Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 1-8, 2018

Economic Heterosis for Seed and Oil Yield in Sunflower (Helianthus Annuus L.) Hybrids over Locations in Heterosis Breeding for West Bengal

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Received : 04.05.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

Eighteen locally developed sunflower (*Helianthus annuus* L.) hybrids and national Check Sunflower Hybrids were evaluated at three irrigated locations, for two consecutive seasons (2015/16 and 2016/17) in order to estimate stability of performance for seed yield per ha (kg). A randomized complete block design with three replicates was applied at each location. Data on seed yield was collected. The variance of genotype x environment interaction (GxE) was highly significant, suggesting that the yield of the hybrids was inconsistent in different environments. The average ranking of the 18 hybrids, according to stability parameters showed that 249A X EC-413056 was the first ranked hybrid followed by CMS-249 A X SCG-25, CMS-249 A X EC-601951& 302A Ec-601951, 234A XEC-279309 and CMS-249 A X ID-30.From this study, highest oil yield of 836 kg/ha was recorded in sunflower hybrