the pH of the litchi pericarp and prevents the anthocyanin from irreversible transformation into a non-cloured carbinol base. Anthocyanin stability is more effective at < pH 3.0 (Brovillard, 1982). Acid treatment is helpful in retaining the red colour by maintaining the pH of the pericarp near to 3.0 and thus decreases the rate of enzymatic browning of litchi fruits.

However, most of the technologies are cost effective. There is need to develop appropriate easy and low cost post-harvest technologies for extending the shelf life and maintaining the fruit quality as well as for control the pericarp browning of fresh litchis for commercial purpose. Keeping this in view, the present investigation was undertaken with the objective to study the effect of different post-harvest treatments on the changes in the physico-chemical characteristics and the shelf life of fresh litchi fruits under ambient storage conditions.

Materials and Methods

The fully ripen litchi fruits were harvested from uniformly managed litchi plants (cv. Bombai). The fruits were then taken to the laboratory of the Department of Horticulture & Postharvest Technology, Institute of Agriculture, Visva-bharati, Sriniketan, West Bengal. The work has been done during fruiting season of 2016. Fruits with long stalks in clusters were sorted for uniform size, optimum maturity and fruit colour. Selected fruits with short stalks were washed thoroughly with water and hydro cooled at 4 ± 2^{0}C for 15 minutes to remove the field heat and to control fruit respiration rate. Then the fruits were treated with different solutions like $CaCl_2$ (0.5% and 1.0%), $AgNO_3$ (50ppm and 100ppm), Ascorbic Acid (1000ppm and 2000ppm) and distilled water (as control) for 10 minutes. Then the fruits were stored at ambient condition (27-32 ^{o}C and 72-85% RH). The observations like physiological losses in weight (PLW in %), total soluble solids (TSS in ^{o}Brix), acidity (%), reducing sugar (%) and anthocyanin content were recorded at one day interval up to 7th day as per following procedure:

Physiological Loss in Weight (PLW): Fruits were weighed before storage and periodically on one day interval up to 7th day. Weighing was done with electronic balance having an accuracy of 0.01g. PLW was worked out based on initial weight and loss in weight during storage and expressed in percentage. To determine the physiological losses in weight, initial weight and final weight of the sample was taken and calculated by the following formula.

$$PLW = \frac{\text{Initial weight of sample} - \text{final weight of sample}}{\text{Initial weight of sample}} (X\ 100\ \%)$$

Total soluble solids (^{0} Brix): Total soluble solids (^{0}Brix) of fruit samples were measured using digital refractometer (Model: ATAGO PAL-1,3810). A drop of the fruit juice samples were placed on the prism of the refractometer and TSS is measured in terms of °Brix with respect to double distilled water as zero standard.

Titrable acidity (%): Titrable acidity of fruit aril was determined by the AOAC method (1990). A known quantity of aliquot was titrated against 0.1N NaOH using phenolphthalein as an indicator until pink colour persisted.

Sugars : Both reducing and total sugars of the fruit aril were analyzed by Lane and Eynon Method as described by Ranganna (1999).

The data was subjected to analysis of variance test using one-way ANOVA as per the method suggested by Gomez and Gomez (1984).

Results and Discussion

The results of the present experiment in the aspect of influence of different post-harvest treatments on litchi (cv. Bombai) under ambient condition on changes in physical and chemical characteristics of litchi fruits for shelf life extension and maintaining quality during ambient storage are presented in the tables 1 to 7.

Physiological losses in weight: The result of physiological losses in weight (PLW) of the litchi fruits under present has been presented in table 1, showed significant variation. The PLW has increased with the advancement of the storage period. The maximum physiological losses (21.35%) was recorded under control T_7 (distilled water), followed by T_6 (ascorbic acid @ 2000 ppm) (19.28%), T_5 (ascorbic acid @1000) (18.97%) on 7th day of storage. However, the minimum physiological losses in weight (10.11%) were recorded in T_2 ($CaCl_2$ @ 1.0%) on 7th day of storage. This may be due to the increasing the calcium content of litchi pericarp as a result of post-harvest treatment of $CaCl_2$. Reduced PLW was also observed in the fruits treated with growth regulators with wax emulsion (Nigam *et al.*, 2001). Similarly Underhill and Simons (1993) found that regulation of water loss in litchi fruit has direct bearing over extent of pericarp desiccation and browning of litchi fruits. Sharma and Ray (1987) also observed the PLW in the litchi fruits treated with the fungicide Bavistin (25-100 ppm) was low during ambient storage conditions.

Total soluble solids (°Brix): In the present experiment the result of total soluble solid (TSS) revealed significant variation (table 2). The TSS of the litchi fruits under different treatments has shown the increasing trend with the advancement of storage period. The highest TSS (24.67° Brix) was estimated under T_3 ($AgNO_3$ @ 50 ppm) followed by T_6 (ascorbic acid @ 2000 ppm) (23.01° Brix) on 7th day of storage. TSS on the other treatments were observed as 22.54°Brix in T_7 (Distilled water), 22.83°Brix in T_5 (ascorbic acid @1000), 22.36°Brix in T_4 ($AgNO_3$ @ 100ppm), 21.73°Brix in T_1 ($CaCl_2$ @ 0.5%) and 21.85°Brix in T_2 ($CaCl_2$ @ 1.0%) on 7th day of storage. However, the lowest TSS (21.73°Brix) on 7th day of storage was recorded in T_1 ($CaCl_2$ @ 0.5%).

Acidity (%): In the present experiment the total acidity of the litchi fruits has decreased in every treatment with advancement of storage period which is presented in the table 3. As shown in the table it was observed that different post-harvest treatments had a significant effect on the acidity on 3rd, 5th and 7th day of storage. On 7th day of storage minimum acidity was recorded in T_3 ($AgNO_3$ @ 50 ppm) at 0.28% followed by T_6 (ascorbic acid @2000 ppm) at 0.34% and maximum acidity (0.34%) was observed in T_7 (Control). The reduction in acidity may be due to the utilization of acids or conversion into other compounds during the storage period. Sharma and Ray (1987) also found that there was increase in TSS and decrease in acidity content of the litchi fruits during ambient storage conditions.

Reducing sugar content (%): The effect of different post-harvest treatments of litchi fruits has shown significant difference on reducing sugar content on 3rd, 5th and 7th day of storage (table 4). As shown in the table it was observed that there was significant effect of different post-harvest treatments on reducing sugar at 7th day of storage and shelf life. Maximum value of reducing sugar was recorded in T_3 ($AgNO_3$ @ 50 ppm) at 11.41% followed by T_6 (Ascorbic acid @2000 ppm) at 11.26% and minimum value was observed in Control with 9.12%. This is due to the higher conversion of complex sugar into its simpler form under silver nitrate and ascorbic acid treatment followed by lesser utilization of those reducing sugars.

Total sugar content (%): It was seen from the table that there was significant effect of different post-harvest treatments on total sugar content on different days of storage from 3rd to 7th day (table 5). The trend of changes of total sugar content was not same. In most of the cases total sugar initially decreased and increased at the end. This may be attributed to increasing the juice concentration and TSS due to the increasing PLW with the advancement of storage. On 7th day of storage highest total sugar (11.97%) was the recorded in T_3 ($AgNO_3$ @ 50 ppm) followed by 11.95% in T_6 (Ascorbic acid @ 2000 ppm) and lowest (9.71 %) in Control. Pesis *et al.*, (2002) also observed similar trends in the pool of total sugars and reducing sugars in litchi fruits during storage under MAP.

TABLE 1. Changes in PLW (%) of litchi under different post harvest chemical treatments during the storage

Treatments	1st day	3rd day	5th day	7th day
T_1 $CaCl_2$ @ 0.5%	-	6.27	8.30	12.17
T_2 $CaCl_2$ @ 1.0%	-	5.05	7.12	10.11
T_3 $AgNO_3$ @ 50 ppm	-	6.20	10.07	13.22
T_4 $AgNO_3$ @ 100 ppm	-	8.92	12.85	15.62
T_5 Ascorbic Acid @1000 ppm	-	8.62	15.25	18.97
T_6 Ascorbic Acid @2000 ppm	-	8.50	16.37	19.82
T_7 Distilled water(Control)	-	9.90	17.92	21.35
SE(±)m	-	**0.38**	**0.40**	**0.69**
CD (P = 0.05)	-	**0.72**	**1.16**	**1.30**
CV (%)	-	**8.24**	**11.12**	**7.24**

TABLE 2. Changes in TSS (°Brix) of litchi under different post harvest chemical treatments during the storage period

Treatments	1st day	3rd day	5th day	7th day
T_1 $CaCl_2$ @ 0.5%	17.75	18.95	20.15	21.73
T_2 $CaCl_2$ @ 1.0%	18.10	18.84	20.40	21.85
T_3 $AgNO_3$ @ 50 ppm	17.95	20.92	22.45	24.67
T_4 $AgNO_3$ @ 100 ppm	18.27	19.69	20.78	22.36
T_5 Ascorbic Acid @1000 ppm	18.07	19.81	21.11	22.83
T_6 Ascorbic Acid @2000 ppm	18.52	20.00	21.30	23.01
T_7 Distilled water(Control)	18.83	20.11	21.37	22.54
SE(±)m	0.62	0.42	0.49	0.65
CD (P = 0.05)	NS	0.90	1.10	1.22
CV (%)	9.22	8.32	10.11	9.07

TABLE 3. Changes in acidity (%) of litchi under different post harvest chemical treatments during the storage period

Treatments	1st day	3rd day	5th day	7th day
T_1 $CaCl_2$ @ 0.5%	0.49	0.46	0.42	0.40
T_2 $CaCl_2$ @ 1.0%	0.48	0.44	0.42	0.38
T_3 $AgNO_3$ @ 50 ppm	0.47	0.41	0.36	0.28
T_4 $AgNO_3$ @ 100 ppm	0.47	0.44	0.41	0.36
T_5 Ascorbic Acid @1000 ppm	0.49	0.45	0.41	0.36
T_6 Ascorbic Acid @2000 ppm	0.46	0.42	0.39	0.31
T_7 Distilled water(Control)	0.49	0.45	0.44	0.42
SE(±)m	0.015	0.010	0.009	0.014
CD (P = 0.05)	NS	0.021	0.022	0.027
CV (%)	5.56	7.49	8.14	9.32

TABLE 4. Changes in reducing sugar (%) of litchi under different post harvest chemical treatments during the storage period

Treatments		1st day	3rd day	5th day	7th day
T_1	$CaCl_2$ @ 0.5%	7.37	8.57	9.89	10.05
T_2	$CaCl_2$ @ 1.0%	7.45	8.43	9.66	10.15
T_3	$AgNO_3$ @ 50 ppm	7.62	9.51	11.21	11.41
T_4	$AgNO_3$ @ 100 ppm	7.28	8.94	10.11	10.35
T_5	Ascorbic Acid @1000 ppm	7.31	8.40	9.23	9.94
T_6	Ascorbic Acid @2000 ppm	7.48	9.74	10.92	11.26
T_7	Distilled water(Control)	7.69	8.55	9.17	9.12
SE(±)m		0.35	0.36	0.53	0.52
CD (P = 0.05)		NS	0.70	1.02	1.10
CV (%)		6.78	9.51	8.47	10.57

TABLE 5. Changes in total sugar (%) of litchi under different post harvest chemical treatments during the storage period

Treatments		1st day	3rd day	5th day	7th day
T_1	$CaCl_2$ @ 0.5%	12.01	10.83	10.42	10.35
T_2	$CaCl_2$ @ 1.0%	11.86	10.89	10.21	10.33
T_3	$AgNO_3$ @ 50 ppm	11.99	10.01	11.61	11.97
T_4	$AgNO_3$ @ 100 ppm	12.11	10.47	11.82	11.01
T_5	Ascorbic Acid @1000 ppm	11.72	10.67	10.16	10.43
T_6	Ascorbic Acid @2000 ppm	11.97	9.63	11.83	11.95
T_7	Distilled water(Control)	12.09	11.28	10.58	9.71
SE(±)m		0.42	0.36	0.53	0.41
CD (P = 0.05)		NS	0.70	1.02	0.84
CV (%)		8.93	9.51	8.47	11.23

TABLE 6. Changes in sugar-acid ratio of litchi under different post harvest chemical treatments during the storage period

Treatments		1st day	3rd day	5th day	7th day
T_1	$CaCl_2$ @ 0.5%	15.12	18.60	23.52	25.17
T_2	$CaCl_2$ @ 1.0%	15.55	19.17	23.11	26.64
T_3	$AgNO_3$ @ 50 ppm	16.31	23.21	26.77	40.81
T_4	$AgNO_3$ @ 100 ppm	15.47	22.37	24.14	28.95
T_5	Ascorbic Acid @1000 ppm	14.88	18.68	22.55	27.76
T_6	Ascorbic Acid @2000 ppm	16.30	23.16	28.70	36.45
T_7	Distilled water(Control)	15.65	19.05	20.81	21.82
SE(±)m		0.61	0.57	0.78	1.27
CD (P = 0.05)		NS	1.07	1.54	2.63
CV (%)		10.02	7.28	11.61	9.86

Sugar acid ratio: Significant variation in sugar acid ratio was recorded in litchi in the present experiment (table 6). Sugar acid ratio has shown increasing trend with increasing in storage period. This was due to the increase in reducing sugar content and decrease in acidity of the litchi fruits. Thus with the advancement of storage period the fruits became sweeter. The highest sugar acid ratio (40.81) was recorded under T_3 ($AgNO_3$ @ 50 ppm) followed by T_6 (ascorbic acid @ 2000 ppm) (36.45). Although, the lowest sugar acid ratio (21.82) was recorded in T_7 (distilled water) (14.17).

Anthocyanin content: In the present experiment the result of anthocyanin content revealed significant variation among different post-harvest treatments. The anthocyanin content was decreased with the advancement of storage. It was due to the conversion of anthocyanin into the other oxidized pigments during the storage (Lin *et al*., 1988 and Zhang *et al*., 2001). The rate of degradation of anthocyanin was different under different treatments which was reflected by the total anthocyanin content on that particular day of storage under a specific treatment. On the 7th day of storage the highest content of anthocyanin (36.14 mg/100gm) was recorded under T_6 (ascorbic acid @ 2000 ppm) followed by T_5 (ascorbic acid @1000) (6.56 mg/100gm). Moreover, the lowest content of anthocayanin (14.17 mg/100gm) was recorded in T_7 (distilled water). Perhaps ascorbic acid increased the acidity and thus reduced the pH of the litchi fruit pericarp which helped in retention of pericarp colour by reducing the conversion of anthocyanin into oxidized pigments (Kumar *et al*., 2013 and Neog and Saikia, 2010).

Shelf life (days): Perusal of the observations on the shelf life of the litchi under different treatments showed significant variation. The maximum shelf life (7.32 days) was recorded under T_6 (ascorbic acid @ 2000 ppm) followed by T_5 (ascorbic acid @1000) (6.56 days). However, minimum shelf life (2.89 days) was recorded in T_7 (distilled water). Although the shelf life of 5.83 days, 5.60 days, 3.65 days and 3.24 days were observed under T_3 ($AgNO_3$ @ 50 ppm), T_4 ($AgNO_3$ @ 100 ppm), T_2 ($CaCl_2$ @ 1.0%)and T_1 ($CaCl_2$ @ 0.5%) respectively.

Conclusion

From the findings of the present experiment projects that the post-harvest treatments of different chemicals has significant effect on changes in quality, shelf life and maintenance of pericarp colour of litchi (cv. Bombai). Physiological losses in weight was recorded minimum in T_2 ($CaCl_2$ @ 1.0%) and maximum in control. Minimum acidity maximum reducing & total sugar, sugar-acid ratio obtained in T_3 ($AgNO_3$ @ 50 ppm) and minimum in control. However, maximum anthocyanin content and shelf life was observed under T_6 (ascorbic acid @2000). T_6 also exhibited lower PLW, acidity and higher sugars and sugar-acid ratio. Thus it can be concluded that better fruit quality, pericarp colour and longer shelf life of litchi stored under ambient condition post-harvest treatment of ascorbic acid @2000 ppm is best among the treatments of the present experiment.

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TABLE 7. Changes in total anthocyanin content (mg/100g) of litchi under different post harvest chemical treatments during the storage period.

Treatments		1st day	3rd day	5th day	7th day
T_1	$CaCl_2$ @ 0.5%	47.21	38.47	29.16	23.81
T_2	$CaCl_2$ @ 1.0%	46.45	38.06	28.52	22.50
T_3	$AgNO_3$ @ 50 ppm	46.02	37.18	27.05	24.64
T_4	$AgNO_3$ @ 100 ppm	45.11	39.43	32.68	26.78
T_5	Ascorbic Acid @1000 ppm	46.34	40.02	34.67	30.59
T_6	Ascorbic Acid @2000 ppm	45.02	41.89	39.14	36.14
T_7	Distilled water(Control)	47.16	38.56	25.21	14.17
SE(±)m		0.51	0.68	0.72	0.98
CD (P = 0.05)		NS	1.24	1.53	2.10
CV (%)		10.24	9.51	8.47	11.23

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Management of Garlic Leaf Mite *Aceria Tulipae,* Keifer with Acaricides

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Abstract

Aceria tulipae Keifer is an important Eriophyoid mite pest of Garlic in both field and storage condition. In order to management of *A. tulipae* seven acaricides molecules were tested in field condition. The experiment was conducted at the Jaguli Instructional Farm of Bidhan Chandra KrishiViswavidyalaya, Kalyani, Nadia, West Bengal during winter months of 2016 and 2017. Garlic variety *Goldana* was planted during 1st week of November. Among the acaricides tested Etoxazole 10 SC @ 2.0 ml per liter of water was found to be significantly superior over all other treatments. Propergite 57 EC @ 1.5 ml per liter and Profenophos 50 EC @ 1 ml per liter were also found to be effective in reducing the mite population.

Keywords **:** acaricides, *aceria tulipae*, etoxazole, garlic, West Bengal.

Introduction

Garlic (*Allium sativum* Linn.) or 'Lasun' or 'Rashun' belongs to the family Alliaceae, has been recognized all over the world as a valuable condiment and popular medicine for various ailments and physiological disorders. In Ayurveda it is known as the "Nectar of life" (Muthukumar and Selvakumar, 2013). Garlic is consumed as green as well as dried in the form of spice (Singh *et al*., 2009). It has been cultivated throughout the world from the antique past. It is second most important bulb crops next to onion. It has important role in Indian economy by earning a good amount of foreign currency. Among the non insect pest, the garlic mite, *A. tulipae* (Keifer) has been identified as one of the constraints in garlic production. It is also known as the dry bulb mite or tulip mite and considered as one of the most damaging sucking pest of garlic.Other than Garlic the mite species also attacks the Onion, Leek, Tulip, Shallot and Chieve. The damage signs due to mite attack in Garlic appeared as twisting and curling of leaves, which did not open properly, creating a micro-environment on the upper leaf surface where all the biological stages of the mite, namely eggs, nymphs and adults, colonized along the mid-rib. Both nymph and adult suck sap from leaves. The infested leaves typically arched downwards with the tip tucked into the next young leaves (Channabasavanna,1966). In heavy infestations, leaves showed yellow streaks, most often along the mid-rib and leaf margin. In a heavily infested field, the leaves showed typical symptoms of curling, leading to the formation of a "Pig tail" like symptom. Mite infestations were found as early as the 3-4 leaf stage of the crop, during the last week of December. This mite was also reported to transmit onion mite-borne latent virus in onion and shallot mite-borne latent virus in shallot (Dijk *et al.* 1991). Later, Dijk and Vlugt (1994) isolated other viruses transmitted by *A. tulipae* from rakkyo, shallot and wild leek. This mite has been reported as yield reducing organism of garlic. Budai *et al.* (1997) reported a 20–100% infestation of garlic cloves and a considerable amount of storage loss. According to Larrain, 1986 it causes up to 23% yield ruction of garlic. With this background, a research was conducted to understand the relative efficacy of seven acaricides in managing this destructive mite pest under field condition.

Materials and Methods

Location and soil type

The experiments were conducted in the Jaguli Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, West Bengal, India. The area is situated in 22°57' N latitude and 88°29' E longitudes with elevation of 9.75 m above MSL. The soil type is sandy loam with P^H range 5.75 to 6.5.

Field description

The plot area was 300 square meter. There were bunds (50 cm) and Channels (1m). Direction of the field was south to north to allow maximum sunlight.

Land preparation

Plot size 3m X 3m are prepared by giving 4-5 ploughing and weeds are removed from during land preparation. Well rotten F.Y.M. was mixed thoroughly in the soil at the time of land preparation.

Sowing of cloves

Generally medium and bigger size healthy cloveswere selected for planting. Cloves (8-10 mm diameter) required 350-500 kg/ha. The cloves were planted at spacing of 15cm ´10 cmduring the 1st week of November.

Methods of planting

Dibbling:Individual Cloves were dibbled at 5 cm depth keeping their growing ends upward.

Acaricides treatment Details

Layout of experiments: The experiment was done in Randomized Block Design with 8 treatments and 3 replications. Garlic variety "Goldana" was planted during 1st week of November in 3m x 3m plots with row to row and plant to plant spacing of 15cm x 10 cm. Seven acaricides were used for the experiment and all the selected acaricides were recognized as treatments. Water was applied in untreated control. The chemicals were applied twice at 2 weeks interval.

Result and Discussion

Bio-efficacy of seven acaricides against *A. tulipae*

The acaricides were screened during 2016 and 2017 cropping season for the management of active stages of *A. tulipae* on Garlic and the data has been presented in the tables. In the year 2016, the pretreatment population count of mites ranging between 25.7-28.0 mites/cm^2 leaf in all the treatments before first spraying (Table 2). Among the treatments tested Etoxazole 10 SC @ 2ml/lt recorded 44, 76, 83.4, 41.9 per cent mortality after 1,3,7 and 14 days after 1st spray and Propergite 57 EC @ 1.5 ml/lt recorded 42.7, 72.2, 80 and 26.3 per cent mortality. Prophenophos 50 EC @ 1 ml/lt recorded 40.5, 69.8, 76.7 and 20.6 per cent mortality. These three acaricides are reported as superior than other used acaricides and Etoxazole is the best one.

In the second round spraying in 2016 (Table. 3) Etoxazole 10 SC @ 2 ml/lt recorded 45.9, 69.4,

Table 1. Different chemicals and their concentration used

Treatments	Components	Doses
T1	Etoxazole 10 SC	2 ml/L
T2	Hexythiazox 5.45 EC	1 ml/L
T3	Spiromesifen 22.9 SC	1 ml/L
T4	Difenthiuron 50 WP	0.5 gm/L
T5	Propergite 57 EC	1.5 ml/L
T6	Fenpyroximate 5 SC	1 ml/L
T7	Profenophos 50 EC	1 ml/L
T8	Untreated	_

Table 2. Effect of different acaricides on garlic mite, *A. tulipae* (var. Goldana) during 2016 (1st spray)

Treatments	Doses	Pretreatment	Percent mortality							
			1st DAS		3rd DAS		7th DAS		14th DAS	
Etoxazole 10 SC	2 ml/L	28.0	44.0	(41.9)*	76.0	(61.0)	83.4	(66.3)	41.9	(40.6)
Hexythiazox 5.45 EC	1 ml/L	27.7	37.5	(38.1)	56.7	(49.1)	59.2	(50.6)	13.3	(21.8)
Spiromesifen 22.9 SC	1 ml/L	26.7	24.0	(29.7)	55.3	(48.3)	51.5	(46.1)	12.7	(21.3)
Difenthiuron 50 WP	0.5 gm/L	27.3	9.9	(18.8)	26.2	(31.1)	28.9	(32.8)	6.2	(15.1)
Propergite 57 EC	1.5 ml/L	25.7	42.7	(41.1)	72.2	(58.5)	80.0	(63.8)	26.3	(31.2)
Fenpyroximate 5 SC	1 ml/L	26.0	23.4	(29.2)	45.3	(42.6)	40.2	(39.6)	10.2	(19.1)
Profenophos 50 EC	1 ml/L	27.0	40.5	(39.8)	69.8	(57.0)	76.7	(61.5)	20.6	(27.3)
Control		27.3	0.0	(4.1)	0.0	(4.1)	0.0	(4.1)	0.0	(4.1)
F-test				sig		sig		sig		Sig
SEM				4.32		2.43		2.64		3.28
CD at 5%				13.11		7.36		8.02		9.94

* Figures in the parentheses are angular transformed value.

Table 3. Effect of different acaricides on garlic mite, *A.tulipae* (var.Goldana) during 2016 (2nd spray)

Treatments	Doses	Pretreatment	Percent mortality							
			1st DAS		3rd DAS		7th DAS		14th DAS	
Etoxazole 10 SC	2 ml/L	16.3	45.9	(42.9)	69.4	(56.7)	85.5	(68.0)	39.0	(38.96)
Hexythiazox 5.45 EC	1 ml/L	24.0	21.1	(27.7)	54.1	(47.6)	61.1	(51.7)	18.4	(25.74)
Spiromesifen 22.9 SC	1 ml/L	23.3	17.2	(24.9)	51.3	(46.1)	52.4	(46.6)	14.3	(22.61)
Difenthiuron 50 WP	0.5 gm/L	25.7	15.9	(23.9)	34.5	(36.3)	33.3	(35.6)	10.5	(19.34)
Propergite 57 EC	1.5 ml/L	18.7	40.8	(40.0)	67.6	(55.6)	82.8	(65.8)	27.6	(32.02)
Fenpyroximate 5 SC	1 ml/L	23.3	16.4	(24.3)	43.2	(41.4)	32.6	(35.1)	13.2	(21.71)
Profenophos 50 EC	1 ml/L	21.3	36.7	(37.6)	65.8	(54.5)	71.8	(58.2)	23.8	(29.52)
Control		30.3	0.0	(4.1)	0.0	(4.1)	0.0	(4.1)	0.0	(4.05)
F-test				sig		sig		sig		Sig
SEM				2.25		1.83		2.19		1.55
CD at 5%				6.81		5.55		6.65		4.70

* Figures in the parentheses are angular transformed value

Table 4. Effect of different acaricides on garlic mite, *A.tulipae* (var.Goldana) during 2017 (1st spray)

Treatments	Doses	Pretreatment	Percent mortality							
			1st DAS		3rd DAS		7th DAS		14th DAS	
Etoxazole 10 SC	2 ml/L	32.7	44.7	(42.3)	69.2	(56.6)	82.6	(65.7)	26.4	(31.2)
Hexythiazox 5.45 EC	1 ml/L	33.3	37.9	(38.3)	56.9	(49.2)	53.9	(47.5)	14.0	(22.4)
Spiromesifen 22.9 SC	1 ml/L	35.3	24.4	(29.9)	55.7	(48.6)	44.3	(42.0)	12.3	(20.9)
Difenthiuron 50 WP	0.5 gm/L	33.0	9.0	(18.0)	25.7	(30.8)	28.6	(32.6)	5.1	(13.6)
Propergite 57 EC	1.5 ml/L	34.0	32.4	(35.0)	72.5	(58.7)	75.4	(60.6)	20.9	(27.6)
Fenpyroximate 5 SC	1 ml/L	33.0	42.2	(40.8)	46.6	(43.3)	58.4	(50.1)	9.8	(18.7)
Profenophos 50 EC	1 ml/L	33.0	48.4	(44.4)	75.5	(60.7)	84.8	(67.5)	42.2	(40.8)
Control		34.3	11.4	(20.2)	11.4	(20.2)	11.4	(20.2)	11.4	(20.2)
F-test				sig		sig		sig		Sig
SEM				5.51		5.41		3.84		4.37
CD at 5%				16.71		16.40		11.64		13.26

* Figures in the parentheses are angular transformed value

Table 5. Effect of different acaricides on garlic mite, *A.tulipae* (var.Goldana) during 2017 (2nd spray)

Treatments	Doses	Pretreatment	Percent mortality							
			1st DAS		3rd DAS		7th DAS		14th DAS	
Etoxazole 10 SC	2 ml/L	24.0	41.5	(40.4)	68.1	(55.9)	83.4	(66.3)	25.0	(30.3)
Hexythiazox 5.45 EC	1 ml/L	28.7	17.2	(24.9)	53.6	(47.3)	62.7	(52.7)	9.3	(18.2)
Spiromesifen 22.9 SC	1 ml/L	31.0	16.1	(24.0)	51.6	(46.2)	54.8	(48.0)	14.0	(22.4)
Difenthiuron 50 WP	0.5 gm/L	31.3	22.5	(28.7)	36.3	(37.4)	34.4	(36.2)	12.5	(21.1)
Propergite 57 EC	1.5 ml/L	26.7	45.1	(42.5)	63.6	(53.2)	75.1	(60.4)	27.3	(31.8)
Fenpyroximate 5 SC	1 ml/L	29.7	15.5	(23.6)	46.3	(43.2)	52.8	(46.9)	17.8	(25.3)
Profenophos 50 EC	1 ml/L	19.0	38.4	(38.6)	66.4	(54.9)	84.1	(66.9)	38.4	(38.5)
Control		30.3	0.0	(4.1)	0.0	(4.1)	0.0	(4.1)	0.0	(4.1)
F-test				sig		sig		sig		Sig
SEM				3.20		2.35		2.07		1.97
CD at 5%				9.70		7.12		6.28		5.97

* Figures in the parentheses are angular transformed value

85.5 and 39 per cent mortality after 1,3,7 and 14 days after spraying. Propergite 57 EC @ 1.5 ml/lt recorded 40.8, 67.6, 82.8 and 27.6 per cent mortality after 1, 3, 7 and 14 days after spraying. Prophenophos 50 EC @ 1 ml/lt recorded 36.7, 65.8, 71.8, 23.8 per cent mortality.

In the second season spraying i.e. 2017, the population of mite before 1st spraying (Table. 4) was ranging between 32.67-35.3 mites/cm^{2}leaf in all the treatments. Among the treatments Etoxazole 10 SC @ 2 ml per liter of water showed 44.7, 69.2, 82.6 and 26.4 percent mortality, Propergite 57 EC @ 1.5 ml/lt recorded 32.4, 72.5, 75.4, 20.9% mortality, Prophenophos 50 EC @ 1ml/lt recorded 48.4, 75.5, 84.8, 42.2 percent mortality level.

In the second round spraying (Table 5) Etoxazole 10 SC application showed 41.5, 68.1, 83.4, 25 percent mortality, Propergite 57 EC has been recorded 45.1, 63.6, 75.1 and 27.3 percent mortality and Prophenophos 50 EC shows 38.4, 66.4, 84.1, 38.4 percent mortality of garlic leaf mite.

Acaricides namely Etoxazole, Hexythiazox, Spiromesifen, Difenthiuron, Propergite, Fenpyroximate and Prophenophoswere evaluated against Garlic leaf curl mite, *A. tulipae*. Among these chemicals Etoxazole 10 SC @ 2 ml/lt, Propergite 57 EC @ 1.5ml/lt, and Prophenophos 50 EC @ 1 ml/lt of water were found to be superior over all other treatments in minimising the mite population. Same trend was found in second season also. Katkar*et al*. (1998) who reported in Maharastra, India, dipping of seedin wettable sulphur (0.3%) + dimethoate (0.03%) resulted to minimize the number of mites (5.0/cm leaf) in a pre-sowing experiment. Post-sowing, these same pesticides applied as foliar sprays resulted in the lowest number of mites (4.7/cm leaf). These treatments also gave the highest yields (138.7 q/ha pre sowing and 159.2 q/ha post sowing respectively). Dicofol 18.5 EC was found to be the most effective acaricideten days after application and significantly reduces population (1.40 mites per sq. cm.) (Bala et al, 2015).

Sharma and Sharma (2016) reported dicofol 18.5 EC (0.5 ml/L), propargite 57 EC (0.2 ml/L), fenpyroximate 5 EC (2.0 ml/L) and hexythiazox 5.45 EC (1.8 ml/L) to be very effective against eriophyid mite, *Aceria*sp. (Acarina: Eriophyidae) infesting seabuckthorn (*Hippophae*L.) in North West Himalayas. The results revealed that two sprays of these acaricides done at ten days interval reduced mite population by 98.8- 99.4, 99.5-99.6, 96.1-99.3 and 84.1-99.5% respectively.

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Women in Agriculture: A Case Study of Koch-Bihar District, West Bengal

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Abstract

Women contribute substantially to agricultural income of our country.The economy of the Koch Bihar district mainly depends on agriculture. A very large number of people are dependent on agriculture. In this district 285426 numbers are agricultural workers of which 59.63% are male and 40.37% are female (Census 2011). Female farm women contribute significantly to household and their earnings are found crucial for their family but the status and role of farm women is very poor in this area. Although rural farm women played a vital role in agricultural, domestic their view was very negligible. It is high time for planners, policy makers and extension personnel to realize the immense potential of rural farm women resources in agriculture and develop appropriate policy measures. Beside this, it is necessary to provide need based educational programmes and market linkages to rural farm women so as to get additional income and employment opportunity in the days to come.

Keywords **:** agriculture, socio-economic status, wages, women's participation

Introduction

Agriculture is the single largest production in India and it has been widely accepted that women are an integral part of the agricultural production systems. Women of India, numbering 495.7 million constitute 48.27% of total population of which 72.72% live in rural areas. Female labour force in rural areas is 31.56% with most of them (87%) being employed as agricultural labourers and cultivators (Sridhara, 2009). Women contribute substantially to agricultural income of the country. Agriculture including crop production, animal husbandry, and storage of food grains is highly dependent on the time devoted by women. In India men and women participate in agriculture as a family unit on the farms. Female farm labourers contribute significantly to household and their earnings are found crucial for their family. But the status and role of farm women is very poor. Female agricultural workers belonging to big farm households have a better say as compared female farm labourers. Female agricultural labourers contribute significantly to households but they lack education, modern agricultural techniques and often do not have access to economic resources. Moreover, they are not integrated into mainstream of the development process. Scarcity of resources, economic deprivation, gender bias in wages, lack of freedom in decision makingfor agricultural activities as well as domestic matters has made life miserable and unjustifiably hard for farm women. The present study examines the issues of women's contribution to agriculture, valuation of women work in field and household, lower wages for women compared to men and major problems of farm women.

Objectives

The following objectives were set up for this study:

1. To analyze the relationship between the socio economic status of farm women and involvement of the farm women in agriculture and allied activities.

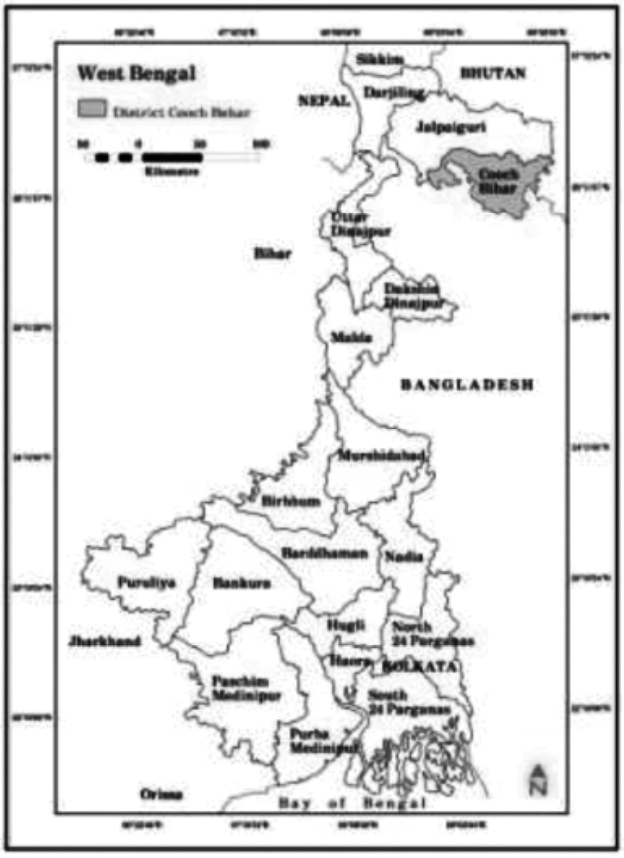
2. To study the factors that influencing differentials in wages between men and women agricultural labours.

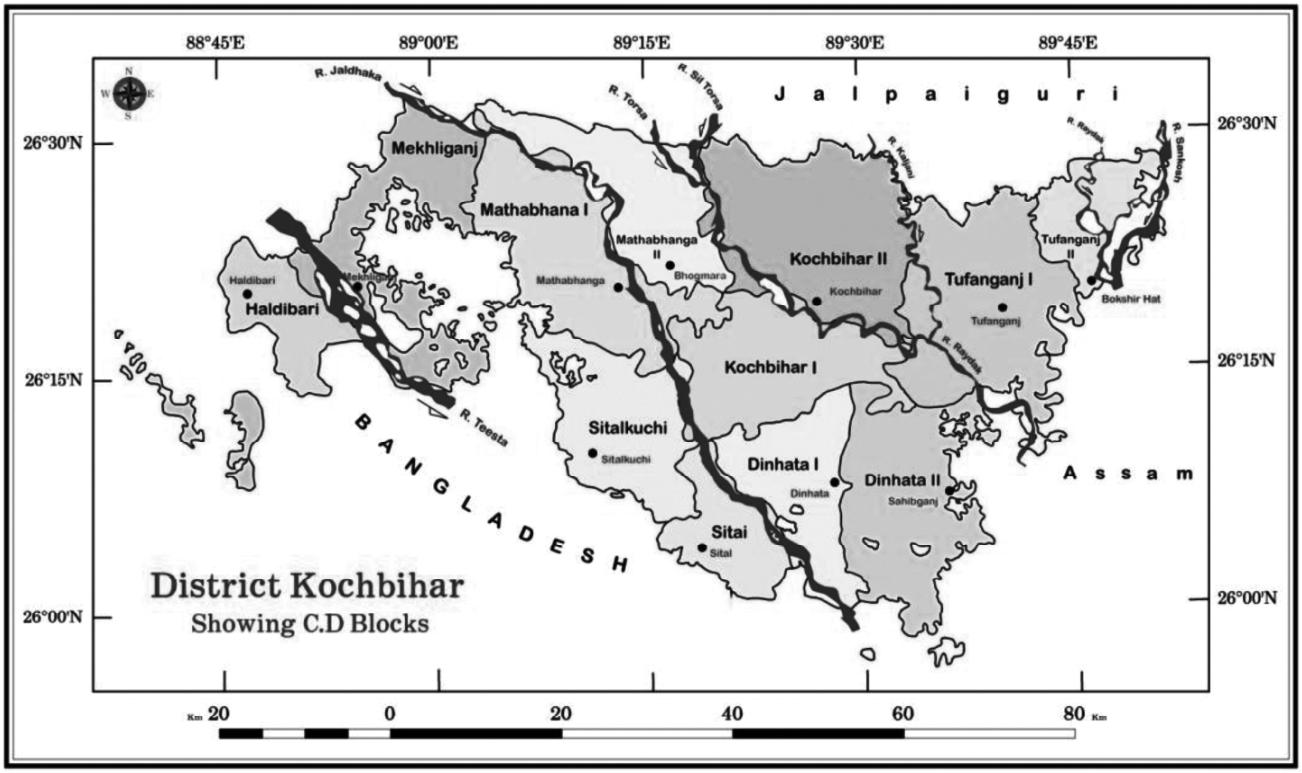
3. To identify the problems of farm women regarding their involvement in agriculture and to find out the way to solve these problems.

Study area:

The economy of the Koch Bihar district mainly depends on agriculture. There is no noticeable industry except one tea factory in this area causing low income of the people. Infrastructural facilities like transport network, degree of urbanization, industry, education and medical facilities are very poor particularly in rural areas. The rate of increase of population has increased the pressure on land and reduced the man-land ratio. A very large number of people are dependent on agriculture. The number of women in Koch Bihar district is 1369190 contributing about 48.51% of total population of the district (census 2011). In this district 285426 numbers are agricultural workers of which 59.63% are male and 40.37% are female. Thus women are integral part of agricultural production systems of Koch Bihar. Farm women share abundant responsibilities and perform a wide spectrum of duties in crop production activities such as seed sowing, transplanting, weeding, fertilizer application, plant protection measures processing, storage etc. as well as in allied field activities such as dairy, goatee, piggery, poultry, fisheries etc. in addition to their household activities. Although, improved technology in relation to crop production has been introduced in this area but farm women are not aware of this phenomenon. Besides, numbers of male, living their homelands have migrated to other places within and outside the state to earn money, causing shortage of male labour and more involvement of female labour. Although women bear the burden of work in the field of agriculture and allied sectors they remain as helpers of men without any proper recognition in this district. For this the present study was conducted in Koch Bihar district to focus on farm women status in our society.

Location map of the study area





Methodology :

Sampling design (Selection of the area and the respondents): The random sampling technique was followed in case of selecting the area and the respondents of the present study. The district, the sub-divisions was selected systematically; the blocks from the chosen sub-division were selected with the help of simple random sampling. An exhaustive list of farm women within the selected blocks was prepared. From this total list, five hundred farm women were selected randomly as respondent for the present study.

Variables and their measurements: On the basis of the delineated objectives the involvement indices were considered as dependent variables and the different socio-personal, economic, other variables were considered as independent variables. The variables to be considered for this study were operationalised and measured in following way.

Status of the farm women: It refers to the position that farm women occupy in the family. The farm woman whose husband has migrated or widow women has to act as family head. In nucleus family farm woman act as a family co-head. If the farm woman occupy the status of daughter or daughter in low is dominated by the elder members of the family. Thus farm women are classified into four categories and accordingly the score was given as under Daughter, 1; Daughter-in-low, 2; Family-co-head, 3; Family Head, 4.

Age: Age is the one's orientation towards development and growth. Individual behaves according to her orientation and her orientation gives to determine his/her character. The chronological ages developed through experiences and introspection, excise influence in orienting the participation process. As a result the present study was consider the age of women as a predictor variable and measured by directly registering the chronological age of the responded women.

Religion & Caste: Caste is an aggregate of individual whose share of obligations and privileges are fixed by birth, as well as sanctioned and supported by religion which comprises of Hindu, Muslim, Christian, Others. This variable was divided into four distinguished

caste prevailing in the present social system namely Scheduled Tribe, Scheduled Caste, Other Backward Caste, General caste. The variable was measured with the help of slightly modified scale devised by Bhairamkar scale on caste (2010). The score would be assigned as Scheduled Tribe, 1; Scheduled Caste, 2; Other Backward Caste, 3; General, 4.

Education: According to the International Encyclopedia of the Social Science, education is an institutionalized form of socialization to adult roles. Education helps an individual to know and give shape and direction to the thinking processes. The variable education was operationalised as the formal education successfully completed by the respondents and it would be measured with the help of slightly modified scale derived by Supe (2007). The score was assigned as Illiterate, 0; Can read only, 1; Can read & write, 2; Primary, 3; Middle school, 4; High school, 5; Graduate, 6; Above, 7.

Family education status: It refers to the education status of all the members of the family in the eligible age group for formal education i. e. excluding the children below six years of the age. This variable was measured with the help of procedure followed by Bhairamkar (2010). The total score was obtained by adding the respective standard completed by each member and the Family Education Status score was obtained by dividing the total score with eligible number of family members. Family Education Status would be calculated with the help of following formula;

$$\text{Family Education Status} = \frac{E_1 + E_2 + \text{————} E_N}{N}$$

Family occupation: Occupation is considered as one of the factors which influence the decision making by farm women. Accordingly five prominent professions like wage earning, agriculture, allied fields, business, service were considered and scored as under Wage Earning (working on others farm), 1; Agriculture, 2; Allied fields, 3; Business, 4; Service, 5.

Family annual income: Annual income can give inputs in case of developing the attitude towards participation in any activities. The annual income was operationalised and measured as the earnings of the family from primary and secondary sources of income per year in rupees. This variable was measured by assigning the score as Below Poverty Level or BPL (family annual income below 18-20 thousand), 1; Above Poverty Level or APL (family annual income above 18-20 thousand), 2.

Family annual expenditure: It shows the attitude of the respondent's family towards the consciousness on health, education, savings etc.

Land holding: Land holding is the representation of economic status within a rural system. The land holding wasoperationalised and measured as total land caused by respondent family in hectares. It was measured by assigning the score as No Land, 0; Marginal (below 1 hec.), 1; Small (1 hec. & above but < 2 hec.), 2; Semi-medium (2 hec. & above but < 4 hec.), 3; Medium (4 hec. & above but < 10 hec.), 4; Large (10 hec. & above), 5.

Land utilization pattern: It shows the use of land of the respondent's family. It was measured by assigning the score as House, 1; Cultivated land, 2; Pond, 3; Pasture land, 4; Orchards, 5; Others, 6.

Farm power: The possession of farm power indicates the efficiency of an individual in case of managing the agriculture and livestock enterprise. It wasoperationalised by the number of drought animal and improve tillage implements. It was measured by assigning the score as, No drought animal, 0; One pair of drought animal, 1; Two pair of drought animal, 2; Three pair of drought animal, 3; Power tiller, 4; Tractor,5.

Irrigation: Irrigation is one of the important aspects of cultivation practices like selection of crops, selection of variety, time of sowing of the crops etc. This variable was measured by assigning the score as No irrigation, 0; Tank, 1; Shallow tube well, 2; River lift pump, 3; Deep tube well, 4.

Possession of assets: The information related topossession of assets of the respondent's family would be obtained and was considered for scoring. The variable would be measured with the scale as Cart, 1; Bicycle, 2; Radio, 3; Improved plough, 4; Sprayer

(heavy weight/light weight), 5; Paddle thresher, 6; Seed drill, 7; Television, 8; Telephone/Mobile, 9; Refrigerator, 10; Motor cycle, 11;

Livestock Possession: The information parting to the growing population available to the respondents would be obtained and their type was considered for scoring livestock possession. This variable was measured with the scale developed by Hadole (2005), as follows; Piggery, 1; Cow (local/cross bred), 2; Goat/Sheep, 3; Fishery, 4; Buffalo, 5; Poultry, 6.

House type: The type of house owned by the respondents was taken into consideration for operationalising the variable house type as it some impact on the participation process. It was measured by the Supe's scale (2007) by assigning the scare as No house, 0; Hut, 1; Kutcha, 2; Mixed, 3; Pucca, 4; Mansion, 6.

Utilization pattern of communication sources: It wasoperationalised as the frequency of respondent's exposure to the extension personal of lime dependents, information, muss media and cosmopolite source of during last one year with a view to seek guidance on the issues related to agriculture, livestock and poultry. The variable was measured with the help of the slightly modified scale of Haidikar (1998). The variable was measured by assigning the score to the frequency of exposure as most often, 4; often, 3; sometimes, 2; rarely, 1; never, 0 and the identified communication sources are Pranibandhu, V. S. & B. L. D. O., Private Organisation, Animal scientists, NGOs.

a.Communication with extension worker/ organisation: The scores composed based on the frequency of communication with extension worker or any other organisation and scale prepared having score of '0' to '4'. The corresponding responses are 'never'; 'rarely'; 'sometime'; 'often' and 'most often' and also having score of '0' to '4' for the corresponding responses of 'never'; occasionally'; 'regularly'; 'supervision' and 'doing'.

b.Use mass media: The scores composed based on the extent of use of mass media channels and scale prepared having score of '0' to '4'. The corresponding responses are 'never'; 'rarely'; 'sometime'; 'often' and 'most often'.

c.Mobility: As per the review of available literature mobility/outside contact also be regarded as important socio-economic character regarding decision-making. The responses regarding the visit of the respondent of the nearest town, district town and cities are coded against a 5-point scale, which is composed of five responses like 'never'; 'rarely'; 'sometime'; 'often' and 'most often' with corresponding scores of '0','1','2','3' and '4' respectively.

Risk preference: It is the degree to which a farmer is oriented towards risk and uncertainty and has courage to face the problems in farming. This variable was measured with the help of scale developed by Supe (2007). This scale consisted of six items, in which first four statements are positive and two statements are negative.

Scientific orientation: It is the degree to which a farmer is oriented to the use of scientific methods in decision making and farming. This variable was measured with the help of scale developed by Supe (2007). This scale consisted of six items, in which first five statements are positive and statement no. six is negative.

Economic motivation: It is defined as the occupational success in terms of profit maximization and the relative value placed by a farmer on economic ends. This variable was measured with the help of scale developed by Supe (2007). This scale consisted of six items, in which first five statements are positive and statement no. six is negative.

Independence scale: It is the degree to which a farmer places positive value independence or autonomy in decision-making. This variable was measured with the help of scale developed by Supe (2007). This scale consisted of six items, in which first five statements are positive and statement no. six is negative.

Attitude towards agriculture: It was measured by scale developed by Mathew and Reddy

(1989). This scale consists 12 statements and response would be rated on five point continuum ranging from strongly agree to strongly disagree.

The responses were recorded on five point continuum ranging from strongly agree to strongly disagree for risk preference, scientific orientation, economic motivation, independence scale and attitude towards agriculture. The scoring procedure used is as follows;

for strongly disagree response and vice-versa in case of negative statements. The score for each individual on the management orientation scale was obtained by Summation of the score awarded for each one of the items included.

Agricultural knowledge & awareness test: Knowledge is the pursuit of wisdom and information application. The knowledge of the selected enterprise wasoperationalised twenty five dichotomous (yes/no)

SL. NO.	PARTICULARS	RESPONSE				
		SA	A	UD	DA	SDA
1.	SCORE FOR POSITIVE STATEMENT	5	4	3	2	1
2.	SCORE FOR NEGATIVE STATEMENT	1	2	3	4	5

SA= Strongly Agree; A=Agree; UD=Undecided; DA=Disagree; SDA=Strongly Disagree

Attitude towards animal rearing & poultry: It was measured by slightly modified scale developed by Rajkamal&Kunzru (1993). This scale consists 10 statements and response was rated on three point continuum ranging from agree to disagree. The scoring procedure used is as follows;

type statements which refers the knowledge of the respondents on agriculture, livestock and poultry enterprise. The knowledge score was obtained with the help of the total positive answers of the statements. The score would be assigned to the response as yes, 1 and no, 0.

SL. NO.	PARTICULARS	RESPONSE		
		A	UD	DA
1.	SCORE FOR POSITIVE STATEMENT	3	2	1
2.	SCORE FOR NEGATIVE STATEMENT	1	2	3

A=Agree; UD=Undecided; DA=Disagree

Management orientation: It is operationally defined as the degree to which a farmer is oriented towards scientific farm management comprising planning, production and marketing function of the farm. This variable was measured with the help of scale developed by Samanta (1977). The scale consisted eighteen statements, six statements each for planning, production and marketing orientation. In each group positive and negative statements would be mixed, retaining at the same time a more or less same order of statements. Each item would be provided with four point response continuum. The positive statements was given a score of four for strongly agree, three for agree, two for disagree and one

Activity-Involvement Index (AII): Activity-Involvement Index is the physical involvement in the agriculture, livestock and poultry rearing activities. The women bear the responsibility of performing of every activity of agriculture, livestock and poultry rearing activities. The variable was operationalised as the performance of activities on the bases of their physical involvement. It was measured with the help of three point scale on the basis of extent of physical involvement and the extent was categorized and score as no involvement, 0; joint involvement, 1; independent involvement, 2. It was measured by slightly modified scale developed by Pareek-Trivedy (1964). The Activity-Involvement Index was calculated as;

$$AII = \frac{O_{Aj}}{\sum M_{Aj}} \times 100$$

where, O_{Aj}= obtained activity score (weighted) in j^{th} enterprise /crop/area

M_{Aj}= maximum activity score (weighted) achievable in j^{th} enterprise/crop/area

Result and Discussion:

Actual socio-economic conditions of women farmers of Koch Bihar district are stated below in a broad manner. It explored the areas of relational analysis between the involvement of different socio-personal, socio-economic and communication related attributes of women in agriculture and allied sectors within the district of Koch Bihar.

The majority of the respondents are enjoying the status of family head (65.8%) followed by status of family co-head (31.4%) and daughter-in-law (2.4%). The status of womenin the family always controls the involvement pattern in any activities associated in farm and home.

The farm women in KochBihar district of West Bengal are classified into three groups according to their age. The results show that majority of the respondents is under the age group of 18-39 years (69.60%) followed by 40-61 years age group (28.60%) and 62-83 years age group (1.80%) respectively. The data indicate that the young aged women are much prone to decision making as well as actively participate for conducting the agricultural and allied activities.

In the present research setting 2 types of religionsare dominating. The majority of the women respondents are under Hindu (80%) and Muslims are the minority (20%). In the study area there is a mix of Hindu and Muslim religion in case of delimiting their differential participation in agriculture and allied sectors.

The study shows that majority of the respondents is Scheduled caste (57%) followed by General caste (37%). According to the study the scheduled caste and general caste women are getting the information and utilizingthat information in case of delimiting their involvement status with caste.

Educationis an important indicator for a society. The study show that majority of the respondents is under middle school educated group (30%) followed by can read and write educated group (20.6%), primary school educated group (17.6%) and high school educated group (15.8%) respectively. Middle school educated women are much more responsive for involving themselves in any activity.

The field study presents the distribution of the respondents of Koch Bihar districts of West Bengal according to their family education status. The results show that majority of the respondents' family education status are under the medium group of 2.3-4.5 (75.8%) followed by low education status group of 0-2.2 (61%) and high education status group 4.6-6.8 (60%) respectively. Family education status is also medium means the respondents and their family members are not so much highly educated consequently they involve in agriculture and allied activities.

The study showsthat majority of the respondents is under joint family types group (60.2%) followed by nuclear family type group (39.8%) respectively. Though nuclear family is much more prominent in the present context but in present study the joint families women are contribute much more in making the entire sample.

The study shows that majority of the respondents' primary occupation is agriculture & allied (74.4%) followed by agriculture (20.2%) and wage earning group (3.2%) respectively. It is clearly showed that in the present study area most of the women are associated with agricultural and allied field activities and their primary vocation is agriculture and allied. They are mostly dependent on agriculture to maintain their livelihood.

The study shows that majority of the respondents are under low annual income group of 6000/- to 86000/- (88%) followed by medium annual income group 86000/- to 166000/- (11.6%). The women of the study area are mostly pro-poor in nature. Most of the women are doing well with their

TABLE 1. Distribution of the respondents according to the selected variables(N=500)

Category	Score	Frequency	Percentage
Status of farm women (X_1), N=500			
Daughter	1	2	0.4
Daughter in law	2	12	2.4
Family co-head	3	157	31.4
Family Head	4	329	65.8
Age Group (X_2), N=500			
1st aged group	18-39	348	69.60
2ndaged group	40-61	143	28.60
3rdaged group	62-83	9	1.80
Religion (X_3), N=500			
Hindu	1	400	80
Muslim	2	100	20
Caste (X_4), N=500			
Scheduled tribe	1	11	2.2
Scheduled caste	2	285	57
Other backward caste	3	19	3.8
General	4	185	37
Education (X_5), N=500			
Illiterate	0	3	0.6
Can write only	1	76	15.2
Can read and write	2	103	20.6
Primary	3	88	17.6
Middle school	4	150	30
High school	5	79	15.8
Graduate	6	1	0.2
Family education status (X_6), N=500			
Low	0-2.2	61	12.2
Medium	2.3-4.5	379	75.8
High	4.6-6.8	60	12
Family type (X_7), N=500			
Nuclear	1	199	39.8
Joint	2	301	60.2
Occupation (X_8), N=500			

Wage earning (working on others farm)	1	16	3.2
Agriculture	2	101	20.2
Allied fields	3	5	1
Allied fields with wage earning	4	1	0.2
Agriculture and allied fields	5	372	74.4
Agriculture with business	6	2	0.4
Allied fields with business	7	1	0.2
Agriculture, Allied fields with business	9	2	0.4
Annual income (X_9), N=500			
Low	6000-86000	440	88
Medium	86000-166000	58	11.6
High	166000-246000	2	0.4
Expenditure (X_{10}), N=500			
Low	6000-36000	221	44.2
Medium	37000-67000	274	54.8
High	68000-98000	5	1
Land holding of the family (X_{11}), N=500			
Small	1 hec. & above but < 2 hec.	401	80.2
Semi-medium	2 hec. & above but < 4 hec	93	18.6
Medium	4 hec. & above but < 10 hec.	6	1.2
Farm power (X_{12}), N=500			
No farm power	0	12	2.4
Indigenous farm implement	1	88	17.6
One pair of drought animal	2	287	57.4
Power tiller	3	91	18.2
Tractor	4	22	4.4
Source of irrigation (X_{13}), N=500			
No irrigation	0	4	0.8
Tank	1	2	0.4
Shallow tube well	2	483	96.6
River lift pump	3	11	2.2
Deep tube well	4	0	0
Possession of assets (X_{14}), N=500			
Low	0-13	180	36
Medium	14-27	283	56.6
High	28-41	37	7.4
Livestock possession (X_{15}), N=500			

Low	0-3	213	42.6
Medium	4-7	180	36
High	8-11	107	21.4
House type (X_{16}), N=500			
No house	0	0	0
Hut	1	0	0
Kutcha	2	272	54.4
Mixed	3	216	43.2
Pucca	4	12	2.4
Mansion	5	0	0
Utilization pattern of communication sources (X_{17}), N=500			
Low	1-7	78	15.6
Medium	8-15	414	82.8
High	16-23	8	1.6

Source: Field survey, 2017-18

agricultural vocation and their economic condition is not so high and they are willing to apply agricultural innovation for augmenting their annual income.

The study shows that majority of the respondents are under medium annual expenditure group of 37000/- to 67000/- (54.8%) followed by low expenditure income group 6000/- to 36000/- (44.2%).Though their annual income is not so high but still they incurred a medium amount of money for maintaining their livelihood status. Consequently the gap between their income and expenditure is too large.

The present study presents the distribution of the farm women according to their land holding per family of the study area. The results show that majority of the respondents are under the Semi-medium land holding group 60.6% followed by medium land holding 27.2% and small land holding group 9% respectively. Due to the land fragmentation and land reformation of the study area the possession of the land of the family of the women respondents is very low. So it will reflect of the economic condition as well as her family.

In the present research setting 3 types of farm power are dominating. The majority of the women respondents have one pair of drought animal (57.4%) followed by power tiller (18.2%) and indigenous farm implement (17.6%). Farm power is also an indicator of the economic condition and application of new agricultural technology. It is clear that drought animals is very common in women respondents household for conducting agriculture but power tiller, tractor and other indigenous farm implements are not so much common in the study area but still these implements are available.

In the present research setting the majority of the women respondents have shallow tube well irrigation facilities (96.6%) followed by river lift pump (2.2%). Among the various sources of irrigation the shallow tube well is very common in the study area. The women farmers are mostly depending upon shallow tube well in case of irrigating their own land as the rent for irrigation water is not very high and within the reach of the pro-poor women farmers.

Most of the respondents are under the medium material possession group, 14-27 (56.6%) followed by low material possession group 0-13 (36%) and high material possession group, 28-41 (7.4%) respectively. As the respondents are not very rich in their economic condition, the women respondents are showing very clear penchant towards a medium to low assets possession.

The study shows that majority of the respondents are under low livestock Possession group, 0-3 (42.6%) followed by medium livestock Possession group 4-7 (36%) and high livestock Possession group, 8-11 (21.4%) respectively. Almost every family posses very minimum level of animals in their homestead area. Most of the respondents are not following the scientific practices of rearing of animals. High value livestock are not very common in the study area as the women are very resource poor in nature and they are following subsistence livelihood status.

The respondents mostly have Kutcha house (54.4%) followed by mixed type of house (43.2%) and pucca house (2.4%) respectively. As the kutcha house is predominant in the study area which reflects the scarcity of resources among the women respondents of the study area. Pucca houses are very uncommon in the area as the farm women are dependent on agriculture.

Majority of the respondents are under the medium pattern of communication sources, 8-15 (82.8%) followed by low pattern of communication sources group 1-7 (15.6%) and high pattern of

TABLE 2. Distribution of the respondents according to the selected variables(N=500)

Variables	Category	Score	Frequency	Percentage
Risk preference (X_{18})	Low	6-12	94	18.8
Medium	13-19	266	53.2	
	High	20-26	140	28
Scientific	Low	10-16	134	26.8
orientation (X_{19})	Medium	17-23	354	70.8
	High	24-30	12	2.4
Economic	Low	12-17	8	1.6
motivation(X_{20})	Medium	18-23	438	87.6
	High	24-29	54	10.8
Independence	Low	14-17	236	47.2
Scale (X_{21})	Medium	18-22	235	47
	High	23-27	29	5.8
Attitude towards	Low	31-37	129	25.8
agriculture (X_{22})	Medium	38-44	360	72
	High	45-51	11	2.2
Attitude towards	Low	18-22	24	4.8
animal rearing and	Medium	23-27	459	91.8
poultry (X_{23})	High	28-31	17	3.4
Management	Low	41-50	122	24.4
orientation (X_{24})	Medium	51-60	356	89
	High	61-70	22	4.4
Agricultural knowledge	Low	8-14	136	27.2
and awareness (X_{25})	Medium	15-21	362	72.4
	High	22-28	2	0.4

Source: Field survey, 2017-18

communication sources group, 16-23 (8%) respectively. Information sources are very much important for getting new information related to the agriculture and allied sectors. Women respondents are still in the rural areas and are lacking in case of accessing the information from various communication sources. They know about the different communication sources but they don't know how to utilize this information in their own situation.

Table no. presents the distribution of respondents according to their risk preference, economic motivation, independence, attitude towards agriculture, attitude towards animal rearing and poultry, management orientation and agricultural knowledge and awareness.

The majority of the respondents are under the medium risk preferred group of 13-19 (53.2%) followed by high risk preferred group of 20-26 (28%) and low risk preferred group of 6-12 (18.8%) respectively. Taking risk is the mother of invention and profit maximization for administering any innovation in agriculture. Practices in local situation requires high amount of risk preference among the users. In the study area the women prefer to take risk in medium level in case of pursuing any agricultural activities.

The results show that majority of the respondents are under the medium scientific oriented group of 17-23 (70.8%) followed by low scientific oriented group of 10-66 (26.8%) and high scientific oriented group of 24-30 (2.4%) respectively. The data clearly indicate that the scientific orientation of the women respondents is medium to low level and the women folk of the family do not practices the new agricultural techniques due to lack of scientific orientation.

Most of the respondents are under the medium economic motivated group of 18-23 (87.6%) followed by high economic motivated group of 24-29 (10.8%) and low economic motivated group of 12-17 (1.6%) respectively. Motivation is drive to achieve something. Women are very much accounted with household activities but still they are resource poor in nature. Consequently motivation level is medium for getting much more economic profit from their enterprises.

The results show that majority of the respondents are under the low independent group of 14-17 (47.2%) followed by medium independent group of 18-22 (47%) and high independent group of 23-27 (5.8%) respectively. In the male dominated society the women members of the family are mostly dependent on the male counterpart. Hardly they are taking independent decision in case of involving themselves as a results, their independent score is low to medium.

The majority of the respondents are under the medium attitude towards agriculture group of 38-44 (72%) followed by low attitude towards agriculture group of 31-37 (25.8%) and high attitude towards agriculture of 45-51 (2.2%) respectively. The women are mostly conducting the household activities and very rarely associated with outside activities like agriculture that signifies in medium level of attitude towards agriculture.

Most of the respondents are under the medium attitude towards animal rearing and poultry group of 23-27 (91.8%) followed by low attitude towards animal rearing and poultry group of 18-22 (4.8%) and high attitude towards animal rearing and poultry of 28-31 (3.4%) respectively. Women are mostly conducting the household activities and very rarely associated with outside activities like animal rearing and poultry that signifies to medium level of attitude towards agriculture animal rearing and poultry.

The results show that majority of the respondents are under medium management orientation group of 51-60 (89%), followed by the low management orientation group 41-50 (24.4%) and high management orientation group 61-70 (4.4%). The management orientation is medium to low as women are not always directly managing the agricultural enterprises outside.

Most of the respondents are under medium agricultural knowledge and awareness group of 15-21 (72.4%), followed by the low agricultural knowledge and awareness group 8-14 (27.2%) and high management agricultural knowledge and awareness 22-

28 (4.4%). The medium to low level of awareness and knowledge regarding agricultural practices indicates the lower degree of participation in agricultural activities.

Involvement Index:

It is the ratio between weighted sum of obtained score and weighted sum of maximum score obtainable in any field/enterprise/crop, multiplied by 100. The present study is directly deals with women's involvements in every dimension of agriculture and allied sectors. The different indicators were developed to explore the efficacy of women in terms of their Activity involvement in agriculture and allied sectors. The involvement of farm women in agriculture and allied sectors was categories into two sections namely Activity involvement, involvement in decision making with the help of correlation co-efficient analysis.

Above table depicts the correlation coefficient of activity involvement index with twenty five casual variables. The result of the correlation analysis reveals that the variables status in the family, annual expenditure of the family, source of irrigation, livestock possession and attitudes towards agriculture are significantly and positively associated with the activity involvement index of women in agriculture and allied activities. The variables land holding status and scientific orientation are significantly and negatively associated with the activity involvement index of women in agriculture and allied activities.

TABLE 3. Correlation co-efficient of AII (Y2) with twenty five causal variables

Variables (X)	Coefficient of correlation (r)
Status in the family (x_1)	0.124**
Age (x_2)	-0.087
Religion (x_3)	0.006
Caste (x4)	0.038
Education (X_5)	-0.001
Family education status (X_6)	0.010
Type of family (x_7)	-0.060
Occupation (X_8)	-0.022
Annual income (x_9)	0.068
Annual expenditure (x_{10})	0.096*
Land holding in bigha(x_{11})	-0.096*
Farm power (X_{12})	-0.066
Source of irrigation (X_{13})	0.116**
Possession of assets (X_{14})	-0.045
Livestock possession (X_{15})	0.130**
House type (x_{16})	0.060
Communication sources (X_{17})	0.050
Risk preference (x_{18})	-0.020
Scientific orientation (x_{19})	-0.131**
Economic motivation (x_{20})	-0.075
Independence scale (x_{21})	0.058
Attitude towards agriculture (x_{22})	0.144**
Attitude towards animal rearing & poultry (x_{23})	0.123**
Management orientation (x_{24})	-0.004
Agricultural knowledge & awareness(x_{25})	0.052

**significant at 1% level

*significant at 5% level

Status of women in the family and Activity Involvement Index of women in agriculture and allied sector:

The status of women in the family is considered in the present study in four categories namely family head with height score, family co head, daughter-in-law and daughter in lowest score. In rural areas the family head by women means that women family head has the liberty to take independent decision and that decision can be implemented with the other family members in case of agricultural practices. The women family head is also playing a discriminatory role to involve the family members in favour of her decision and other women who are in others status within the family are only getting the little opportunity to directly involve themselves in outside activities like agriculture and allied sectors. Due to this particular cause the women family head involve in actively in case of increasing the productivity in agriculture and allied sectors. That is why the variable status in the family of women is positively and significantly associated with activity involvement index of women in agriculture and allied activities.

Family annual expenditure and Activity Involvement Index of women in agriculture and allied sector:

The annual expenditure of the family indicates the purchasing power of that family in a particular year. The primary vocation of the family from where the data were collected is agriculture and the livelihood of that family depends on agriculture and allied activities. The expenditure increases with the increase of income. The families with high annual expenditure motivate to actively involve within the agriculture and allied activities. So that the profit increases from the agricultural enterprises and women can maintain the high level on expenditure throughout the year. For this reason family annual expenditureis positive and significant association of the variable annual expenditure with activity involvement index of women in agriculture and allied activities.

Sources of irrigation and Activity Involvement Index of women in agriculture and allied sector:

Sources of irrigation is also a determine factor in case of judging the activity involvement index of women in agriculture and allied activities. The availability and accessibility of water for irrigation are always contributing towards the productivity enhancement and income generation from agriculture and allied sectors. The easily available and ready accessible irrigation for field crop always motivate and create an environment to involve physically for productivity and income enhancement. In the study area the sources of irrigation is mostly shallow tube well and this is the easy way to irrigate the farm within the very short period of time and this type of irrigation structure also help in case of attaching the women in case of agriculture and allied practices. That is why the variable sources of irrigation is positively and significantly associated with activity involvement index of women in agriculture and allied activities.

Livestock possession and Activity Involvement Index of women in agriculture and allied sector:

Livestock Possession is a very important indicator in case of delineating of activity involvement index of women in agriculture and allied activities. Livestock possession is measured by the number of livestock possess by the women in a family. It is very important to maintain that mostly the women in a family are providing their physical effort to nurture and care of livestock and ultimately gets the profit from this allied agricultural sector. So their activity involvement for livestock maintain by ultimately contributes the annual earning of the family. This earning leads to the more activity involvement in agriculture and allied sectors. This is the reason for positive and significant relationship of livestock possession with activity involvement index of women in agriculture and allied activities.

Attitudes towards agriculture and Activity Involvement Index of women in agriculture and allied sector:

Attitudes are the pre disposition of individuals' behaviour. The perception of individuals is expressed

with the help of their attitudes. The positive attitudes towards agriculture of women indicate the higher level of involvement (physically and mentally) in agriculture and allied sectors which ultimately lead to the greater prosperity and dignity in the society. That is the basic reason behind positive and significant relationship between Activity involvement index and attitudes towards agriculture of women in agriculture and allied activities.

Attitudes towards animal rearing & poultry and Activity Involvement Index of women in agriculture and allied sector:

It has been already shown that farm women have positive and significant relationship between Activity involvement index and attitudes towards agriculture. Agriculture and animal rearing are almost associate activities. Those who are engaged in agricultural activities mostly they are doing animal rearing also, because it helps to upgrade individual's economic status. That is why a positive and significant relationship found between activity involvement index and attitudes towards animal rearing and poultry.

Land holding and Activity Involvement Index of women in agriculture and allied sector:

Land holding is the indicator of prestige of a society. The women who holds good amount of land does not show any intension to do the work physically in the field and the always try to enjoy the status of land owner and employ several agricultural labourer for getting good profit. Consequently women with low land holding status works in the agricultural field as agricultural labour with a high level of physically labour. That is why the variable land holding significantly and negatively is associated with Activity involvement index of women in agriculture and allied activities.

Scientific orientation and Activity Involvement Index of women in agriculture and allied sector:

Scientific orientation is a psychological belongingness of individual with the analytical raising of a phenomenon and object. The individual of high level of scientific orientation always searches the rationale behind any activity. If he or she finds the reason behind conducting an activity then only he or she goes alone with this activity in future. The people with high level of scientific orientation is only tries to take decisions and involves themselves in any activity mentally which preferably lacks the actively involvement in any activity in case of agriculture and allied activities. The women with high level of scientific orientation always take parts in decision making and give instructions to others for physically conducting the agriculture and allied activities. That is why variable scientific orientation significantly and negatively co-related with Activity involvement index of women in agriculture and allied activities.

Gender gap in the wages of agricultural labourers:

There is a wage inequality among the male and female agricultural labourers in the study area. Female main workers are replacing male main workers in the rural sectors because of out migration of male family members in this district. The condition of female agricultural labourers is even worse. They not only face low wages but also they face discrimination. Though west Bengal govt. fixed equal wages for both male and female agricultural labourers (210 .00/- per day without food) but in practical situation on one can follow this. Mostly women agricultural labourers get 130/- to 170/- and male agricultural labourers get 170/- to 190/- per day without food (source:field survey,2018). Wages are likely to be high in peak seasons in the rice growing for both male and female agricultural labourers. Most of the people including female agricultural labourersbelieved that male agricultural labourers are superiors than female agricultural labourers in terms of various agricultural activities like preparatory tillage, forming ridges and furrows, ploughing, land preparation, manure and fertilizer application, irrigation, plant protection measures etc. so that they thought it is quite natural to get low wages than male agricultural labourers.

Constrains identified in the life of women in agriculture:

Traditional role: Women are traditionally home makers and care givers. Apart from household

management, child care and social responsibilities, rural women unpaid workers on the farm either as labourers or helping their men folk in rising, harvesting and storing crops leaving little time for effective participation in local organization. Their views or their decision making power also neglected in their family.

Lack of or inadequate education: Inadequate education is a key contributing factor to gender bias in accessing resources. Women's education is vital for their empowerment, to develop basic skills needed to participate in knowledge intense agriculture and economic activities. Information and communication technology (ITC) has great to inform and educate rural women about agriculture, health and nutrition provided they are user friendly, have gender responsive content and applications. However, there are barriers to increased use of ITCs such as inadequate infrastructure, high cost, limited capacity and content relevancy.

Modernization in agriculture and technological development: Technological developments have not been responsive to household drudgery associated with routine activities of rural women at home and on farm. In most technologies women's actual needs are ignored. Modernization in agriculture have led to increased agricultural productivity and decreased drudgery but have adversely affected the women from lower castes, lower income groups and landless families or with small holding by reducing demand for labour. Introduction of weedicides and pesticides has deprived a large number of women labourers of their meager source of income.

Limitations of agricultural extension system: The agricultural extension system conceived and operating to train and capacity building of farmers is almost exclusively composed of men and the attempts to reach out to women farmers is highly inadequate. Further, most of the transfer of technology is conceived with male farmers as the target. The time and location of training hardly takes into consideration the time and work pattern of farm women.

Occupational health hazards of farm women: General implication of pesticides have very adverse effects on women health like leukemia, lymphoma, aplastc anemia, soft tissue sarcoma and cancers of various kinds, a variety of reproductive health problems of women. Very low levels of pesticides have been found to induce DNA damage, mental retardation and delayed milestones in children born to mothers exposed to pesticides. Pesticide risk is higher to people suffering from asthma, diabetes and cardiovascular diseases.

To analyze the relationship between the socio economic status of farm women and involvement of the farm women in agriculture and allied activities

Summary and conclusion:

Socio-economic status has the largest impact on women and it has wider detrimental impact on development. Within the household, women have less entitlement to household goods are poorer command over a range of other productive resources including education, land, information and financial resources and the labour to help them to undertake economically gainful activities. Women play a crucial role in all societies. However, socio-economic status of the farm women in the study area is very much associated with their involvement in agricultural activities such as their status in their family, risk preference, management orientation etc. Rural women contribute much towards agricultural activities on farm and in post harvest storages, much more than men. Still they are never conscious of gender discrimination. They do not complain against bias. Women agricultural labourers slog much more in the field and get paid less for the strenuous jobs they discharge. They actually balance the triple burden of field work, home and social prejudice. But there are no complaints, no protests. Instead they manage a well adjusted life of domestic and on farm responsibility. It is a philosophical acceptance that life is a responsibility, home and contributing to family income together. Indian agriculture no doubt is sustained on the backs of rural women who have been poorly rewarded in terms of income, access to resources and socio economic status. It is important now to recognize this and provide equal wages to the female labour and resources such as land, assets and suitable share in the agricultural

income to the unpaid women workers in the family farms. Rural women need to be educated as to utilize the modern agricultural training and techniques. They need to be recognized as farmers and given their due share.

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Biomass Production and Partitioning at Various Phenophases of Elephant Foot Yam as Influenced by Fertility Levels

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Abstract

Elephant foot yam is a high value cash crop in the eastern part of India and has high energy production per unit area. It has become popular due to its high productivity and net returns. The difference in biomass production and partitioning at various phenophases of elephant foot yam under varied fertility levels was evaluated under the study. The biomass accumulation of pseudostem increased with advancement of age and maximum biomass production was recorded in T_7 (66.86 g) followed by T_8 (65.45 g) and minimum in T_1 (30.26 g) at harvest (8 MAP). The biomass accumulation of corm at harvest was ranged from 177.5 g in T_1 to an extent of 428.48 g in T_7 at harvest (8 MAP). The corm yield was highest in T_7 (37.6 t ha^{-1}) followed by T_8 (36.1 t ha^{-1}), T_6 (35.4 t ha^{-1}) and the lowest was in T_1 (18.3 t ha^{-1}).

Keywords **:** Elephant foot yam, biomass production and partitioning, phenophases and yield.

Introduction

With ever-increasing population pressure and fast depletion of natural resources, it has become extremely important to diversify the present-day agriculture in order to meet various human needs (Janardhanan *et al.,* 2003). Supply of essential nutrients for human health by crop production and measures for the improvement of nutritional quality of crop plants have spurred great interest in recent years. One of the most important roles of agricultural crop production is to provide almost all essential mineral and nutrients to humans through biofortification. Basic substances that humans require include carbohydrates, lipids and proteins (amino acids), as well as 17 mineral elements and 13 vitamins. Tropical tuber crops are the third most important food crops to the human being after cereals and grain legumes. The underground storage organ (tuber) confers unique dimension to the productivity of plants. Elephant foot yam is having high potential energy production per unit land area (Chattopadhyay et al., 2006). It has a higher biological efficiency as a food producer and shows the highest rate of biomass production per day per unit area. It has become popular due to high productivity in a short growing season and high returns. A differential flow of photo assimilates result in patterns of biomass distribution among the plant organs. The distribution of biomass among plant organs is one of the key variables which affect the yield of the crop. Greater care and crop maintenance is required to achieve the potential productivity of elephant foot yam which is very high about 50 t ha^{-1}. Nutrient management imparts the greater effects on the balance of competition between crops and increases the overall production potential (Ravindran *et al*., 2001). The information to the effect of varied fertility status under rain fed alfisols is very scanty. Elephant foot yam removes huge quantity of macro and micro nutrients due to high yield. It also responds well to application of manures and fertilizers. However, the response varies with the

continuous availability of soil moisture. Under irrigated conditions, elephant foot yam responds more for applied manures and fertilizers than rain fed situation. Further, the climatic conditions of the region also influence the crop growth and yield. Eastern region of India, particularly Odisha is having hot wet season and cool dry season which determines elephant foot yam crop duration. In tropical conditions, elephant foot yam plant growth continues throughout the year. But in Eastern region of India, particularly Odisha elephant foot yam plant senescence starts November onwards irrespective of irrigation and fertilizer application. The manures and fertilizer schedule recommended for elsewhere will not be suitable for Eastern region of India, particularly Odisha under alfisols. The objective of this report is to summarize information on the effects of fertilizer on dry matter production and partitioning in different parts of the plant at various phenophases.

Materials and Methods

Experimental site

A field experiment was carried out for consecutive two years during May–December in 2011 and 2012 at Regional Centre of Central Tuber crops Research Institute (20°14'53.25'' N and 85°47'25.85'' E and 33m above mean sea level), Dumduma, Bhubaneswar, Odisha, India. Texturally the soil was sandy loam with neutral soil reaction (p^H 6.7). The soil type of experimental site was alfisols and falls under the family on Typic Rhodustalfs and characterised by low available N (91.5 kg ha^{-1}), low available P (14.9 kg ha^{-1}), moderate K (235.7 kg ha^{-1}) and organic carbon C (3.70 g kg^{-1}) content. The site experiences a typical humid tropical climate. The mean annual precipitation during the crop growing period was 1097.3 mm and the annual of means of daily temperature maximum and minimum were recorded 34.5°C and 21.2°C, respectively. The crop was irrigated as and when required.

Experimental design and treatments

The variety Gajendra which was a local selection from Kovvur area of Andhra Pradesh was used for studying biomass production and partitioning. The experiment was laid out in a randomized block design (RBD) with three replications. The experimental land measuring (36 m × 13.5 m) was ploughed and pulverized 2-3 times by tractor driven mould board plough followed by laddering to obtain fine tilth for proper corm bulking. The experimental plot was divided into 24 plots with eight plots per row replicated thrice in randomized fashion, each plot measuring 4.5 m × 4.5 m, accommodating 36 plants per plot. The experiment was comprised of eight treatments viz. T_1- Control, T_2 - 60-60-60 N-P_2O_5-K_2O kg ha^{-1}, T_3 - 80-60-80 N-P_2O_5-K_2O kg ha^{-1}, T_4 -100-60-100 N-P_2O_5-K_2O kg ha^{-1}, T_5 - FYM 10 t ha^{-1} +60-60-60 N-P_2O_5-K_2O kg ha^{-1}, T_6 – FYM@ 10 t ha^{-1} +80-60-80 N-P_2O_5-K_2O kg ha^{-1}, T_7 - FYM 10 t ha^{-1} + 100-60-100 N-P_2O_5-K_2O kg ha^{-1}, T_8 –FYM @ 25 t ha^{-1}.

Crop husbandry

The variety Gajendra was planted at the spacing of 75 cm × 75 cm. The fertilizers and manures were applied as per treatments. Single super phosphate was applied as basal dose during the final ploughing and 1/3rd of N and K were applied as basal dose where as rest of N and K were applied in two equal splits at one and two months after planting (after sprouting of tubers). The crop was planted during the month of May in each year, mainly rain-fed situation. The package of practices as standardized by Central Tuber Crops Research Institute (CTCRI), Thiruvanthapuram (ICAR) was followed (Mohankumar *et al.*, 1994).

Sampling and measurements

Biomass measurements were done at 2, 3, 4, 5, 6, 7 and 8 months after planting (MAP) by uprooting three plants at a random per plot at each months after planting. After uprooting the plants were separated into shoot and corm. The shoot and corm were chopped uniformly into small pieces seperately. The pieces were air dried and then oven dried at 72°C till constant weight was obtained. Finally the dry weight was recorded and expressed in percentage.

Corm bulking rate (g $plant^{-1}$) : Tuber formation rate was recorded during different phases of growth viz. 0-3, 3-5 and 5-8 MAP (at harvest) and expressed in g day^{-1} which was calculated as follows,

$$\text{CBR (g plant}^{-1}) = \frac{W_2 - W_1}{t_1 - t_2}$$

Where, W_2 and W_1 are the final and initial weight in gram (g) per plant at time t_1 and t_2 respectively.

Corm bulking efficiency (%): Based on the mean corm weight per plant the corm bulking efficiency expressed as percentage was worked out using the following equation.

$$\text{CBE (\%)} = \frac{C_O - C_S}{S_C} \times 100$$

Where, C_O and C_S are the corm weight at the time of observation and weight of seed corm (S_C) planted, respectively.

Statistical Analysis

The data were analyzed using descriptive statistics and Analysis of Variance (ANOVA). All the statistical analyses were performed using Gen Stat Discovery (edition 3; VSN International). The critical difference (CD) between treatment means were compared as suggested by Panse and Sukhatme (1976).

Results and Discussion

Biomass production and partitioning

It was observed from the Table 1 that the pseudostem (shoot) biomass accumulation was gradually increased with the advancement of age of the plant. However, the enhancement in biomass continued up to 7 MAP, there after decreased during 8 MAP (at harvest). This might be due to onset of leaf shrinkage and senescence of the crop accompanied with transport of lower photosynthates towards developing corm. The biomass accumulation of pseudostem (shoot) of elephant foot yam varied significantly due to various fertility levels. At 2 MAP, maximum biomass was recorded in treatment T_8 followed by T_7 and T_6. The treatment T_1 resulted in minimum biomass accumulation in pseudostem (shoot) and the rest of the treatments were significantly superior to T_1. At 3 and 4 MAP, similar trend was observed. At 5, 6, 7 and 8 MAP, T_7 resulted in higher biomass accumulation in pseudostem (shoot) followed by T_8 and the lowest was in T_1.

It is inferred from the Table 1 that the biomass accumulation in corm steadily increased with the advancement of age of the crop. At 5 MAP, the biomass accumulation was 4 times more in comparison to 3 MAP, later on showing a gradual decline on the biomass accumulation rate. The highest increment was in between 4 MAP and 5 MAP, where there was a substantive increase of 22.87% in corm dry weight. Higher biomass accumulation in taro corm with nitrogen and potash fertilization (Mandal et al., 1982). The increased biomass of tannia corm when fertilized with NPK fertilizers vis-a-vis unfertilized (Enyi, 1968). It is evident from the Table 1 that the biomass accumulation in corm of elephant foot yam cv.Gajendra was significantly influenced by varied fertility levels during the course of investigation. At 2 MAP, the treatment T_1 recorded minimum biomass accumulation of 15.33 g and a maximum of 35.88 g in T_7. At 3 MAP, the biomass accumulation in corm was highest in T_7 (55.0 g) and the lowest of 24.33 g was in T_1. At 4 MAP, the treatments T_7 and T_8 were found to be statistically at par and significantly superior to all other treatments. At 5, 6, 7 and 8 MAP, the treatment T_7 recorded maximum biomass accumulation in corm followed by T_8 and minimum in T_1. The treatments T_6 and T_5 were found statistically at par and significantly superior to T_4, T_3, T_2 and T_1.

Perusal of the data from Table 1 indicated that the total biomass accumulation in elephant foot yam cv. Gajendra varied significantly due to effect of fertility levels. After 2 MAP, maximum biomass was recorded in the treatment T_7 and was found statistically superior to all other treatments except treatment T_8. At 3 MAP, maximum biomass accumulation was recorded in the treatment T_7 followed by T_8 and minimum in the treatment T_1. At 4, 5, 6, 7 and 8 MAP, maximum biomass accumulation was recorded in T_7 followed by T_8 and minimum in T_1. Das et al., (1997) also reported similar effect of fertility levels on biomass accumulation in elephant foot yam.

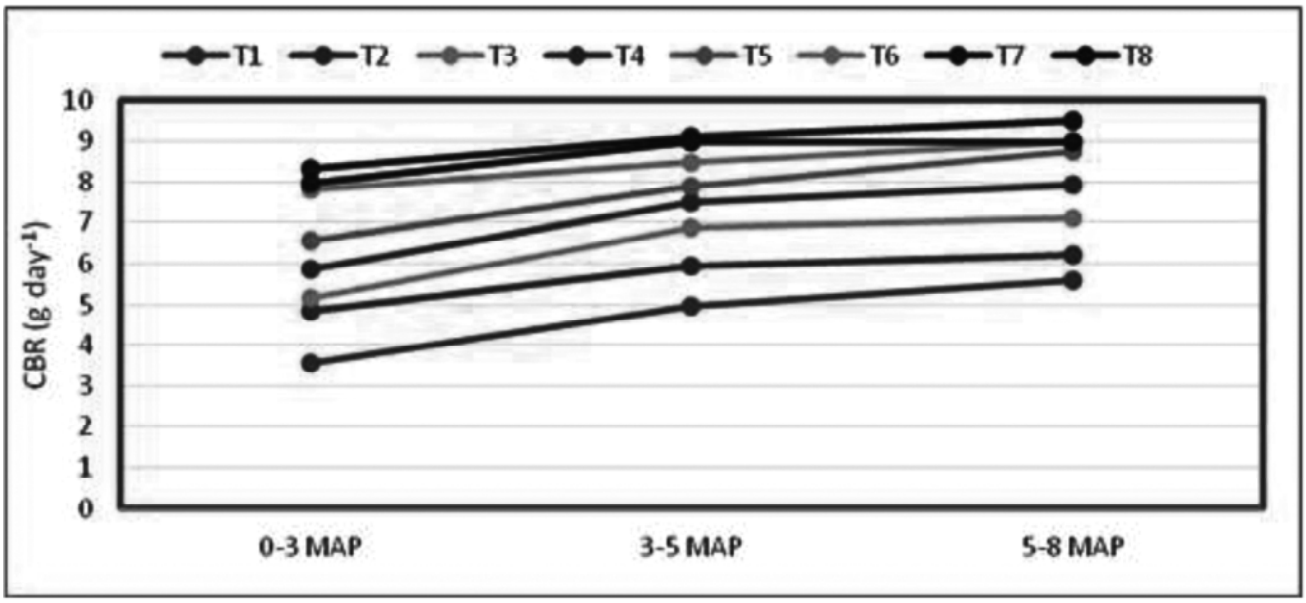

Fig. 1 Corm bulking rate (CBR) of elephant foot yam at various phenophases as influenced by fertility levels (Poled mean of 2 years)

Corm bulking rate (CBR)

The CBR was increased the advancement of the age of the crop (Fig.1). The maximum CBR was observed between 5 and 8 MAP, and minimum CBR was noticed between planting and 3 MAP in all the fertility level treatments. At all the phenophases, the lowest CBR was recorded in control (T_1) where as highest CBR was recorded in T_7. The CBR of T_8 was statistically comparable with T_7 between 3 and 5 as well as 5 and 8 MAP. Nedunchezhiyan et al. (2016) also reported similar findings in elephant foot yam.

Corm bulking efficiency (CBE)

The CBE was increased the increase of the age of the crop (Fig.2). The greater CBE was observed between 5 and 8 MAP whereas lower CBE was noticed between planting and 3 MAP in all the fertility level treatments. The CBE was also followed the similar trend of CBR. At all the phenophases, the lowest CBE was recorded in control (T_1) where as highest CBE was recorded in T_7. The CBE of T_8 was statistically at par with T_7 between 3 and 5 as well as 5 and 8 MAP.

Yield attributes and yield

Corm diameter (cm)

The effect of differential fertility levels on the yield and yield attributes on elephant foot yam study during 2011 and 2012 has been depicted in Table 2. It revealed that the treatment T_7 resulted in highest corm diameter followed by T_8, T_6 and T_5. These four treatments were statistically at par and superior to rest of the treatments. The four treatments viz. T_7, T_8, T_6 and T_5 were statistically at par with each other which might be due to conjoint application of organic manure with chemical fertilizer at its optimum level. Minimum corm diameter was observed in T_1 (control). Treatments T_2 did not differ significantly from the control. Saravaiya *et al.*, (2010) and Nedunchezhiyan (2017) also reported variation of yield attributes of elephant foot yam with respect to fertility levels.

Corm Yield (g plant^{-1})

The mean data presented in the Table 2 revealed that the treatment T_7 also exerted its significant influence on the corm yield per plant with highest corm yield followed by T_8, T_6, T_5 and T_4. As expected, elephant foot yam plant having no fertility supplements i.e. T_1 (control) produced the lowest corm yield per plant. The corm yield increased gradually with increase in fertility levels. The increase in yield was about 97.12 % (T_8) and 105.74% (T_7) over control (T_1). Higher yield in T_7 and T_8 may be ascribed to the substantially higher total biomass production in this variety which could provide better translocation of photosynthates

TABLE 1. Effect of fertility levels on biomass accumulation and partitioning (g plant^{-1}) in elephant foot yam (Poled mean of 2 years)

Treatments	2 MAP			3 MAP			4 MAP			5 MAP			6 MAP			7 MAP			8 MAP		
	Pseudostem	corm	Total	Pseudostem	corm	Total	Pseudostem	corm	Total	Pseudostem	corm	Total	Pseudostem	corm	Total	Pseudostem	corm	Total	Pseudostem	corm	Total
T_1	7.20	15.53	22.73	11.03	24.33	35.28	14.80	87.95	102.75	18.55	111.10	129.65	23.63	136.95	160.58	26.81	152.55	179.36	30.26	177.5	209.26
T_2	9.83	22.01	31.85	15.56	34.5	49.41	20.30	128.4	148.70	25.35	162.55	187.90	30.75	192.05	222.80	34.48	213.2	247.68	39.41	252.81	292.23
T_3	11.3	25.93	37.23	18.13	40.4	57.68	23.55	136.85	160.40	29.6	180.83	210.43	35.57	224.55	260.12	40.90	248.1	289.00	46.2	295.85	342.05
T_4	12.51	28.61	41.13	18.50	43.88	62.93	25.86	140.85	166.71	32.47	200.71	233.18	39.28	256.25	295.53	46.35	291.85	338.20	50.23	322.00	372.23
T_5	12.8	29.64	42.44	21.16	46.08	65.60	26.41	165.9	192.31	33.45	211.00	244.45	41.45	253.5	294.95	48.56	292.05	340.61	52.66	337.56	390.23
T_6	14.65	31.06	45.71	20.86	45.55	67.81	30.11	167.8	197.91	37.31	224.43	261.75	44.55	250.9	295.45	52.02	286.5	338.52	56.93	364.85	421.78
T_7	16.86	35.88	52.74	26.00	55.00	80.30	34.25	204.5	238.75	44.05	271.08	315.13	53.75	314.35	368.10	61.33	365.35	426.68	66.86	428.48	495.35
T_8	17.22	35.10	52.32	25.26	53.75	79.93	35.2	209.6	244.80	43.91	265.38	309.30	52.28	313.05	365.33	61.00	358.8	419.80	65.45	419.55	485.00
SEm±	0.88	2.68	0.46	0.23	3.96	0.76	1.64	8.21	3.84	1.92	9.61	4.73	1.99	10.27	4.97	2.76	10.44	6.04	2.21	9.80	7.26
CD @5%	2.58	7.85	1.36	0.68	11.59	2.22	4.79	24.0	11.24	5.62	28.3	13.82	5.82	30.00	14.52	8.06	30.51	17.64	6.46	28.63	21.22

from source to sink, resulting in higher corm yield. Nedunchezhiyan et al. (2017) also reported similar finings in elephant foot yam.

Corm yield (t ha^{-1})

The corm yield as influenced by different fertility management, as given in Table 2 revealed that all the fertility levels except the treatment T_2 significantly increased the corm yield. Application of FYM @10 t ha^{-1} along with N-P_2O_5-K_2O @100-60-100 kg ha^{-1} (T_7) increased the corm yield by 105% over the control (T_1) which only recorded 18.3 t ha^{-1}. The treatment T_7 also recorded significantly higher corm yield than T_4, thus justifying integrated use of FYM and fertilizer. The treatment T_8, sole application of FYM @ 25 t ha^{-1} produced 36.1 t ha^{-1} which was at par with that of T_7 (37.65 t ha^{-1}). The treatments comprising of only NPK fertilizers (T_3 and T_4) also recorded significantly more yield over control. However, the corm yield did not changed appreciably at lower doses of N-P_2O_5-K_2O i.e. N-P_2O_5-K_2O @60-60-60 kg ha^{-1} (T_2). The positive responses were only obtained above the dose of N-P_2O_5-K_2O @ 60-60-60 kg ha^{-1}. The higher yield of corm might be due to inherent genetic character and positive response to the variety Gajendra to the applied manures and fertilizers. Similar to yield attributes, as fertility levels decreased the yield ha^{-1} also decreased correspondingly. Similar results were reported by Mohankumar et al. (1984), Mukhopadhyay and Sen (1986), and Chattopadhyay et al. (2006).

Conclusion

The field experiment conducted with elephant foot yam cv. Gajendra in Odisha state revealed that the application of FYM @ 10 t ha^{-1} along with N-P_2O_5-K_2O @ 100-60-100 kg ha^{-1} is required for higher biomass production and partitioning as well as higher corm yield (37.6 t ha^{-1}) in alfisols under protective irrigation conditions.

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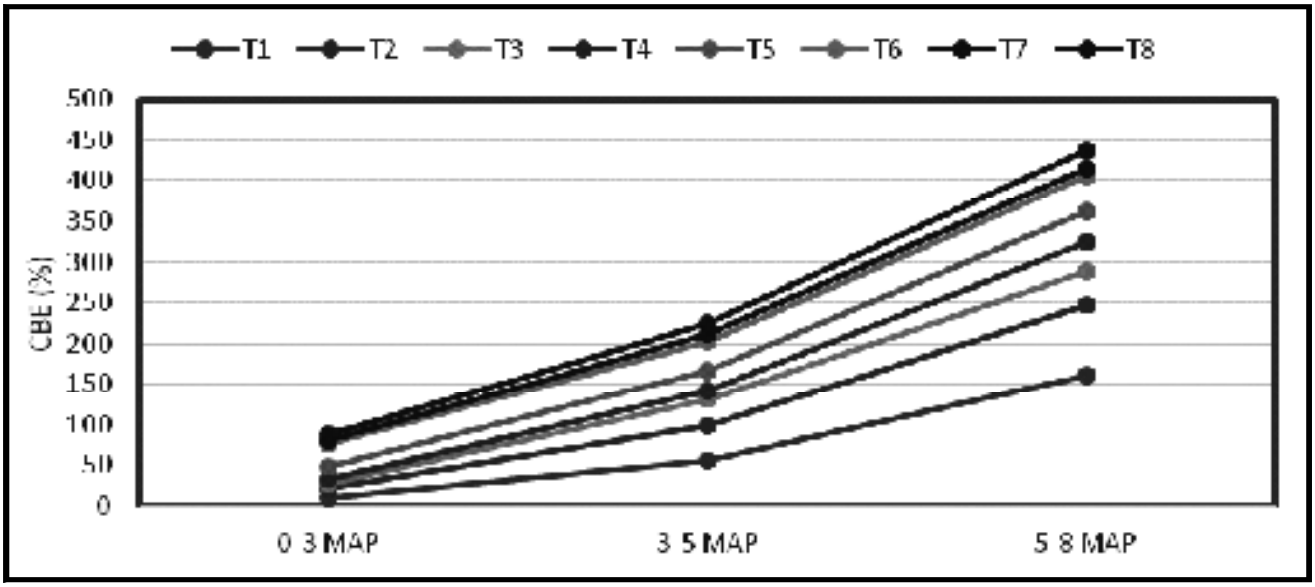

Fig. 2 Corm bulking rate (CBR) of elephant foot yam at various phenophases as influenced by fertility levels (Poled mean of 2 years)

TABLE 2. Effect of fertility levels on yield attributes and yield of elephant foot yam (Pooled mean of 2 years)

Treatments	Corm diameter (cm)	Corm yield (g plant^{-1})	Corm yield (t ha^{-1})
T_1	19.55	1045	18.3
T_2	20.60	1390	24.3
T_3	21.60	1555	27.2
T_4	23.00	1695	29.6
T_5	23.40	1845	32.3
T_6	24.50	2020	35.4
T_7	25.55	2150	37.6
T_8	24.65	2060	36.1
SEm±	0.651	42	0.71
CD @ 5%	1.90	124	2.1

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Breeding Rice (*Oryza sativa* L.) For Zn-Deficient Soil

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Abstract

Zn-deficiency in soil reduced production and productivity of rice in many parts of terai zone in West Bengal. Identification of resistant genotypes and their involvement in breeding with high yielding varieties may destroy productivity level of rice. In the present investigation forty six genotypes were evaluated on the basis of 'Khaira disease' appearance on leaf at the early stages of growth and the genotypes are categorized as highly resistant, moderately resistant and highly susceptible types. IET 13544, IET 4786 and Chakadumra(a local variety) were found as highly resistant while MW-10-1, IR 64, AVT IEU 2102 was found as highly susceptible types. These genotypes were crossed in diallel design to estimate gca as well as sca for making breeding strategies for development of high yielding genotypes showing resistance to Zn-deficiency in soil. The characters considered in the experiment were grain yield and its component traits like number of tillers plant^{-1}, grains panicle^{-1}, floret fertility, and harvest index. Significant gca, sca effect was highlighted for all the traits due to the influence of all the character for additive and dominant gene effect. IET 4786, IET 13544 and Chakadumra were found to be best general combiners for yield plant^{-1} along with its some component traits. Four crosses AVT-IEH-1906 x IET 4786,MW 10 1 x AVT-IEU-2102, Chakadumra x AVT-IEU-2102, Chakadumra x AVT-IEH-1906 showed highly significant sca effect for yield and its component traits except grains

panicle^{-1} for the third crosses. Of all the crosses one of the parents was high general combiner and the others were poor general combiners and the characters were influenced by both additive and non-additive gene effect for which population improvement method may be followed to develop Zn-deficient resistant high yielding lines.

Keywords **:** breeding resistance, combining ability, oryza, rice, terai zone, zn-deficient soil.

Introduction

Rice (*Oryza sativa* L.) in India is an important calorie rich food crop. The cultivation of such an important crop has been extended to various agro-geographical regions in India and some parts are highly affected by various abiotic factors (Swamy *et al*., 2016). Taraizone in West Bengal is highly deficient in major macro and micro nutrients and poor production of rice had been identified due to deficiency of Zn in its soil. The influence of Zn in rice production ranked third after nitrogen and phosphorus and its deficiency had been demonstrated as a causal factor for yield reduction (Annonymous, 1975). Dwivedi and Randhawa, 1973, Kumar *et al*.,1976 reported carbohydrate production as an response to Zn supplementation. Plant yield alongwith plant height, number of tillers per plant, LAI increased with application of Zinc in both rabi and kharif crop (Maharana et al. 1993).

The critical range of DTPA-Zn in soil varies widely between 0.45-2.0ppm in terai zone. Zn-content in soil even in some parts was found well below the critical range (0.20ppm) causing poor yield in rice (Das 2000). Variation within genotypes in rice to Zn-deficiency had been reported by Ramadass and Krishnasamy, 1992 and the tolerant genotypes produced more dry matter when grown at low levels of Zn in soil.

In the present investigation attempts had been made to evaluate forty six genotypes of rice to identify genotypes least affected for Zn-deficiency. Nine genotypes were identified as tolerant of which Chakadumra (a local variety), Farashi, IR 50, IET 135444 were highly tolerant and IET 4786, Banna, IRAT 144, Bhupen and IET 9315, moderately tolerant. Three resistant lines IET 13544, Chakadumra, IET 4786 were combined in half-diallel fashion with three extremely susceptible genotypes, AVT-IEU-2102, IR 64, MW-10-1 to estimate gene effect on resistant genotypes alongwith combining abilities among genotypes. Such estimation of genetic control may help to design breeding strategies to evolve high yielding and Zn-deficiency tolerant genotypes.

IET 4786, IET 13544, Chakadumra were found best general combiners for yield plant^{-1} alongwith most of its component traits. Some of the crosses also showed high sce effect for yield plant^{-1} and some of its component traits and in most cases high and poor general combining parents resulted satisfactory sca effect. Biparental or reciprocal selection could be advocated to obtain desirable segregants with high yield and resistance to the abiotic stress.

Materials and Methods

The experimental materials consisted of forty-six rice genotypes of which eleven were AVT lines made available by courtesy of Directorate of Rice Research Institute, Hyderabad, India and another four genotypes were collected from Rice Research Station, Govt. of West Bengal, Chinchurch, India and rest from Uttar Banga Krishi Viswavidalaya, Pundibari Table 1. These genotypes were screened in the Department of Plant Breeding, B.C.K.V. On the basis of intensity of Khaira disease appeared on leaves under Zn-deficient condition by growing them in pots filled with Zn-deficient soil alongwith control where Zn @ 5 ppm in the form of $ZnSo_4$ was applied. Symptoms cause and control of Khaira disease in rice was first reported by Nene, 1966. Three resistant lines Chakadumra, IET 13544 and IET 4786 and three susceptible lines AVT IEU 2110,MW 10 1, IR 64 were selected for crossing following dialle mating system without reciprocals in the year 2012. In the next Aman season all the parents and F_1s were grown in farmers field at Tufanganj, Dist Coochbehar, West Bengal following RBD design with three replications to estimate genetic components for the

TABLE 1. List of genotypes with their sources

Group	Genotypes	Source of collection
A	AVT-IEH-1901, AVT-IEH-1903,AVT-IEH-1904,AVT-IEH-1905, AVT-IEH-1906, AVT-IEH-1908,AVT-IEU-2102, AVT-IEU-2104, AVT-IEU-2105,AVT-IEU-2106,AVT-IEU-2110.	Directorate of Rice Research Institute, Hyderabad.
B	Ajay, Bhupen, Bikash, MW 10, Banna, Basmati 385, IR 50, IR 64, IET 1707, IET 1708, IET 1804, IET 1809, IET 1812, IET 4049, IET 4786, IET 8286, IET 8786, IET 9315, IET 9947, IET 10384, IET 13250, IET 13544, IET 13783.	Rice Research Centre, Chinsurah, hooghly Govt. of West Bengal.
C	Chakadumra, Chapalu, Farashi, CR 237-1-8, IR 61608-2B, IRAT 144, KGR 19, Nipun Pumde, Nipun Pumso, PNR 381, PNR 519, MW-10-1.	Uttar Banga Krishi Viswavidalaya, Pundibari, Coochbehar.

traits alongwith gca and sca effect. The traits considered were number of effective tiller plant^{-1}, grains panicle^{-1}, floret fertility, harvest index and yield plant^{-1}.Model 1,method 2 of Griffings,1956 was followed for estimation of various genetic components.

Results and Discussions

On the basis of evaluation of Khaira disease the parents were divided into distinctly three groups as resistant, moderately resistant and susceptible genotypes and three extremely resistant lines like IET 13544, Chakadumra, IET 4786 and three extremely susceptible lines like AVT-IEU-2102, IR 64 and MW 101 were considered for crossing among themselves following diallel design. Significant variations within the genotypes affected due to Khaira disease were noticed. Significant variations due to Zinc treatment on the genotypes alongwith their interaction effect were also exhibited in the present investigation Table 2. All the varieties showed lesser extent of deficiency symptoms due to Zn-application in the soil though the recovery of genotypes from Khaira disease due to Zn-treatment was found to be least in IET 1395 and Bhupen which were found to be fairly less affected. Only the genotype, IET 9315 failed to show genotype x Zn-treatment interaction effect. On the basis of the analysis, the genotypes were classified as highly resistant (Chakadumra, Farashi, IR 50, IET 13544), moderately resistant (IET 4786, Banna,IRAT 144, Bhupen and IET 9315), susceptible (PNR 381, Bikash, IET 9947, IR 61608-28, Basmati 385, PNR 519, MM 10, IET 4049), moderately to highly susceptible (IET 8286, Ajay, IET 8786, AVT IEH 1904,IET 13783, AVT IEH 1908, IET 1812, AVT IEU 2105,IET 1707, AVT IEU 2104, AVT IEH 1905,IET 1809, AVT IEH 1903,IET 10384, IET 1808, IET 13250, Nipun Punde,IET 1804, Nipun Pumso, AVT IEH 1906, CR 237-1-8, AVT IEU 2106,Chapalu) and extremely susceptible(AVT IEU 2110,MW 10 1, IR 64, AVT IEU 1901, AVT IEU 2102). On the basis of screening, three resistant lines like IET 13544, Chakadumra, IET-4786 and three extremely susceptible lines like AVT-IEU-2102, IR 64, MW 10 1 were selected in the crossing programme. Analysis of variance showed significant gca and sca effect for all the traits which suggested that these traits were highly influenced by both additive and dominant gene effect which was also evidenced from their predictability ratio. Additive effect were found to be higher than dominance effect for grains panicle^{-1}, harvest index and yield plant^{-1} and such effect on opposite direction was found

Table 2. Varietal, zinc treatment and interaction effect of khaira disease

Genotypes	Zn-0	Zn-1
AVT-IEH-1901	45.75	16.87
AVT-IEH-1903	31.46	15.39
AVT-IEH-1904	26.99	13.32
AVT-IEH-1905	31.06	14.87
AVT-IEH-1906	36.71	18.04
AVT-IEH-1908	27.51	12.92
AVT-IEU-2102	45.95	19.83
AVT-IEU-2104	31.06	14.66
AVT-IEU-2105	29.38	9.93
AVT-IEU-2106	38.25	11.87
AVT-IEU-2110	40.05	17.38
Ajay	24.12	11.81
Bhupen	9.65	7.58
Bikash	16.64	9.95
Banna	7.25	0.00
Basmati 385	19.40	10.53
Chakadumra	0.00	0.00
CR 237-1-8	37.02	17.41
Chapalu	39.83	20.46
Farashi	0.00	0.00
IR 50	0.00	0.00
IR 64	42.46	20.73
IR 61608-28	19.37	8.18
IET 1707	29.70	13.38
IET 1708	33.85	19.60
IET 1804	34.83	18.86
IET 1809	31.12	13.51
IET 1812	28.02	12.11
IET 4049	20.62	9.95
IET 4786	5.27	0.00
IET 8286	23.95	13.46
IET 8786	25.38	14.58
IET 9315	8.22	6.78
IET 9947	17.75	8.50
IET 10384	32.80	15.77
IET 13250	33.96	19.63
IET 13544	0.00	0.00
Genotypes		

IET 13783	27.48	13.78
IRAT 144	8.97	0.00
KGR 19	6.19	0.00
MM 10	19.84	10.61
MW 10 1	42.21	20.26
Nipun Pumde	34.41	13.53
Nipun Pumso	35.34	20.28
PNR 381	15.90	9.90
PNR 519	19.60	11.10

	Genotype	Zn	Interaction
SE(m)	0.449	0.094	0.635
LSD(0.05)	1.253	0.262	1.772

TABLE 3. Analysis of variance and predictability ratio

Source	Degrees Of freedom	Number of effective tillers	Grains per panicle	Floret fertility	Harvest index	Yield per Plant (g)
Gca	5	40.290*	1423.8439	370.936*	0.0263*	84.878*
Sca	10	11.845*	113.9043	113.660*	0.0053*	19.753*
Error	20	0.066*	1.0173	0.273	0.0003	0.7296
2g		10.056	355.706	92.665	0.0065	21.037
2s		11.779	112.887	113.387	0.0052	19.023
Predictability Ratio		0.460	0.759	0.449	0.553	0.525

*significant at 5%level

for floret fertility and number of effective tillers plant^{-1} Table 3. High gca for number of effective tiller plant^{-1} was observed in IET-4786 followed by IET-13544 and Chakadumra and that for grains panicle^{-1} in IET-13544 followed by IET-4786; IET-4786 was found as best general combiner for floret fertility followed IET-13544 and Chakadumra. Best general combiner for harvest index was found to be IET-4786 followed by IET-13544 and Chakadumra. Similarly IET-4786 was found to be best general combiner for grain yield^{-1} followed by IET-13544 and Chakadumra. All other parents were found to be poor general combiners for the traits. IET-4786 were found to be best general combiner for all the traits followed by IET-13544 Table 4. Wide variation in sca effect for all the traits were observed among the crosses. Significant positive sca effect were observed in eight crosses for number of effect tillers plant^{-1}, nine for grains panicle^{-1}, twelve for floret fertility, eleven for harvest index and ten for yield plant^{-1}.Superior crosses with high sca effect were identified as (MW 10 1 x AVT IEU 2102), (MW 10 1 x IET 13544), (Chakadumra x IET-4786) for number of effect tillers plant^{-1}, (IET 13544 x AVT IEU 2102), (Chakadumra x MW 10 1), (IET 4786 x MW 10 1), (AVT IEH 1906 x IET 13544) for grains panicle^{-1}, (MW 10 1 x AVT IEU 2102), (AVT IEH 1906 x AVT IEU 2102), (AVT IEH 1906 x MW 10 1), for floret fertility, (AVT IEH 1906 x AVT IEU 2102),(MW 10 1 x AVT IEU 2102), (Chakadumra

TABLE 4. Estimation of general combining ability (gca) effects for yield and yield Components in F_1

Parents	Number of effective tillers	Grains per panicle	Floret fertility	Harvest index	Yield per Plant (g)
Chakadumra	0.99*	-10.19*	5.48*	0.04*	2.08*
IET 4786	2.77*	15.72*	7.12*	0.07*	3.65*
AVT-IEH-1906	-2.04*	-6.41*	-3.74*	-0.04*	-1.49*
MW 10 1	-1.73*	-12.35*	-7.42*	-0.06*	-3.37*
IET 13544	2.17*	17.97*	5.64*	0.05*	2.84*
AVT-IEU-2102	-2.16*	-4.73*	-7.09*	-0.06*	-3.71*
SE(gi)	0.08287	0.32553	0.16875	0.00194	0.27569

*significant at 5%level

x AVT IEU 2102), (Chakadumra x AVT IEH 1906) for yield plant^{-1} and (AVT IEH 1906 x AVT-IEU 2102), (MW 10 1 x AVT IEU 2102), (AVT IEH 1906 x MW 10 1) for harvest index Table 5. Most of the crosses giving high sca effect for the concerned MW 101 x AVT IEU 2102, MW 101 x IET 13544,Chakadumra x IET-4786 for number of effect tillers plant^{-1}, IET 13544 x AVT IEU 2102, Chakadumra x MW 101, IET 4786 x MW 101, AVT IEH 1906 x IET 13544 for grains panicle^{-1}, MW 101 x AVT IEU 2102, AVT IEH 1906 x AVT IEU 2102, AVT IEH 1906 x MW 101 for floret fertility, AVT IEH 1906 x AVT IEU 2102, MW 101 x AVT IEU 2102, Chakadumra x AVT IEU 2102, Chakadumra x AVT IEH 1906 for yield plant^{-1} and AVT IEH 1906 x AVT-IEU 2102, MW 10 1 x AVT IEU 2102, AVT IEH 1906 x MW 101 for harvest index were identified from combinations between parents with high x poor gca or poor x poor gca.

Predominant additive effect for grain yield^{-1} and predominance non-additive effect for number of effective tillers plant^{-1} and number of grains panicle^{-1} was also found by Kalaimani et al. 1987. Majumder *et al.* 1990 observed involvement of additive with some dominance gene effect in controlling resistance to Zn-deficiency. As the genotypes IET-4786 and IET-13544 were found to be good general combiners for all the traits these could be favourably utilized to improve the crop under Zinc deficient condition.

Significant positive sca effect was found in different crosses for different traits in combination with genotypes Chakadumra, IET 4786 and AVT IEH 1906 bearing high gca which proved their effectiveness for development of high yielding resistant lines to the abiotic stress. Singh et al.1995.found some crosses with high sca effect for grain yield^{-1} alongwith some important traits in combination with parents with high gca effect. Verma *et al*. 2004, Torres et al. 2007 also observed significant gca and sca effect for number of productive tillers, grain yield^{-1}, number of grains panicle^{-1} and 100- grain weight. The parents Chakadumra, IET 4786 and AVT IEH 1906 showed significant sca effect in combination with most of the parents. The (high x poor) general combiners could give high sca effect if additive effect of one parent and complementary epistatic effect (if present in the cross) act in the same direction to maximize the potentialities of desirable plant traits. In case of (poor x poor) combination the parental lines may had origin from diverse genetic background to influence favourably the sca component. Significant sca effect in crosses with (high x poor) and (poor x poor) combiners were also reported by Muthuramu et al. 2010 for these traits, they also suggested that biparental or reciprocal selection method may be followed to obtain desirable early segregants from (high x poor) cross combination whereas for (poor x poor) combinations cyclic

TABLE 5. Estimation of specific combining ability (sca) effects for yield and yield Components in F_1

Crosses	Number of effective tillers	Grains per panicle	Floret fertility	Harvest index	Yield per Plant (g)
Chakadumra x IET 4786	3.21*	-9.31*	0.55*	0.03*	2.78*
Chakadumra x AVT-IEH-1906	1.43*	4.22*	4.25*	0.04*	3.56*
Chakadumra x MW 10 1	-0.64	11.71*	4.23*	0.02*	1.74*
IET 4786 x IET 13544	-3.77*	-16.12*	-3.61*	-0.01*	-2.88*
IET 4786 x AVT-IEU-2102	-1.40*	8.18*	-0.88*	-0.01*	-2.03*
AVT-IEH-1906 X MW 10 1	0.59	4.83*	10.75*	0.07*	2.56*
AVT-IEH-1906 X IET 13544	-0.30	8.36*	0.60*	-0.01*	0.21
AVT-IEH-1906 X AVT-IEU-2102	2.27*	4.76*	12.58*	0.09*	6.01*
MW 10 1 x IET 13544	4.03*	-6.20*	4.23*	0.04*	3.29*
MW 10 1 x AVT-IEU-2102	5.80*	2.15*	13.66*	0.08*	4.39*
IET 13544 x T-IEU-2102	0.56	16.28*	5.80*	0.02*	-0.21
SE(Sij)	0.2276	0.8941	0.2148	0.000028	0.7572

*significant at 5% level
*significant at 5% level

method of breeding involving selection of desired recombinants and their inter-se crossing may be practiced to obtain desirable results.

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Screening for High Productive and Elevated Macro and Micronutrients Lines in Chickpea

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Abstract

Chickpea (Cicer arietinum L.) is an important pulse crop grown and consumed for its unique compositions of nutrients in comparison to other plant foods in all over the world. There is an urgent need to increase the demand of chickpea to meet up the hunger in all over the world. Sixty chickpea germplasms were evaluated at Calcutta University's experimental farm, Baruipur during rabi season for four consecutive years. Beside production, nutritional quality is also very important so that chickpea can be used as supplementary protein deficiency to the people. Chickpea has several potential health benefits due to its unique composition of macro and micronutrients namely, protein, fat, ash, crude fibre, carbohydrate, vitamin C, carotenoid, calcium and phosphorus. Therefore the experiment was based on screening the high productive and nutritionally superior chickpea germplasms to fulfill the demand and improve the nutritional status of the people in developing and under developing nations. Based on the present investigations, the germplasms namely CUSL4, BGM408 and IC268966 were the top three germplasms in respect of both yield and quality parameters.

Keywords **:** Chickpea, yield, macronutrients, micronutrients

Introduction

The world population is intensifying at an alarming speed and is going to surpass 8 billion by 2030 and 9.6 billion by 2050 (Godfray, 2010). This rapidly increasing population posed a severe ultimatum to the food and nutritional security of human beings. Consequently, most of the human populations were suffering from insufficient dietary intake in crucial mineral elements and vitamins. Macro and micronutrient malnutrition and hidden hunger affects the populations in developing and under developing countries like Asia, Africa, and Latin America. Most of the people in these regions depend mainly on cereal diets which are frequently deficient in some macro and micro nutrients. Hence, long-term and sustainable solutions are urgently needed to diminish malnutrition in these regions. Pulses combined with cereals are major dietary components for billions of people. Among all the pulses, chickpea is the third leading grain legume in the world and first in the South Asia. Chickpea is one of the most significant legume crops inherently loaded with nutrients. Consumption of chickpeas will be great alternative containing all the necessary micronutrients. In the semi-arid tropics, chickpea is an important legume of those people who are vegetarian either by choice or due to poor economic status. There is a growing demand for chickpea due to its nutritional value. During the last three decades, the production of chickpea is hampered due to shifting into production of wheat and cotton by the people in northern India. There is an acute shortage of chickpeas which resulted imports of chickpea from other countries (Ramanappa *et al*., 2013). The strategic research has been developed to increase the productivity to meet up the demand of the people. There is a great success in breeding of high yielding crops has been achieved through simple

selection from germplasm (Ramanappa *et al*., 2013). Therefore the objective of this present study was to identify chickpea germplasms which are high-yielding in order to increase the production and productivity and as well as more nutritious to provide macro and micronutrients in the diets of people than traditional varieties.

Materials and Methods

Sample collection: Sixty chickpea germplasms were collected from NBPGR, Berhampore and some of them were local collection. The experiment was conducted at Calcutta University's experimental farm, Baruipur, South 24 Parganas with three replications in each year using randomized block design (RBD). The experiment was executed during rabi season for four consecutive years from 2014 to 2018. The germplasm was sown in a single row of 4 m length with a row to row spacing of 30 cm and 10 cm from plant to plant. Normal inter-culture operations were done throughout the growing periods. Around 130-140 days after planting, harvesting of all germplasms were carried out manually. Data of five best selected plants were taken from each replication for eight traits.

Analysis of macro and micronutrients:

Protein was extracted by Lowry method (1951). Ash, fat and carbohydrate were done using the method of A.O.A.C. 1990. The analysis of carbohydrate was done by following the method of Mustapha and Babura 2009. Estimation of calcium in chickpea was done by titrimetric method (Anonymous, 2005). The phosphorus content was determined according to the method of Pradhan and Pokhrel, (2013). Ascorbic acid was extracted by the method described by Al-Ani *et al*., (2007). The method of Mustapha and Babura (2009) was followed to evaluate carotenoid in chickpea seeds. All these entire analysis were done in triplicates with slight modifications.

Statistical analysis: All the statistical analysis was perform by using SPSS Program version 20. The data of mean performances of chickpea germplasms are expressed as mean ± SE. All the treatments data presented are presented as means± S.D.

Results and Discussion

Mean performance: In all breeding program, high seed yield is one of the most complex quantitative chief trait. Twenty five chickpea germplasms were selected as high yielding from the mean performances of sixty chickpea germplasms over four consecutive years and presented in Table 1. The germplasms namely Digbijoy, BR78, CUSL4, CUSL3, BGM408, HC5 and JG74 exhibited considerable high values for yield and yield contributing traits compared to check germplasms.

Analysis of macronutrients: Table 2 represents the analysis of macronutrients of all the high yielding chickpea germplasms.

Protein:

Protein–energy malnutrition occurred due to the lack of protein and energy in the diet affects especially in infants, young children and nursing mothers of developing countries in Asia and Africa (Haider and Haider, 1984). Among the different pulses, chickpea has been reported to have a higher protein bioavailability (Yust et al., 2003 and Sa´nchez-Vioque et al., 1999). The protein content in chickpea ranged between 17.13-19.94g/100g. These results were in accordance with Gonzales I.C. *et al*., (2016) and Serrano *et al*., (2017). The germplasm CUSL4 exhibited the highest protein content (19.94g/100g) followed by Annigeri (19.90g/100g) and WBG 29 (19.88g/100g).

Fat:

Fat provide twice amount of energy than protein and carbohydrate. Chickpea contained fat ranging from 4.81g-6.32g/100g. L550 recorded highest amount of fat 6.32g/100g followed by BGM408 (6.03 g/100g) and IC 268966 (6.02g/100g). Gopalan *et al*., (2007) and Serrano *et al*., (2017) reported similar type of ranges in fat content. Though the amount of fat in chickpea is quite high than mungbean and lentil but it is healthy due to high amount of PUFA and MUFA than SFA.

Ash:

The ash content helps to measure total amount

TABLE 1. Mean performances of yield related traits of twenty five chickpea germplasms:

Germplasms	Plant height (cm)	No. of Branches Plant^{-1}	No. of Pods Plant^{-1}	Pod Length (cm)	No. of Seeds Pod^{-1}	100 seed Weight (g)	Harvest Index	Seed yield Plant^{-1}
1. Digbijoy	**75.13**	**6.59**	**85.17**	**1.57**	**1.40**	**18.47**	**51.81**	**22.02**
2. Dcp-92-3	**63.82**	**6.98**	**110.79**	**1.53**	**1.42**	**12.62**	**50.08**	**20.13**
3. Avrodhi	**62.79**	**6.07**	**83.62**	**2.02**	**1.68**	**14.00**	**48.67**	**20.01**
4. Radhey	**70.95**	**6.44**	**90.29**	**1.84**	**1.58**	**11.50**	**46.69**	**16.48**
5. GCP-105	74.58	5.22	47.33	1.52	1.38	14.40	38.60	8.92
6. Pant -G186	**70.98**	**6.62**	**78.10**	**1.53**	**1.46**	**13.33**	**45.97**	**16.04**
7. GNG 469	**65.03**	**5.73**	**82.33**	**1.86**	**1.82**	**11.23**	**46.33**	**17.14**
8. ICCV 10	65.83	3.92	32.77	1.52	1.40	14.19	33.41	6.65
9. HC 3	55.63	4.42	43.79	1.81	1.48	20.39	42.02	14.04
10. Virat	**68.33**	**6.20**	**88.46**	**1.44**	**1.71**	**12.24**	**48.35**	**18.44**
11. Vishal	51.81	3.82	40.42	1.36	1.32	11.74	33.87	6.40
12. Vijoy	50.47	4.02	48.67	1.46	1.11	12.90	32.02	5.37
13. JG 315	53.41	4.18	46.27	1.52	1.66	11.80	35.99	8.69
14. B116	**70.47**	**6.06**	**78.52**	**1.69**	**1.83**	**11.19**	**40.28**	**16.05**
15. BR 77	62.78	4.43	36.62	1.81	1.49	12.06	36.27	6.45
16. G 24	57.63	3.97	51.94	1.50	1.59	15.06	37.80	10.24
17. BR 78	**69.07**	**6.00**	**87.72**	**1.82**	**1.70**	**14.85**	**50.93**	**23.20**
18. WBG 29	**71.70**	**5.86**	**95.05**	**1.95**	**2.32**	**9.22**	**46.58**	**18.03**
19. Anuradha39/2	53.90	4.28	57.08	1.32	1.26	11.14	30.85	8.00
20. Annigeri	**74.18**	**5.55**	**86.95**	**2.00**	**1.79**	**12.60**	**47.58**	**19.02**
21. RSG 888	**72.83**	**5.61**	**75.36**	**1.79**	**1.93**	**13.78**	**48.19**	**19.72**
22. Saki 9516	54.63	3.81	46.81	1.41	1.58	13.52	35.57	8.68
23. Dahodyellow	53.27	4.28	45.51	1.32	1.19	12.52	38.81	6.91
24. HC5	**62.76**	**6.81**	**98.88**	**1.74**	**1.61**	**11.92**	**50.00**	**19.39**
25. JG 74	**68.09**	**6.29**	**90.94**	**1.62**	**1.64**	**14.36**	**48.50**	**20.47**
26. IC 268863	77.15	6.39	35.02	1.82	1.51	20.94	46.69	10.45
27. IC 268873	55.82	4.29	50.88	1.30	1.17	15.94	38.60	7.75
28. IC 268890	57.93	4.08	48.88	1.30	1.40	14.35	45.97	10.33
29. IC 268943	57.87	4.25	47.01	1.51	1.28	16.81	46.33	10.07
30. IC268948	52.05	3.77	37.98	1.46	1.22	14.15	33.41	6.76
31. L 550	**71.96**	**6.09**	**64.87**	**1.91**	**1.81**	**17.15**	**42.02**	**18.02**
32. IC 268971	50.26	4.20	36.29	1.81	1.55	13.35	48.27	7.46
33. IC 268966	**60.88**	**6.21**	**75.89**	**1.83**	**1.87**	**12.18**	**33.87**	**17.33**
34. Jaki 9218	52.89	4.06	38.74	1.41	1.34	12.79	32.02	6.88
35. JG 14	55.79	4.17	41.97	1.26	1.27	19.87	35.99	9.67
36. JG 16	57.07	4.28	46.64	1.89	1.32	16.86	40.28	10.60
37. PUSA372	51.79	4.30	39.75	1.47	1.31	10.83	35.96	6.03
38. PUSA547	59.06	3.82	47.72	1.52	1.21	23.54	37.85	12.25
39. Rajesh	**70.85**	**5.47**	**79.92**	**1.79**	**1.65**	**11.99**	**36.27**	**16.16**
40. Subhra	70.19	4.93	35.78	1.81	1.17	24.62	37.80	10.84
41. Vaibhev	52.64	3.49	45.78	1.42	1.46	17.94	50.80	12.37
42. Bidisha	60.70	3.48	44.98	1.50	1.52	13.17	46.58	8.89
43. BGM408	**72.30**	**5.90**	**95.75**	**1.96**	**1.78**	**11.40**	**39.85**	**19.34**

Germplasms	Plant height (cm)	No. of Branches Plant^{-1}	No. of Pods Plant^{-1}	Pod Length (cm)	No. of Seeds Pod^{-1}	100 seed Weight (g)	Harvest Index	Seed yield Plant^{-1}
44. CUML1	**66.02**	**5.79**	**117.89**	**1.83**	**1.34**	**10.87**	**53.15**	**18.79**
45. CUML2	**70.80**	**5.43**	**90.79**	**2.01**	**1.97**	**10.79**	**46.98**	**17.02**
46. CUML3	**64.15**	**6.16**	**78.68**	**1.80**	**1.89**	**11.29**	**47.68**	**17.16**
47. CUML4	**73.62**	**5.17**	**85.56**	**1.88**	**1.90**	**11.92**	**47.22**	**17.22**
48. CUML5	63.54	5.35	50.49	1.46	1.10	11.89	36.49	7.03
49. CUML6	52.82	4.51	48.51	1.80	1.44	11.57	31.12	6.02
50. CUML7	51.70	4.48	54.78	1.63	1.50	10.06	28.98	8.49
51. CUML8	55.79	3.93	49.86	1.39	1.72	10.21	26.20	6.51
52. CUML9	64.92	4.32	49.87	1.99	1.95	12.13	35.94	9.57
53. CUML10	56.87	4.31	59.95	1.41	1.45	9.37	32.69	7.75
54. CUSL1	70.23	5.98	51.57	1.53	1.48	10.13	33.02	6.08
55. CUSL2	**63.07**	**5.93**	**82.57**	**1.93**	**1.94**	**12.19**	**44.93**	**17.24**
56. CUSL3	**66.43**	**6.10**	**94.78**	**1.58**	**1.80**	**13.03**	**50.18**	**19.95**
57. CUSL4	**72.68**	**5.05**	**98.62**	**1.56**	**1.54**	**12.20**	**50.09**	**20.09**
58. CUSL5	55.74	5.63	66.12	1.38	1.00	9.63	30.55	6.98
59. NP209**(Check)**	60.71	4.82	46.68	1.29	1.38	11.53	35.96	7.82
60. B 110**(Check)**	68.34	5.34	47.76	1.40	1.62	13.83	37.85	10.83
CD (5%)	**7.33**	**0.85**	**16.39**	**0.23**	**0.25**	**0.94**	**6.09**	**4.80**

of minerals present within the chickpea germplasms. Chickpea contained as varying from 2.79g/100g-3.35%. The germplasm CUSL4 exhibited the highest ash content 3.35% followed by BGM408 (3.32%) and Annigeri (3.31%).

Similar results have been reported by Costa *et al*., (2004) and Serrano *et al*., (2017). It helps to determine the inorganic minerals specifically calcium and phosphorus.

Crude fibre:

Crude fibre is defined as indigestible portion present in chickpea germplasms. Chickpea germplasms contained crude fibre varied from 3.90-5.91g/100g. CUSL4 showed highest crude fibre content 5.91g/100g followed by CUML8 (5.86g/100g) and CUML4 (5.85g/100g). These results were in accordance with Gopalan *et al*., (2007) and Polesi *et al*., (2011). Crude fibre helps to lower the total serum total cholesterol and LDL-cholesterol level in the blood and preventing from the incidence from coronary heart disease.

Carbohydrate:

Carbohydrate is the most important predominating macronutrient which provides maximum amount of energy requirement in human diet in Asian countries. In the present study, the ranges of carbohydrate present in chickpea germplasms varied from 59.85-63.03g/100g. Similar ranges were reported by Doke and Guha 2016 and Kabuo et al., 2015. L550 exhibited the highest carbohydrate content 63.03g/100g followed by CUSL4 (61.65g/100g) and RSG888 (61.60g/100g). The total carbohydrate content in chickpea is higher than peas (14.5g/100g) and faba bean (58.3g/100g).

Analysis of micronutrients: Table 3 represents the analysis of micronutrients of all the high yielding chickpea germplasms.

Calcium:

Calcium content of chickpea varied from 198.26-201.92 mg/100g. The desi type germplasm namely Virat displayed highest calcium content i.e.

TABLE 2. Macronutrient contents in high yielding chickpea germplasm

Germplasms	Protein (g/100g)	Fat (g/100g)	Ash (%)	Crude Fibre (g/100g)	Carbohydrate (g/100g)
1. Digbijoy	19.37±0.05	5.17±0.05	3.29±0.05	4.91±0.05	60.66±0.06
2. Dcp-92-3	17.13±0.04	4.98±0.07	2.99±0.05	4.04±0.05	59.88±0.08
3. Avrodhi	17.51±0.12	4.81±0.07	3.02±0.05	4.01±0.05	60.36±0.05
4. Radhey	17.25±0.06	5.13±0.06	2.96±0.05	4.03±0.05	60.06±0.06
5. Pant -G186	17.10±0.11	5.02±0.05	3.14±0.05	4.02±0.03	60.71±0.06
6. GNG 469	17.60±0.06	5.12±0.05	3.01±0.05	4.06±0.06	60.05±0.05
7. Virat	19.69±0.05	5.18±0.08	3.26±0.05	5.12±0.07	60.03±0.05
8. B116	17.80±0.06	4.82±0.05	2.94±0.06	4.36±0.05	60.07±0.09
9. BR 78	17.68±0.08	4.97±0.06	3.10±0.05	4.64±0.10	60.08±0.07
10. WBG 29	19.88±0.08	5.92±0.05	3.25±0.06	5.60±0.05	61.43±0.08
11. Annigeri	19.90±0.09	5.38±0.05	3.31±0.05	4.15±0.07	60.59±0.09
12. RSG 888	17.88±0.08	5.89±0.05	2.95±0.05	5.80±0.05	61.60±0.10
13. HC5	18.41±0.10	5.26±0.05	2.86±0.06	4.87±0.06	60.10±0.07
14. JG 74	18.48±0.07	5.15±0.05	2.96±0.05	4.97±0.06	60.20±0.06
15. L 550	19.27±0.08	6.32±0.05	2.79±0.05	3.90±0.05	63.03±0.05
16. IC 268966	19.35±0.05	6.02±0.07	3.33±0.06	5.77±0.05	59.85±0.05
17. Rajesh	18.13±0.03	5.23±0.05	3.16±0.05	5.15±0.10	60.14±0.06
18. BGM408	19.70±0.05	6.03 ±0.04	3.32±0.05	5.83±0.05	60.66±0.14
19. CUML1	19.71±0.05	5.82±0.05	3.27±0.05	5.84±0.05	61.14±0.05
20. CUML2	18.18±0.06	5.04±0.05	3.16±0.05	4.09±0.03	60.66±0.06
21. CUML3	17.19±0.03	4.85±0.05	3.18±0.05	5.04±0.05	59.91±0.07
22. CUML4	19.58±0.07	6.01±0.05	3.28±0.05	5.85±0.05	60.38±0.08
23. CUSL2	18.15±0.07	5.21±0.05	2.89±0.05	5.27±0.10	60.27±0.08
24. CUSL3	18.81±0.07	5.95±0.05	3.12±0.05	5.66±0.05	61.57±0.07
25. CUSL4	19.94±0.06	5.99±0.05	3.35±0.05	5.91±0.07	61.65±0.06
CD	0.06	0.10	0.04	0.07	

201.92 mg/100g followed by WBG29 (201.78 mg/100g) and Digbijoy (201.76 mg/100g). Similar results in calcium contents of desi and kabuli chickpeas were in accordance with Gopalan *et al.*, (2007) and Wang and Daun (2004). There was a significant difference between the kabuli and desi germplasms in calcium content, with desi types having a higher content than kabuli types. Human also suffered considerably from diseases caused by calcium deficiency. Adequate levels of calcium are very essential to maintain the skeletal structure, cell signaling, blood clotting, muscle contraction and nerve function.

Phosphorus:

Chickpea germplasms contained phosphorus ranging from 312.89-315.30 mg/100g. IC268966 recorded highest phosphorus content 315.30 mg/100g followed by CUML4 (315.29 mg/100g) and CUSL4 (315.28 mg/100g). Gopalan *et al.*, (2007) and Wang and Daun (2004) found similar results. There was no significant difference found between the kabuli and desi germplasms in phosphorus content. Phosphorus is an essential mineral primarily required for growth and repair of body cells and tissues. Without sufficient phosphorus, body protein manufacture is impaired, which eventually affects overall health.

Carotenoid:

The carotenoid content in chickpea germplasms varied from 189.01-190.61 µg/100g. The highest amount of carotenoid was found in CUML4 (190.61 µg/100g) followed by CUSL4 (190.60 µg/100g) and

TABLE 3. Micronutrient contents in high yielding chickpea germplasms

Germplasms	Vitamin C (mg/100g)	Carotenoid (µg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)
1. Digbijoy	3.43±0.03	189.03±0.05	201.76±0.05	315.06±0.04
2. Dcp-92-3	2.49±0.05	189.06±0.04	198.51±0.05	314.11±0.05
3. Avrodhi	2.94±0.07	189.05±0.05	198.33±0.04	313.07±0.05
4. Radhey	2.28±0.05	189.24±0.05	198.40±0.05	314.22±0.05
5. Pant -G186	2.36±0.05	189.23±0.05	198.55±0.04	314.20±0.05
6. GNG 469	2.92±0.05	189.04±0.05	198.45±0.05	313.31±0.05
7. Virat	3.44±0.03	189.53±0.05	201.92±0.05	315.07±0.05
8. B116	2.58±0.05	189.08±0.05	198.93±0.05	314.21±0.05
9. BR 78	2.56±0.04	189.15±0.05	200.49±0.03	314.25±0.05
10. WBG 29	3.38±0.05	190.32±0.05	201.78±0.05	315.09±0.04
11. Annigeri	3.59±0.04	189.72±0.05	201.71±0.05	315.10±0.06
12. RSG 888	3.09±0.03	190.35±0.05	200.76±0.06	313.33±0.05
13. HC5	2.62±0.05	189.63±0.05	200.92±0.05	313.36±0.02
14. JG 74	2.69±0.05	189.17±0.04	199.89±0.04	314.19±0.05
15. L 550	3.45±0.02	189.01±0.05	198.26±0.04	315.20±0.05
16. IC 268966	3.52±0.05	190.43±0.05	201.65±0.03	315.30±0.05
17. Rajesh	2.72±0.04	190.06±0.05	199.07±0.05	314.84±0.05
18. BGM408	3.67±0.04	190.53±0.05	201.40±0.05	315.15±0.05
19. CUML1	3.62±0.04	190.55±0.05	201.51±0.05	315.08±0.04
20. CUML2	3.18±0.05	190.11±0.05	200.51±0.04	314.29±0.05
21. CUML3	2.94±0.05	189.80±0.05	199.61±0.06	313.35±0.05
22. CUML4	3.50±0.04	190.61±0.05	201.35±0.05	315.29±0.05
23. CUSL2	3.24±0.03	190.09±0.05	200.63±0.05	312.89±0.03
24. CUSL3	3.22±0.05	190.34±0.05	199.45±0.05	314.07±0.05
25. CUSL4	3.55±0.05	190.60±0.05	201.53±0.04	315.28±0.05
CD	**0.49**	**0.13**	**0.14**	**0.02**

CUML1 (190.55 µg/100g). Similar results have been reported by Ashokkumar et al., (2015) and Ashokkumar *et al*., (2014). It protects from skin disorders and several types of cancer (Ashokkumar *et al.*, 2015). In addition, carotenoids help to decrease the lipid peroxidation by efficiently scavenging free radicals and preventing cellular membranes and DNA from oxidative damage (Ashokkumar *et al*., 2015).

Vitamin C:

Chickpea had higher vitamin C content varying from 2.28-3.67 mg/100g. BGM408 recorded highest vitamin C content (3.67 mg/100g) followed by CUML1 (3.62 mg/100g) and Annigeri (3.59 mg/100g). Similar results were in accordance with Gopalan *et al*., (2007) and Sood and Malhotra (2001). Vitamin C is required in the maintenance of body functions. Furthermore, it also helps to maintain the redox balance; hence it could be used in the treatment of chronic degenerative diseases, autoimmune diseases and cancer (Méndez and Arancibia, 2015).

Based on all the studied macro and micro nutrients in high yielding chickpea germplasms, the germplasms namely CUSL4, IC268966 and Annigeri exhibited high amount of both macro and micronutrients and high seed yield plant^{-1}. Hence, these germplasms could be utilized as a promising germplasm in respect of food quality as well as yield in the global market in future. While the germplasms namely, Rajesh, CUML2 and DCP-92-3 exhibited high seed yield but their nutritional qualities were very poor. These germplams could be used for hybridization programme for better enhancement of quality in future.

Conclusion:

This present study revealed the potential nutritional importance of chickpea and its role in improved nutrition and health. The presence of micronutrients in chickpea helps to maintain the proper physiological functions in the body and lower the risk various chronic diseases. Considering all the micronutrients and yield performances, CUSL4, IC268966 and Annigeri were the top three chickpea germplasms. Conclusively, it can be said that high productive chickpea germplasms with superior nutritional qualities has been identified from this study which could meet the nutritional requirements of the world population, particularly those of the developing and under developing nations.

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Heterosis Study in Sunflower for Yield Attributing Traits

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Abstract

The development of new high yielding and stable sunflower hybrids based on hybridization which requires information on the heterotic effects for agronomically important traits in the F_1 generation. Heterotic effects for seed yield and it's attributing traits *viz.,* plant height and head diameter, number of seeds per head, seed filling %, 100 seed weight (g), 100 seed kernel weight (g), volume weight(g/100cc), hull content(%), oil content(%) and oil yield (kg/ha) were studied in the sunflower hybrids developed by the line x tester method. The male restorer inbreds with good combining abilities were used as testers in the form of fertility restorers. The inbred lines and their F_1hybrids differed significantly in their mean values of the traits under the present study. There are significant differences among the sunflower genotypes (inbred lines and F1 hybrids) we tested with regard to the mean values of all the traits involved indicating considerable amount of heterosis foe most of the traits except hull content(%), oil content and seed filling per cent. Most of the crosses exhibited high heterosis especially for number of seeds per head seed yield (kg/ha) and oil yield(kg/ha). However, mean heterosis was comparatively low for hull and oil contents. The study on heterosis in sunflower showed that the crosses with favorable characteristics such as oil and seed yields, oil and hull contents could be bred from correctly selected parents. The cross CMS-853A X EC-623027 reached the breeding aim mentioned above, especially for high vigor in seed and oil yields. CMS-103 A X EC-601878 and PET-89-1A X EC-601878 showed the negative heterosis for thin hull rate and high oil content.

The evaluation of inbred lines based on all three criteria of heterosis showed that the crosses of the female line 853-A and the male line EC-623027, revealed higher hybrid vigor in cross combination than the other lines regarding the characteristics examined in this research. The male line EC-601878 and EC-601751 with regard to all measured traits, the female line CMS- 852 A, CMS-103A and P-89-1A with regard to seed and oil yields and the female lines CMS-103A and CMS-852A with regard to high oil content and low hull rate could be used for increasing hybrid vigor in future sunflower breeding programs.

Based on average heterotic values of inbred lines, negative results were obtained in almost all of them for oil content. The ranking of the female lines was CMS-103A, CMS-850-A, and PET-89-1A for regular heterosis for the same trait. The ranking of the restorer lines was EC-601718, EC-601751 and EC-601725 for regular heterosis for the same trait. heterosis,

Keywords **:** heterosis, heterobeltiosis, seed yield, sunflower, yield components.

Introduction

The main objectives of sunflower breeding programs are the development of productive F1 hybrids with high seed and oil yield. Sunflower oil yield is determined as the product of seed yield per unit area and the oil percentage in grains. Therefore, consideration of both components is important when breeding for high oil yield. National sunflower hybrid (development of new hybrid) breeding programme is a continuous programme which started in our country early 1980s. Sunflower hybrid breeding was started economically in discovering **CMS** by Leclercq in 1960 and restorer genes by Kinman in 1970 (Miller and Fick, 1997).

Heterosis of these crops has been exploited only over the past few decades. Hybrid sunflower became a reality with the discovery of cytoplasmic male sterility and effective male fertility restoration system during 1970. Hybrid vigor has been the main driving force for acceptance of this oilseed crop. Utilization of heterosis has allowed sunflower to become one of the major oilseed in many countries of Eastern and Western Europe, Russia and South America and is an important crop in the USA, Australia, South Africa, China, India and Turkey. Sunflower hybrid breeding has thus played a vital role in improvement of this crop. Increasing seed and oil yields is the top priority of most sunflower breeding programs. Getting benefit from use of heterosis is the main purpose in sunflower hybrid breeding. In this study, effort has been made to discuss the various approaches for hybrid breeding in sunflower and present status for development of high yielding hybrids in sunflower with high seed and oil yield. The present study has been carried out to with the specific objectives to determine performance of sunflower varieties and to measure the vigor of sunflower hybrids in different location and year to identify one /few high yielding Sunflower hybrids with at least 10-12 higher seed and oil yield over best national check and suitable for cultivation in *rabi* season. In India, the sunflower is grown on about 0.7 million ha (Anonymous, 2016) and mostly grown in the states of Karnataka, Maharastra, AP and Tamil Nadu with potential scope of growing in the non-traditional areas like West Bengal (Dutta, 2011). In West Bengal, Sunflower is second important oilseed crop after rapeseed-mustard during *rabi*-summer season and it was grown on about 21,000 ha in last *rabi* season (2016-17). Due to short winter spell and delayed and heavy rainfall during rainy season, the sowing of mustard was delayed which ultimate reduced the production of rapeseed-mustard. The delayed sowing also invites the insect pests in most of the years. Sunflower being a photoperiod natural crop has wide scope to replace the rapeseed-mustard cultivation with high yield potentiality.

Materials and Methods

The present experiment was started in 2014-15 with aimed to breeding and evaluate the performance of the sunflower hybrids in respect to yield and yield component and To identify the superior sunflower hybrids suitable for *rabi-summer* season in West Bengal agro-climatic condition. The objective(s) of the present study was identify the good heterotic combinations, and to study the Heterosis and Heterobeltiosis. The crossing was affected in the line x tester fashion and the resultant hybrids were subjected to combining ability studies. The genotypes were raised in Randomized Block Design with two replications where in each replications were represented by three rows of three meter length. The soil texture was clay loam in "On station" plots. Three irrigations were provided during the cropping period. One foliar spray was given with Boron (@ 2g/lit. of water in ray floret stage. The row per plot were five in number with a row spacing of 60 cm and plant to plant spacing was 30 cm. Uniform dose of fertilizer @80 kg N,40 Kg P_2O_5 and 40 kg K_2O per ha was applied. The germinated seed of sunflower used as the planting materials and one per hill were maintained throughout the cropping period. The data was recorded in ten randomly selected plants from each plot of all replications on the following characters viz., days to 50% flowering, days to maturity, plant height at harvest (cm), head diameter per plant (cm), seed weight per head (g), 100-seed weight (g), husk (hull) content (%), volume weight (g/100cc). The seed yield (kg/ha), oil percentage and oil yield (kg/ha) were estimated on plot basis. The mean values were subjected to statistical analysis. In the very first year (2014-15), 56 of hybrids (developed from line X tester matting design) were evaluated and next year, 2015-16 and 2016-17, 56 superior hybrids were tested along with the two national checks LSFH-171 and DRSH-1 were evaluated for performance (seed&/ Oil yield) higher at research farm under AICRP Sunflower, Nimpith Centre in Randomized complete block design with three replications. The data pertaining to seed yield and other yield attributing traits for these test hybrids along with the checks are presented in **Table 3**.

Results and Discussion

Significant genotypic differences were existed for all the agronomic traits among the lines, testers

TABLE 1. Analysis of Variance parents and hybrids (Mean squares) for Combining ability

Source of variation	d.f.	Days. to 50% flowering	Plant height	Head Dia.	No. of Filled Seeds/hd	**Gr. Filling %**	100 seed weight	Hull Cont%	Vol. Wt. (g/100cc)	Oil cont. %	Seed Yield./Pl	Seed yield/ (Kg/ha)	Oil Yield (Kg/ha)	100 kernel Wt(g)
Location	1	212.46	2978.5**	28.01	14545.1**	176.9	1.182	26.22	39.01	10.58	147.1**	441289.2**	35704.6**	0.250
Repl./Loc	2	27.14	540.8	9.03	6907.4	26.21	2.887	5.93	19.17	18.21	47.34**	143396.6*	47090.2	1.870
Line	7	194.04**	9449.0**	25.2**	21097.7**	36.11**	3.522	57.04**	35.63**	9.49**	650.2**	1965372.0**	229786.2**	1.641**
Tester	6	74.85**	4816.9**	20.23**	17476.8**	17.35**	0.640	55.80**	14.16**	6.49*	317.1**	958346.7**	108418.7**	0.547**
Line X Tester	42	31.86**	510.12**	21.50**	27690.3**	10.51**	0.654	16.30**	13.60**	2.38	58.32	176794.2**	21047.8**	0.394**
Line X LC	7	0.382	6.92	0.031	286.2	0.216	0.004	0.034	0.028	0.007	0.482**	1501.09	116.0	0.0009
Tes X LC	6	0.360	4.27	0.036	69.14	0.199	0.003	0.009	0.033	0.004	0.453	1278.4	114.6	0.001
L X T X LC	42	0.290	2.37	0.026	80.30	0.015	0.002	0.054	0.010	0.005	0.247	752.3	80.27	0.0008
Error	110	0.002	0.261	0.002	155.21	0.029	0.003	0.008	0.006	0.002	0.034	98.22	28.83	0.001

- ***Significant at 5% level; ** Significant at 5% level.**

TABLE 2. Parental mean for yield and yield attributing characters

Name of the parent	**Days to 50% Flow.**	**Pl. Ht. (cm)**	**Hd.Dia. (cm)**	**Seed Yield (kg/ha)**	**100 seed wt.(g)**	**100 kernel weight**	**Hull. Cont. (%)**	**No. of filled grains/Hd.**	**Gr. Filling %**	**Vol. Wt (g/100cc)**	**Oil%**	**Oil Yield (kg/ha)**
CMS Line(L)												
CMS-853A	67.9	118.6	11.5	1385.0	5.7	3.98	30.2	298.0	83.3	42.8	36.2	774.9
CMS-852A	65.6	123.5	11.8	1140.0	5.0	3.40	32.1	280.0	86.8	42.2	35.6	791.8
CMS-850A	66.0	116.0	12.8	1090.0	4.9	3.48	28.9	286.0	90.2	42.0	35.4	605.2
CMS-103A	65.0	129.3	12.3	1035.0	5.3	3.90	26.5	321.0	87.8	45.4	36.2	516.4
PET-2-7-1A	70.4	131.8	13.2	1150.0	5.5	3.68	33.1	364.0	86.9	43.7	35.2	740.5
CMS-207A	68.8	136.0	12.6	1100.5	4.6	3.14	31.8	478.0	88.0	40.4	35.4	677.8
PET-89-1A	71.0	107.8	10.5	1210.0	4.9	3.46	29.3	408.0	84.0	45.4	35.2	704.6
CMS-10A	69.4	141.9	12.4	1225.0	5.3	3.64	31.4	340.0	87.1	42.1	34.0	647.4
Range	**65.0 -71.0**	**107.8-141.9**	**10.5-13.2**	**1035.0-1385.0**	**4.6-5.7**	3.14-3.98	**26.5-33.1**	**340.0 - 478.0**	**83.3-90.2**	**40.4-45.4**	**34.0-36.2**	**516.4-774.9**
GM	**68.01**	**125.61**	**12.14**	**1166.9**	**5.15**	**3.58**	**30.41**	**346.88**	**86.76**	**43.00**	**35.40**	**682.34**
SEm(±)	**1.1**	**2.2**	**0.3**	**36**	**0.17**	**0.08**	**0.9**	**18**	**1.6**	**0.8**	**-**	**12.6**
C.D.(P=0.005)	**3.2**	**6.2**	**0.8**	**108**	**0.52**	**0.21**	**2.8**	**54**	**4.8**	**2.4**	**NS**	**36**
C.V.(%)	**7.7**	**8.4**	**6.8**	**9.4**	**6.2**	**7.6**	**7.1**	**9.2**	**6.1**	**5.4**	**-**	**8.8**
R line(T)												
EC-623027 (M)	71.5	104.8	9.9	1020.0	5.6	4.14	26.0	393	77.5	45.3	38.9	718.1
EC-623023	71.3	95.8	7.5	825.0	5.3	3.76	29.1	283	85.2	43.0	38.2	706.4
EC-623021	64.0	87.4	8.6	780.0	5.0	3.53	29.5	262	87.5	42.0	42.5	671.6
EC-601978	66.3	87.4	11.6	770.0	4.9	3.45	29.6	286	87.9	42.9	42.5	727.8
EC-601751	62.0	91.2	9.0	720.0	5.4	3.78	30.0	256	85.5	43.0	42.0	563.8
EC-601725	70.5	84.2	9.8	880.0	5.2	3.50	32.7	308	83.0	44.6	41.8	731.9
EC-623016	69.8	86.2	6.4	690.5	5.1	3.62	29.0	235	86.3	41.5	41.5	656.8
Range	**62.0-71.5**	**84.2-104.8**	**6.5-11.6**	**690-1020**	**4.9-5.6**	**3.53-4.14**	**26.0-32.7**	**256-393**	**77.5-87.9**	**42.0-45.3**	**38.2-42.5**	**563.3-773.9**
GM	**67.91**	**91.00**	**8.97**	**812.2**	**5.21**	**3.68**	**29.41**	**289.00**	**84.70**	**43.19**	**41.1**	**682.35**
SEm(±)	**1.4**	**2.8**	**0.4**	**41.5**	**0.14**	**0.05**	**1.1**	**16.2**	**1.58**	**0.82**	**0.94**	**14.2**
C.D.(P=0.005)	**4.2**	**8.6**	**1.1**	**120**	**0.42**	**0.17**	**3.4**	**48**	**4.6**	**2.4**	**2.8**	**41.6**
C.V.(%)	**5.8**	**7.2**	**6.1**	**8.8**	**5.5**	**6.8**	**6.4**	**8.2**	**6.6**	**5.8**	**8.5**	**8.6**

TABLE 3. Sunflower hybrids (F_1s) mean for different yield and yield attributing characters

Sl. No	Hybrid combination Flow.	50% (cm)	Pl. Ht (cm)	Hd. Dia. (kg/ha)	Seed Yield Filled Grain/Hd	No. of my %	Autoga wt(g)	100 seed Wt (g)	100 Kernel Cont.%	Hull (g/100cc)	Vol. Wt. (Kg/ha)	Oil%	Oil Yield
1.	CMS-853 A X EC-623027(mono)	75.0	184.5	16.2	2462.0	731.5	87.0	6.1	4.1	32.1	42.8	35.7	879.0
2.	CMS-853 A X EC-623023	74.5	176.5	15.9	2428.0	746.0	87.5	5.9	4.1	29.8	43.0	35.6	864.5
3.	CMS-853 A X623021	73.5	170.0	15.7	2292.0	792.5	87.0	5.6	4.0	27.8	43.7	36.4	834.5
4.	CMS-853 A X EC601751	69.0	158.0	15.4	1861.0	660.0	91.5	5.3	3.9	27.3	42.6	36.8	685.0
5.	CMS-853 A X EC601978	68.5	145.0	15.5	1575.5	543.5	86.5	5.4	4.0	24.8	45.3	37.4	589.0
6.	CMS-853 A XEC601725	75.5	182.5	16.1	2278.0	805.0	87.0	5.5	3.7	33.1	40.0	35.2	802.0
7.	CMS-853 A X623016	72.0	160.5	15.0	2072.0	682.5	87.5	5.5	3.8	31.9	43.8	37.2	770.5
8.	CMS-852A X EC-623027(mono)	76.0	175.0	15.1	2270.0	855.5	92.0	4.9	3.4	29.8	40.0	35.8	813.0
9.	CMS-852A X EC-623023	76.0	170.0	15.4	2328.0	935.0	88.5	4.6	3.0	34.6	43.2	36.1	840.5
10	CMS-852A X EC-623021	77.5	174.0	15.4	2272.0	839.0	91.0	5.0	3.5	29.8	40.0	35.8	813.5
11.	CMS-852A X EC-601751	72.5	160.1	15.4	2284.0	879.0	90.0	4.8	3.3	31.1	41.6	36.4	831.5
12.	CMS-852A X EC-601978	66.0	153.0	15.0	1761.0	637.5	91.5	5.1	3.7	27.3	42.6	36.8	648.0
13.	852A X EC-601725	70.5	155.0	16.7	2072.0	682.5	87.5	5.5	3.8	31.9	43.8	37.2	770.5
14.	852A X EC-623016	73.0	175.5	15.3	2306.0	720.5	88.5	5.8	4.3	25.2	42.7	35.8	825.5
15.	850AX EC-623027 (M)	69.0	133.0	15.2	1861.0	673.5	91.5	5.1	3.7	27.3	42.6	36.8	685.0
16.	850A X EC-623023	64.0	122.5	13.8	1472.0	605.0	91.0	4.5	3.1	30.9	43.6	38.4	565.0
17.	850AX EC-623021	63.0	112.0	13.2	1340.0	516.0	90.0	4.8	3.4	29.0	42.2	37.2	498.5
18.	850A X EC-601751	69.0	133.0	15.4	1861.0	673.5	91.5	5.1	3.7	27.3	42.6	36.8	685.0
19.	850A X EC-601978	65.0	92.5	9.6	1500.0	553.5	94.0	5.0	3.6	27.8	39.7	37.0	555.0
20.	850A XEC-601725	69.0	112.0	13.7	1836.0	664.5	91.5	5.1	3.7	27.3	42.6	37.2	683.0
21.	850X EC-623016	68.0	122.5	13.3	1472.0	605.0	91.0	4.5	3.1	30.9	43.6	38.4	565.0
22.	CMS-103AX EC-623027(M)	67.5	138.5	13.5	1350.0	476.0	89.0	5.1	3.3	34.4	43.2	38.7	518.5
23.	103A X EC-623023	67.0	135.0	12.7	1340.0	516.0	90.0	4.8	3.4	29.0	42.2	37.2	498.5
24.	103AX EC-623021	66.0	132.0	12.7	1348.0	516.0	90.0	4.8	3.4	29.0	42.2	37.2	499.5
25.	103A X EC-601751	67.0	130.1	13.4	1472.0	533.0	91.5	5.1	3.5	30.3	42.6	36.8	541.5
26.	CMS-103A XEC-601978	66.0	124.5	12.8	1533.0	487.5	90.5	5.7	4.4	23.6	48.5	38.4	589.0
27.	103A X EC-601725	62.5	120.5	12.2	1232.0	484.5	91.0	4.7	3.3	29.8	43.4	38.1	469.5
28.	CMS-103AX EC-623016	64.0	124.0	12.7	1340.0	485.0	90.0	5.1	3.5	31.0	42.2	37.2	498.5
29.	P-2-7-1A X EC-623027	73.0	184.0	16.4	2094.0	743.0	89.0	5.1	3.3	34.4	43.2	37.0	775.0
30.	P-2-7-1A X EC-623023	68.0	145.5	15.7	2192.0	735.5	88.5	5.4	3.7	32.5	43.5	37.6	824.5
31.	P-2-7-1A X EC-623021	70.0	168.5	14.9	1872.0	514.5	90.0	6.6	4.4	33.6	42.4	37.8	707.5
32.	CP-2-7-1AX EC-601751	76.0	177.5	15.8	2340.0	770.5	87.5	5.5	3.8	31.9	42.6	35.2	824.0
33.	P-2-7-1AX EC-601978	64.5	137.5	11.5	1340	457.5	90.0	5.3	3.6	30.8	45.6	38.7	518.5
34.	P-2-7-1AX EC-601725	68.0	145.5	15.7	2192.0	735.5	88.5	5.4	3.7	32.5	43.5	37.6	824.0
35.	P-2-7-1AX EC-623016	70.0	155.5	14.9	1878.0	501.0	90.0	6.8	4.5	33.6	42.4	37.8	710.0
36.	207AX EC-623027	63.5	142.5	14.0	1567.0	616.0	92.0	4.7	3.1	32.6	39.6	39.0	611.5
37.	207A X EC-623023	73.0	142.5	14.7	2194.0	922.0	88.0	4.4	3.1	29.3	39.9	36.4	799.0
38.	207-1A X EC-623021	70.5	167.0	14.4	1886.0	696.5	90.0	5.0	3.3	33.8	38.0	37.5	707.5
39.	207AX EC-601751	68.0	145.5	15.7	1962.0	658.0	88.5	5.4	3.7	32.5	43.5	37.6	737.5

40.	207AX EC-601978	67.0	115.0	13.5	1431.0	498.0	90.5	5.2	3.5	31.9	39.2	38.5	551.0
41.	207AX EC-601725	71.5	172.5	14.8	2017.0	776.0	86.0	4.8	3.2	33.1	40.0	36.8	742.5
42.	207AX EC-623016	68.5	153.0	14.0	1547.0	665.5	92.0	4.3	2.9	32.4	40.2	38.5	596.0
43.	P-89-1AX EC-623027(M)	73.5	180.0	15.6	2218.0	911.0	88.0	4.5	3.1	30.9	45.1	37.6	834.0
44.	P-89-1A X EC-623023	73.0	168.5	15.0	1974.0	793.0	89.0	4.6	3.1	31.6	39.7	36.8	726.5
45.	P-89-1A A X EC-623021	71.0	148.5	14.2	1856.0	714.0	89.0	4.8	3.3	31.6	39.7	36.8	683.0
46.	P-89-1A AX EC-601751	71.0	154.0	15.1	2144.0	761.0	85.5	5.1	3.5	30.6	45.5	37.4	802.0
47.	P-89-1A AX EC-601978	68.5	123.0	12.0	1445.0	533.5	91.5	5.0	3.7	25.8	45.2	38.8	561.0
48.	P-89-1A X EC-601725	73.0	148.5	15.0	1960.0	787.5	89.0	4.6	3.1	31.6	39.7	36.8	721.5
49.	P-89-1AX EC-623016	67.0	136.5	13.9	1611.0	583.0	90.0	5.1	3.4	33.1	41.0	37.5	604.5
50.	10AX EC-623027	72.5	167.5	15.4	1722.0	577.5	88.0	5.4	3.7	30.6	40.8	36.5	628.5
51.	10A X EC-623023	64.0	154.0	14.6	1380.0	531.0	92.0	4.8	3.4	29.0	42.2	38.6	532.5
52.	10A A X EC-623021	71.5	162.5	15.2	1722.0	577.5	88.0	5.4	3.7	30.7	40.8	36.5	628.5
53.	10AX EC-601751	73.5	142.5	14.7	1967.0	826.5	87.0	4.4	3.0	31.6	39.6	36.4	716.0
54.	10AX EC-601978	64.5	119.0	12.8	1306.0	482.5	92.0	5.0	3.5	29.8	40.3	38.2	499.0
55.	10AX EC-601725	70.5	156.5	15.4	2240.0	795.0	86.0	5.1	3.4	32.5	44.6	37.6	842.5
56.	10AX EC-623016	68.0	145.5	15.0	1792.0	601.0	87.5	5.4	3.7	32.5	41.5	38.2	685.0
	G. Mean	**69.6**	**148.8**	**14.5**	**1840.5**	**661.8**	**89.4**	**5.1**	**3.6**	**30.6**	**42.2**	**37.2**	**682.3**
	Range	**64-76**	**112.0 - 184.5**	**9.6-16.4**	**1232 - 2462**	**476 -935**	**87.0-94.0**	**4.4 -6.8**	**3.1 - 4.4**	**24.8-34.6**	**38.0-48.5**	**35.2-38.5**	**498.5-879.5**
	LSFH-171(Ch-1)	**80.0**	**194.0**	**15.6**	**2256**	**634**	**85.5**	**5.24**	**3.24**	**38.1**	**38.78**	**33.7**	**760**
	DRSH-1(CH-2)	**75.0**	**168.7**	**14.8**	**1978**	**557**	**87.2**	**5.68**	**3.76**	**34.5**	**41.36**	**38.0**	**751**
	SEm(±)	**1.1**	**6.3**	**0.34**	**30.1**	**20.3**	**0.5**	**0.2**	**0.15**	**0.5**	**0.9**	**0.7**	**23.2**
	C.D.(P=0.005)	**3.1**	**6.8**	**1.0**	**90.2**	**60.4**	**1.5**	**0.6**	**0.45**	**1.4**	**2.7**	**2.1**	**68.6**
	C.V.(%)	**6.8**	**9.2**	**6.1**	**9.6**	**9.2**	**7.5**	**5.8**	**6.5**	**8.2**	**7.1**	**8.2**	**9.4**

and hybrids. The analysis of variance shows significant differences among the genotypes for all the above said characters studied. Hybridization helps to augment the desirable genes of various parents in one combination. Irrespective of general combining ability of the parents, certain combination of parents can give superior hybrids (Table-3). Among the sunflower hybrids, for days to 50% flowering, the heterosis was observed from -7.33 per cent (CMS-207AX EC-623027(M)) to 20.37 per cent (CMS-10AX EC-601751), for plant height, the heterosis was ranged from 13.10 per cent (CMS-207AX EC-601978) to 123.2 per cent (CMS-853 A X EC-623027(Mono), for head diameter , the heterosis was ranged from 19.90 per cent (CMS-103A X EC-601725) to 101.02 per cent (CMS-10AX EC-623016), for seed yield(kg/ha), heterotic variation was observed from 42.3 per cent (P-2-7-1AX EC-623016) to 241.3 per cent (CMS 10AX EC-601725), for number of filled seed/head, the heterotic variation was observed from 56.1 per cent (CMS-850AX EC-623021) to 277.3 per cent (P-2-7-1AX EC-601751), for seed filling %, the heterosis was ranged from -3.47 per cent (CMS-853 A X EC601978) to 40.77 per cent (CMS-853 A X EC601751), for100 seed weight(g) the heterosis was ranged from -8.49 per cent (CMS-852A X EC-623027(mono) to 29.14 per cent (CMS-850A X EC-601978), for 100 seed kernel weight(g) the heterotic variation was observed from -20.14 per cent (CMS-207AX EC-623016) to 67.9 per cent (CMS-850A X EC-623016), for hull content, the heterosis was ranged from -14.46 per cent (CMS-103A X EC-601978) to 26.06 per cent (CMS-103A X EC-623027); for volume weight(g/100 cc) the heterotic variation was observed from -12.68 per cent (CMS-207AX EC-623027) to 31.10 per cent (P-2-7-1AX EC-601978); for oil content %, the heterotic variation was observed from -14.92 per cent (CMS-853 A X623016) to 8.98 per cent (P-2-7-1A X EC-601751); for oil yield (kg/ha), heterotic variation was observed from 71.5 per cent (CMS- EC-623021) to 223.8 per cent (CMS-10AX

TABLE 4. Heterobeltiosis and Heterosis of sunflower hybrids for yield and yield attributing characters

Sl. No	Hybrid combination	Days to 50% Flow.		Pl. Ht (cm)		Hd. Dia.(cm)		Seed Yield (kg/ha)		No. of Filled Grain/Hd		Gr. Fil.%	
		h^2 BP	h^2 MP	h^2 BP	h^2 MP	h^2 BP	h^2 MP	h^2 BP	h^2 MP	h^2 BP	h^2 MP	h^2 BP	h^2 MP
1.	CMS-853 A X EC623027(mono)	**3.91**	6.91**	**72.30****	123.28**	53.27 **	68.02**	101.74**	170.1 **	90.00**	140.5**	3.86	8.84*
2.	CMS-853 A X Ec623023	**9.42** *	12.58**	52.09 **	78.74**	61.98 **	74.30**	119.73 **	192.03 **	106.65 **	164.2**	1.87	7.68*
3.	CMS-853 A X623021	**10.37** **	13.60**	37.11 **	66.73**	56.22 **	66.53**	111.73 **	182.0 **	119.38 **	172.7**	6.89 **	7.32*
4.	CMS-853 A X EC601751	**6.15** *	6.00**	31.74 **	48.50**	33.33 **	55.44**	72.71 **	136.1 **	82.19 **	180.1**	2.49	40.77**
5.	CMS-853 A XEC601778	**6.72** *	10.27**	27.30 **	38.96**	51.22 **	**75.33****	49.69 **	92.4 **	59.50 **	73.06**	4.63	**3.47**
6.	CMS-853 A XEC601725	**11.03** **	14.24**	57.76 **	87.39**	53.99 **	67.54**	101.15 **	175.0 **	115.67 **	214.4**	3.18	35.24**
7.	CMS-853 A X 623016	**5.49** *	8.55**	35.04 **	51.08**	46.60 **	64.79**	99.71 **	148.1 **	99.27 **	192.8**	11.99 **	**34.30****
8.	CMS-852A X EC-623027(M)	**10.14** **	13.31**	38.31 **	65.07**	32.17 **	43.66**	110.19 **	175.4 **	130.44 **	188.5**	2.91	12.61**
9.	CMS-852A X EC-623023	**12.18** **	15.43**	46.38 **	66.00**	54.17 **	65.29**	136.95 **	212.8 **	169.26 **	240.5**	4.42	6.57*
10	CMS-852A X EC-623021	**16.98** **	**20.39****	60.61 **	76.57**	50.98 **	61.07**	136.67 **	213.2 **	141.44 **	205.2**	3.03	9.84**
11.	CMS-852A X EC-601751	**13.73** **	13.50**	39.52 **	60.06**	31.62 **	53.45**	139.16 **	225.8 **	152.22 **	292.8**	6.21 **	34.77 **
12.	CMS-852A X EC601878	**0.38**	3.77	40.98 **	57.71**	44.23 **	67.38**	89.35 **	140.7 **	94.95 **	109.8**	3.06	7.19*
13.	852A X EC-601725	**5.62** *	8.68*	47.62 **	51.12**	54.63 **	68.48**	105.15 **	179.5**	89.85 **	184.8**	2.25	32.35**
14.	852A X EC-623016	**8.96** *	12.14**	45.57 **	65.44**	46.13 **	65.83**	152.02 **	208.4 **	119.16 **	221.2**	9.12 **	32.23**
15.	850AX EC-623027	**-0.36**	7.17**	19.15 **	38.16**	33.92 **	64.72**	76.40 **	119.2 **	82.89 **	91.3**	3.76	11.96**
16.	850A X EC-623023	**-5.88***	1.35	14.41 **	32.24**	35.63 **	71.88**	53.73 **	91.4 **	75.74 **	83.2**	1.29	9.58*
17.	850AX EC-623021	**-5.26** *	2.16	8.92 *	26.68**	23.36 **	59.69**	43.32 **	78.6 **	49.78 **	56.1**	2.75	8.59*
18.	850A X EC-601751	**7.81** *	12.77**	29.35 **	47.07**	26.23 **	75.95**	100.11 **	156.4 **	94.93 **	141.2**	7.00 *	36.98**
19.	850A X EC-601878	-1.52	6.68*	-11.69 **	13.88**	-11.93 **	24.87**	65.75 **	98.4 **	54.83 **	74.1**	5.66 *	10.05**
20.	850A XEC-601725	2.99	10.98**	10.64 **	29.08**	21.24 **	58.46**	86.40 **	139.8 **	86.40 **	124.3**	3.12	38.37**
21.	850X EC-623016	1.12	8.92*	19.83 **	35.68**	38.54 **	67.42**	65.39 **	90.5 **	85.73 **	115.4**	7.68 *	35.95**
22.	CMS-103AX EC-623027	-1.82	0.99	17.05 **	20.23**	21.62 **	25.24**	30.41 **	70.3 **	39.41**	73.3**	4.05	8.23*
23.	103A X EC-623023	-0.74	2.11	18.66 **	21.03**	27.96 **	32.98**	44.09 **	89.6 **	62.52 **	103.1**	2.68	7.74*
24.	103AX EC-623021	0.00	2.91	16.52 **	22.98 **	21.53 **	29.67**	47.66 **	94.8 **	62.39 **	102.8**	4.15	7.97*
25.	103A X EC-601751	-5.51 *	5.26	10.74 **	18.91 **	12.13 **	30.17**	63.10 **	121.8 **	67.22 **	162.4**	4.44	36.01**
26.	103A XEC-601978	0.76	4.14	11.71 **	24.34 **	20.19 **	38.80**	74.70 **	120.9 **	64.00 **	72.9**	6.56 *	5.38**
27.	103A X EC-601725	-6.02 *	-3.30	11.65 **	14.02**	10.41 **	19.90**	28.67 **	75.1 **	46.93 **	120.2**	3.39	36.62**
28.	CMS-103AX EC-623016	-4.12	-1.35	7.84 **	13.53	25.83 **	34.05**	55.36 **	88.7 **	62.21 **	137.0**	8.27*	33.48**
29.	P-2-7-1A X EC-623016	2.10	8.11*	53.85 **	82.18	41.99 **	74.86**	93.00 **	145.9 **	109.89 **	168.7**	2.85	12.66**
30.	P-2-7-1A X EC-623023	-3.20	2.54	26.47 **	49.43**	51.33 **	91.85**	121.97 **	184.2 **	122.88 **	188.5**	3.21	10.19**
31	P-2-7-1A X EC-623021	1.82	11.13**	52.08 **	86.95**	36.70 **	83.87**	93.99 **	161.1 **	55.79 **	105.3**	0.11	12.67**
32	P-2-7-1AX EC-601751	14.72 **	18.14**	60.20 **	86.53**	27.42 **	77.52**	143.75 **	221.4**	132.60 **	277.3**	4.41	36.61**
33	P-2-7-1AX EC-601978	-5.49 *	0.65	21.98 **	59.99**	8.60	46.64**	43.32 **	76.6 **	47.70 **	61.2**	4.18	8.89**
34	P-2-7-1AX EC-601725	-1.81	4.08	33.24 **	59.02**	36.52 **	78.43**	115.96 **	185.4**	114.90 **	232.6**	3.93	39.60**
35	P-2-7-1AX EC-623016	0.72	6.79*	41.11 **	63.65**	52.04 **	83.86**	104.13 **	42.3 **	60.83 **	143.3**	13.93**	40.20**
36	207AX EC-623027	-11.50 **	-7.33*	12.59 **	22.15**	17.25 **	28.47**	47.80 **	84.6 **	67.28 **	93.5**	4.02	11.78**
37	**207A X EC-623023**	3.55	8.50*	18.45 **	26.09**	42.88 **	51.85**	127.89 **	185.3**	167.83 **	211.1**	4.96	5.22
38	207-1A X EC-623021	2.17	7.11*	39.24 **	53.50**	30.79 **	45.03**	52.58 **	95.40 **	102.18 **	134.8**	2.97	7.84*
39	207AX EC-601751	2.26	4.08	23.45 **	31.27**	42.08 **	50.74**	143.75**	170.3**	90.45 **	169.3**	3.86	31.31**
40	207AX EC-601978	-2.19	2.98	8.30	13.1**	38.41**	44.31**	43.32 **	89.2 **	53.65 **	105.7**	0.68	5.26

41	207AX EC-601725	2.88	7.80*	46.70 **	60.97**	31.45**	43.53**	115.96 **	163.3**	93.40**	195.6**	5.85 *	28.92**
42	207AX EC-623016	-1.79	2.92	26.00 **	38.24**	32.68 **	45.60**	74.13 **	100.2 **	117.67 **	169.4**	3.61	36.28**
43	P-89-1AX EC-623027	4.26	11.35**	47.87 **	91.70**	38.67 **	72.24**	47.80 **	174.4**	104.30 **	207.3**	6.60 *	10.02**
44	P-89-1A X EC-623023	5.42 *	12.69**	43.80 **	86.70**	48.88 **	91.18**	127.89 **	170.9**	125.91 **	188.8**	9.46*	13.55 **
45	P-89-1A A X EC-623021	4.80	12.14**	31.50 **	72.64**	33.96 **	75.59**	100.58 **	161.5**	109.10 **	159.8**	4.46	9.70*
46	P-89-1A AX EC-601751	8.81 *	13.02**	36.37 **	74.87**	24.79 **	76.35**	109.78 **	212.8**	88.14 **	242.4**	1.71	31.44**
47	**P-89-1A AX EC-601978**	1.86	9.49*	27.10 *	56.03**	11.11 **	60.00**	57.21 **	101.8 **	75.70 **	100.7**	-2.73	9.40*
48	P-89-1A X EC-601725	6.96 *	14.41**	33.39 **	76.00**	33.93 **	77.27**	103.69 **	170.2**	68.61 **	227.3**	7.02 *	38.22**
49	P-89-1AX EC-623016	-2.19	4.59	21.52 **	55.29**	46.32 **	78.88**	72.80 **	120.1 **	101.15 **	158.9**	7.23 *	38.06**
50	10AX EC-623027	5.45 *	12.81**	34.32 **	79.48**	38.12 **	76.47**	98.92 **	132.9**	61.61 **	108.3**	4.29	8.68*
51	10A X EC-623023	-5.19 *	1.53	28.17 **	71.70**	46.37 **	94.54**	94.00 **	109.2 **	54.31 **	106.8**	13.55 **	18.83**
52	10A A X EC-623021	8.33 *	16.11**	40.21 **	90.16**	44.76 **	96.03**	86.53 **	168.8**	51.61 **	125.8**	7.18*	7.98 *
53	10AX EC-601751	15.75 **	20.37**	22.95 **	62.87**	22.50 **	78.82**	116.57 **	219.12**	64.76 **	201.7**	0.57	31.78**
54	10AX EC-601978	-1.53	6.05**	10.00	52.04	19.63 **	78.53**	49.74 **	101.8**	135.14 **	68.8**	-1.02	8.73*
55	10AX EC-601725	6.02 *	13.59**	36.92 **	86.72**	38.74 **	89.27**	87.56 **	241.30**	46.21 **	258.7**	7.60 *	31.58**
56	10AX EC-623016	1.87	9.12**	26.19 **	66.56**	59.57 **	101.72 **	69.58 **	170.3**	119.31 **	191.3**	3.61	32.23**
	Lowest	-11.50	-7.33	-11.69	13.1	-11.94	24.87	43.32	42.3	39.41	56.1	-2.73	3.47
	Highest	**16.98**	**20.39**	**72.26**	**123.2**	**61.98**	**101.72**	**152.02**	**225.8**	**169.26**	**277.3**	**13.93**	**40.77**
	Crosses with positive and significant heterosis	**19**	**38**	**54**	**56**	**54**	**56**	**56**	**56**	**56**	**56**	**18**	**53**
	Crosses with nagetive and significant heterosis	**6**	**01**	**01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	SEm (±)	**0.03**	**0.02**	**0.62**	**0.53**	**0.07**	**0.06**	**11.40**	**9.87**	**8.30**	**7.20**	**0.20**	**0.17**

Continued Table:4: Heterobeltiosis and heterosis of sunflower hybrids .....attributing characters

Sl. No	Hybrid combination	100 seed wt(g)		100 kernel weight		Hull Cont.%		Vol. Wt. (g/100cc)		Oil%		Oil Yield (Kg/ha)	
		h^2 BP	h^2MP	h^2 BP	h^2MP	h^2 BP	h^2MP	h^2 BP	h^2MP	h^2 BP	h^2MP	h^2 BP	h^2MP
1.	CMS-853 A X EC-623027(mono)	5.49*	**7.96***	1.80	3.50	8.37*	10.14 **	-2.84	0.23	-4.93	-2.28	95.77**	152.1**
2.	CMS-853 A X EC-623023	5.22*	7.27 *	5.74*	6.84 *	-1.34	0.51	0.23	2.21	-4.30 *	-2.39	111.89 **	171.6**
3.	CMS-853 A X623021	1.63	3.74	5.51*	6.23 *	**-9.12***	-6.87 *	3.07	4.81	-7.56 *	-3.49	100.36 **	161.4**
4.	CMS-853 A X EC601751	0.00	2.20	-36.4**	3.49	**-18.78****	**-8.70** *	-0.58	2.50	**-15.60** **	-6.54 *	65.36 **	122.6**
5.	CMS-853 A XEC601778	-3.60	**11.70****	22.8**	3.21	**-22.91****	**17.61** **	5.59 *	**18.06****	-4.35 **	2.63	46.61 **	76.9**
6.	CMS-853 A X EC601725	0.00	**6.20***	**-67.2****	-2.67	**-5.53***	**5.09** *	-8.47 *	-3.84	**-19.68** **	**-9.74** *	84.69 **	149.9**
7.	CMS-853 A X623016	1.85	**8.27***	-63.4**	-1.32	-2.63	**7.60** **	3.91	**5.61** *	-4.25	**-14.92** **	95.68 **	139.5**
8.	CMS-852A X EC-623027(mono)	**-10.07***	**-8.49** *	-9.53**	**-7.97** *	-2.56	-0.83	**-8.57** *	**-5.80***	-3.89	-1.57	102.49 **	160.4**
9.	CMS-852A X EC-623023	**-12.83***	**11.65** **	-17.4**	**16.64** **	**11.04****	**12.91** **	1.41	3.25	-2.17	-0.58	133.15 **	198.2**
10	CMS-852A X EC-623021	-2.74	-1.00	-0.65**	0.00	-5.31*	-3.25 **	-4.99	-3.55	-8.38 *	-4.67	120.46 **	187.7**
11.	CMS-852A X EC-601751	-1.31	-4.04	-68.0**	-4.38	**-9.97***	0.65	-2.23	0.63	-16.20 **	**-6.85** *	126.72 **	206.6**
12.	CMS-852A X EC601878	-2.88	14.37**	1.94	23.3**	**-17.33****	**12.08** **	0.00	**11.72****	-5.15 *	1.37	82.92 **	118.5**
13.	852A X EC-601725	**7.84***	15.20**	8.70 *	**65.4****	**-11.36****	-1.70	0.92	5.92 *	- 14.77 **	-3.88	99.22 **	171.0**
14.	852A X EC-623016	**14.85****	22.91**	24.00 **	**56.4****	**-9.37***	**17.51** **	2.03	3.51	-17.86 **	**-7.13** *	138.41 **	189.3**
15.	850AX EC-623027	-3.35	-4.46	-1.48	7.63*	0.70	-4.04	-2.41	1.27	-2.37	-0.94	74.97 **	114.0**
16.	850A X EC-623023	-4.09	12.32 **	-5.58*	14.58 **	**-6.57***	**6.38***	2.59	5.19*	2.15	4.35	61.20 **	95.2**
17.	850AX EC-623021	-3.35	4.92	-3.57	7.31*	**-19.82****	-0.68	0.48	2.74	-4.55	-4.25	38.86 **	**71.5****
18.	850A X EC-601751	3.58	18.81**	6.38 *	62.8**	**-14.60****	-6.67 *	0.35	4.08	-5.58 *	-1.65	92.01 **	145.4**

19.	850A X EC-601878	-3.41	**29.14****	-1.38	36.4**	**-23.11****	-5.60 *	-6.59 *	**5.21***	- 17.27 **	-4.39	61.22 **	82.3**
20.	850A XEC-601725	0.50	20.97**	5.61 *	**65.0****	-6.97*	-11.36 **	-1.62	3.99	-14.40**	-3.63	81.29 **	133.7**
21.	850X EC-623016	**8.31***	10.55 **	12.77**	**67.9****	**6.56** *	24.16**	4.43	**6.76** *	-0.13	**5.70***	68.03 **	92.8**
22.	CMS-103AX EC-623027	**-8.43***	-6.42 *	-16.6**	15.32 **	2.14	26.06 **	-4.74	-1.47	3.06	1.73	34.33 **	79.5**
23.	103A X EC-623023	**-11.53****	10.38 *	-12.6**	11.76 **	1.06	4.32	-4.52	-2.43	-1.61	0.00	44.49 **	92.9**
24.	103AX EC-623021	**-8.96***	-7.77 *	-10.0**	**-9.40** *	-4.55	3.57	-3.43	-1.56	-15.81**	**-5.52** *	41.30 **	92.4**
25.	**103A X EC-601751**	-0.98	1.27	-66.4**	-4.08	**-22.15****	7.84 *	-3.51	-0.29	-6.54 *	**5.10***	54.16 **	118.6**
26.	103A XEC-601978	**6.54** *	24.44	13.12 **	34.9**	**-10.04****	**-16.46** **	**9.73** *	22.73 **	-13.21**	-1.79	73.87 **	115.6**
27.	103A X EC-601725	-4.91	11.43 *	-70.6**	11.76 **	0.41	0.68	-3.56	1.53	-15.14**	-2.31	26.46 **	80.0**
28.	CMS-103AX EC-623016	-2.88	3.92	-65.8**	-7.07 *	**5.58***	**11.53** **	-2.88	-1.04	-4.25	3.87	50.72 **	90.3**
29.	P-2-7-1A X EC-623016	**-14.65****	**-8.11** *	-13.8**	13.12 **	-2.28	**12.44** **	-2.92	**10.51****	-0.13	5.80	93.27 **	155.6**
30.	P-2-7-1A X EC-623023	**-7.22***	0.00	-2.17	-2.01	2.64	4.34	0.35	**13.02****	2.45	2.30	129.03 **	202.2**
31	**P-2-7-1A X EC-623021**	**19.10****	25.71 **	21.10 **	24.7**	**-12.80****	7.19 *	-1.05	**10.06** **	- 17.51**	-2.77	91.99 **	170.1**
32	CP-2-7-1AX EC-601751	1.65	5.77 *	-63.8**	4.90	**-11.91****	1.59	**-1.62**	**12.19****	-9.45 *	**8.99***	124.98 **	214.2**
33	**P-2-7-1AX EC-601978**	-2.75	6.12*	18.4**	-2.27 *	**-14.61****	-2.22	5.19 *	**31.10****	-12.34**	0.26	46.57 **	80.3**
34	P-2-7-1AX EC-601725	0.93	1.19	-66.7**	1.39	-6.02*	-1.37 *	-1.47	**14.49** **	-11.70**	-2.34	113.33 **	199.3**
35	**P-2-7-1AX EC-623016**	**19.16****	28.30 **	-55.1**	23.84 **	**7.15***	8.05 *	-0.47	**11.89** **	-1.43	**6.98***	105.35 **	157.1**
36	**207AX EC-623027**	-10.46**	11.43 **	-13.7**	15.84 **	**-5.55***	**13.61** **	4.45	**-12.68** **	-0.07	**5.26**	55.90 **	97.5**
37	207A X EC-623023	-13.35**	14.71 **	-18.00 **	-11.7**	**7.92***	0.34	**-9.73** *	-2.30	-0.82	-0.40	127.47 **	186.3**
38	207-1A X EC-623021	0.00	1.30	-7.61 *	-2.70	-5.52*	**14.80** **	-6.03**	**13.04** **	-13.62**	-3.54	96.66 **	152.7**
39	207AX EC-601751	**10.20****	16.16	-63.9**	5.80 *	-2.93	**10.19** **	-1.47	**7.95** **	-3.28	5.84*	111.89 **	174.8**
40	207AX EC-601978	0.97	23.49	-6.71 *	24.4**	-7.52*	**6.17** **	5.64*	**11.31** **	-15.96**	-0.26	**59.71****	87.6**
41	207AX EC-601725	-5.94 *	4.74	-70.3**	-9.14 *	-3.47	1.07	-0.86	**11.11** **	-11.81**	-4.42	96.69 **	163.7**
42	207AX EC-623016	-5.35*	15.00 **	**-70.7****	**-20.14** **	0.29	**11.55** **	-7.48 *	-0.09	0.39	3.24	76.85 **	110.8**
43	**P-89-1AX EC-623027**	-15.98**	12.75 **	-23.12**	**-13.6****	0.60	**10.18** **	5.25 *	**15.5****	1.16	1.21	102.06 **	182.5**
44	P-89-1A X EC-623023	-11.11**	**-8.08** *	-16.93 **	**-8.66***	-0.52	**8.42** **	-4.80	3.35	-2.18	0.00	95.43 **	174.4**
45	P-89-1A A X EC-623021	-4.33	-1.04	-1.30	**-8.31** *	**-11.91****	6.95 *	-3.64	4.39	-5.58 *	**-13.98****	79.62 **	157.1**
46	P-89-1A AX EC-601751	**7.07** *	7.87 *	-64.7**	2.61	**-22.44****	3.21	**9.24** *	**20.0****	-4.04	**6.80***	112.17 **	215.5**
47	P-89-1A AX EC-601978	-1.00	14.71**	-3.42	32.2**	**-12.73****	**14.00** **	**8.39** *	**30.2****	-15.86**	0.26	53.49 **	100.6**
48	P-89-1A X EC-601725	-1.91	-7.14 *	-70.7**	**-11.00** **	-2.35	-3.52	-6.59 *	4.70	-14.04**	-4.66	81.28 **	169.9**
49	P-89-1AX EC-623016	4.12	9.64	-65.4**	**-6.11** *	-2.69	**13.97** **	0.12	**8.41****	-2.47	-0.58	69.09 **	125.3**
50	10AX EC-623027	-0.92	4.18	-6.37 *	8.57*	**-9.74***	**9.46** *	-6.64 *	3.19	0.14	5.43*	54.52 **	130.7**
51	10A X EC-623023	-4.33	10.38 **	-10.00 *	2.30	**-5.35***	-0.34	-0.82	**8.43****	-3.67	6.93 *	45.59 **	120.0**
52	10A A X EC-623021	4.85	11.29**	5.49 *	7.6***	**-10.75****	3.90	-2.97	**5.84****	-16.84**	-4.64	67.94 **	158.7**
53	10AX EC-601751	-4.71	14.71 **	-70.0**	**-13.77** *	**-12.06****	6.59 *	**-6.82***	3.16	-4.90	4.38	92.47 **	209.3**
54	10AX EC-601978	-7.48 *	18.90**	-8.55 *	30.5**	**-11.81****	-0.67	**-5.29** *	**14.49****	-14.52**	0.53	38.80 **	94.2**
55	10AX EC-601725	-2.86	13.24**	-67.3**	-1.57	-6.18*	-0.76	2.88	**16.07****	-12.94**	-0.79	114.92 **	244.4**
56	10AX EC-623016	3.85	20.80**	-62.2**	1.39	**7.65***	**11.90** **	-0.72	**8.27****	-14.40**	1.19	94.88 **	178.9**
	Lowest	-15.98	**-8.49**	-70.7	-20.14	**-23.11**	-16.46	-9.73	**-12.68**	-19.67	**-14.92**	26.46	71.5
	Highest	19.16	29.14	24.05	67.9	11.04	26.06	9.73	**31.10**	3.06	**8.98**	138.4	244.4
	crosses with positive and significant heterosis	**10**	**25**	**12**	**22**	**7**	**26**	**7**	**27**	**0**	**7**	**56**	**56**
	crosses with nagetive and significant heterosis	**10**	**06**	**36**	**12**	**33**	**06**	**9**	**2**	**12**	**7**	**0**	**0**
	SEm(±)	**0.11**	**0.09**	**0.05**	**0.04**	**0.263**	**0.227**	**0.162**	**0.140**	**0.147**	**0.127**	**6.35**	**5.50**

EC-601725) respectively. Significantly less heterosis was recorded in the case of oil content (%) relative to parental mean. A total of 6 crosses exhibited significant better parent heterosis (Heterobeltiosis), for days to 50 % flowering for earliness. The significant contribution in the induction of earliness in the above crosses is from CMS-850A, CMS-103A and CMS-10A. The findings have close proximity with Janjal *et al.* (2016), Chandirakala *et al.* (2016), Manivannan *et al.* (2015).

In sunflower dwarf to medium tall plant is required because tall plants are prone to lodging therefore, negative heterosis in this case is desirable. A perusal of Table 4 revealed that only single cross (CMS-207A X EC-623027 showed significant negative mid parent heterosis for days to 50% flowering. The sunflower hybrids CMS-207AX EC-623027(63.5days), CMS-10A X EC-623023(64 days), CMS-10A X EC-601978(64 days) and CMS-103AX EC-623016 (65days) recorded significantly lower days to 50% flowering.

From our experiment, over the years of study, it was observed that the sunflower hybrids *viz*.CMS-103A X EC-601725 took minimum 92 days to mature followed by 207AX EC-623027(94 days) , 10A X EC-623023(95 days) and CMS-10AX EC-601978(95 days) and CMS-103AX EC-623016 (95 days) respectively. Therefore, these hybrids may be considerd as the early maturing hybrids.Head diameter is one of the most important character related to yield. Large heads accommodate more seeds which help to increase the production. A perusal of Table 3 revealed that many of the hybrids showed significant and positive mid parent heterosis *viz*. CMS852A X EC-623016 followed by 853 A X EC-623027, 852A X EC- 623023, PET-89-1A X EC-601916 and 852 A X EC-623021 respectively for the said trait under study.

The hybrids, *viz*. CMS-852A X EC-623023(935), P-89-1AX EC-623027(911) CMS-852A X EC-601751(879), CMS-852A X EC-623027(M) (856) and CMS-852A X EC-623021(839) showed significant and positive mid parent heterosis for number of filled grain per head. The *per ce* performance of most of these hybrids was significantly superior to highest yielding check LSFH 171. Gangappa *et al.* (1994) and many other workers like also observed higher magnitude of heterosis for number of filled seeds in sunflower. The F1,*viz*. CMS-852A X EC-623027(M) (92.%), CMS-853 A X EC601751 (92.%) and CMS-852A X EC601878 (92.%), followed by CMS-852A X EC-623021(91%), CMS-852A X EC-621951(90%) showed significant and positive mid parent heterosis for seed filling percentage. The *per ce* performance of most of these hybrids was significantly superior to highest yielding check LSFH 171 for grain filling %. Rathi *et al.* (2016) also observed higher magnitude of heterosis for higher seed filling %, 100 seed weight, head diameter in sunflower. Oil yield is the important criteria in sunflower which depends on oil content of the genotype. For oil content the range of heterosis was -14.98 to 8.98%. Only 2 sunflower hybrids, *viz.,* CMS-10A X EC-623023, and CMS 10A X EC-623027 showed significant positive mid parent heterosis for the oil content (%). For oil yield (kg/ha), *per se* performance of most of these hybrids were showed significant positive mid parent heterosis for the same trait among them PET-89-1A X EC-601916 followed by CMS-852A X EC-601751, CMS-853 A X EC623023, CMS-850A X EC-601878, P-2-7-1A X EC-601751, CMS 852 A X EC-623021, **CMS-10A X EC-601725** and CMS-852 A X EC-601725 respectively were found superior ones.

The studies revealed that the best cross combination for semi-dwarf plant height coupled with good seed yield per plant and high oil content were P-2-7-1A X EC-623023 (98 days maturity and seed yield of 2192kg/ha), CMS-207AX EC-601751 (98 days maturity and seed yield of 1962kg/ha), P-2-7-1AX EC-601751(100days maturity and seed yield of 1872 kg/ha) and P-89-1A AX EC-601751(101days maturity and seed yield of 2144kg/ha) respectively.

Seed yield is an exceedingly complex quantitative trait in sunflower, whose control involves a series of genes, because practically all traits have some influence, to a large or small measure, on the seed yield. However, heterosis occurred practically for

all traits with different magnitudes. The highest positive heterosis observed for seed yield was explained by the sum of favorable values of heterosis for the different traits correlated with seed yield. Similar type of report was found by **Suresha** *et al.* (2016) and **Patil** *et al.* (2016) and Raghavendra *et al*. (2004).

Among the 56 sunflower hybrids under study, CMS-853 AX EC-623027 (2462 kg/ha, 77 days to flower, and oil yield of 881 kg/ ha, 100 seed weight 6.2g), CMS-853 AX EC-623023 (seed yield 2428kg/ ha,75 days to flower, oil yield of 861 kg /ha,100 seed weight 6.2g), CMS-852 AX EC-623016 (2306kg/ha,75 days to flower, oil yield of 840 kg /ha and 100 seed weight 5.9g) possessed superiority for seed yield, oil yield as well as high 100 seed weight and high volume weight**.** As per the performance *per se* and heterosis study, it was revealed that the best cross combination for semi-dwarf plant height coupled with good seed yield per plant and high oil content are P-2-7-1A X EC-623023 (98 days maturity, seed yield of 2192kg/ ha), CMS 207AX EC-601751 (98 days maturity, seed yield of 1962kg/ha), CMS-850A X EC-601751(99 days maturity and seed yield of 1861Kg/ha), CMS 852A X EC-601725 (100 days maturity, seed yield of 2072kg/ ha), and CMS-10A X EC-601725(100days maturity and seed yield 2240kg /ha and oil yield 842 kg/ha), P-89-1A X EC-601751(100days maturity and seed yield 2245 kg /ha, oil yield 835 kg /ha) and P-2-7-1A X EC-601725(100days maturity and seed yield 2192 kg /ha, oil yield 824 kg /ha) respectively. Among 56 hybrids studied, the desirable negative significant mid parent heterosis was manifested by F1 *viz.,* CMS-103A X EC-601978 (23.6%) followed by P-89-1A AX EC-601978(25.8%),CMS-853 A X EC601978 (24.8%), CMS-853 A X EC-601751, CMS-852A X EC601978 (27.3%) CMS-10A X EC-623023(29%) and CMS-207A X EC-623016(29.5%), PET-89-1A X EC-601916 (30.2%) and CMS-852AX EC-601751(30.5%) respectively. The parental lines *viz.* CMS-852A, CMS-103 A, PET-89-1A and Rf line *viz.* EC-601978, EC-601751 and EC-623016 for hull content have contributed for desirable significant negative heterosis in the above hybrids for low hull content in desirable negative direction. High volume weight is having direct relation with weight of seed yield and high oil percentage and therefore, high oil yield per unit area. The desirable positive significant mid parent heterosis for the same traits was observed in F_1s *viz.*,CMS-103A X EC-601978 (48.5g) followed by P-2-7-1AX EC-601978(45.6g), CMS-853 A X EC601978(45.3g), P-89-1A AX EC-601751(45.3g), P-89-1A AX EC-601978(45.2g), CMS-852A X EC-601725(43.8g), CMS-853 A X EC-623016(43.6g), CMS-850A X EC-623023(43.6g), 207AX EC-601751(43.5g) respectively. All the three sunflower hybrids were high oil percentage and significantly superior over the LSFH-171 (Table-3 and Table-4). The parental lines *viz*. CMS-852A, CMS-853A CMS-103 A, PET-89-1A and Rf line *viz*. EC-601978, EC-601725, EC-623023 and EC-623016 with might have significant positive GCA effects for volume weight which might be contributed for desirable significant positive heterosis in the above hybrids for high volume weight in positive desirable direction.

In sunflower, 100 seed weight is having direct relation with weight of seed yield. The desirable positive significant mid parent heterosis for the same traits were observed in F1s *viz.,* Pet-2-7-1A X EC-623016(6.8g) followed by P-2-7-1A X EC-623021(6.6g), CMS-853 A X EC-623027(M) (6.1g),CMS-853 A X EC-623023(5.9g),CMS-103A X EC-601978 (5.7 g),CMS-207A X EC-601878 and CMS-10A X EC-623021,CMS -10A X EC-623016 respectively(table-4).The parental lines *viz.* P-2-7-1A ,CMS-853A and CMS-207 A and EC-623027(M), EC-623023, EC-623023 and EC-601978 has contributed for desirable significant positive heterosis among the above hybrids for high 100 seed weight.

Hybridization helps to augment the desirable genes of various parents in one combination. Irrespective of general combining ability of the parents, certain combination of parents can give superior hybrids (Table-3). Higher seed volume weight in sunflower is often associated with higher seed yield as well as oil content. CMS 852A and CMS-853A testers recorded significant values; therefore, these parents can be considered as the good combiners for high oil content as well as for high seed yield. The studies revealed that the best cross combinations for high 100 seed weight and high volume weight were CMS-852A

X EC-601725, P-2-7-1AX EC-623016, CMS-207AX EC-601751 and CMS-207A X EC-601978.

Recently high heterotic hybrids for seed yield were also reported by Chandra *et al*. (2013), Parameshwarappa *et al*.(2008), Gaurishankar *et al*.(2007) and Thombare *et al*. (2007).

These crosses involved at least one parent with high GCA effects and had high seed yield and other yield attributing traits at performance *per se*. The results revealed that it is desirable to involve parents contrasting for gca effects to realize high frequency of hybrids with high overall performance *per se* and heterotic status. Thus, the present study clearly established the superiority of L × H/ H × L type of crosses followed by H × H category of crosses. This type of observations was also brought out in the studies by Tyagi *et al.* (2017), Sahane *et al.* (2016), and Budihal (2017) Supriya *et al.* (2017).

Conclusion

Most of the crosses exhibited high heterosis especially for seed and oil yields. However, mean heterosis was comparatively low for hull and oil contents. The study on heterosis in sunflower showed that the crosses with favorable characteristics such as oil and seed yields, oil and hull contents could be bred from correctly selected parents. The cross CMS-853A X EC-623027 reached the breeding aim mentioned above, especially for high vigor in seed and oil yields. CMS-103 A X EC-601878 and PET-89-1A X EC-601878 showed the negative heterosis for thin hull rate and high oil content.

The evaluation of inbred lines based on all three criteria of heterosis showed that the crosses of the female line 853-A and the male line EC-623027, revealed higher hybrid vigor in cross combination than the other lines regarding the characteristics examined in this research. The male line EC-601878 and EC-601751 with regard to all measured traits, the female line CMS-852 A, CMS-103A and P-89-1A with regard to seed, oil yields and low hull rate could be used for increasing hybrid vigor in future sunflower breeding programs.

Based on average heterotic values of inbred lines, negative results were obtained in almost all of them for oil content. The ranking of the female lines was CMS-103A, CMS-850-A, and PET-89-1A for regular heterosis for the same trait. The ranking of the restorer lines was EC-601978, EC-601751 and EC-601725 for regular heterosis for the same trait. CMS 852A and CMS-853A testers and EC-623027 showed superiority for 100 seed weight and high volume weight, therefore, these parents can be considered as the good combiners for high seed yield and high oil content.

Therefore, these genotypes appeared to possess high concentration of additive genes for seed yield and component traits and, therefore, these parents can be considered as the good combiners for heterosis breeding programme for seed and oil yield improvement in sunflower.

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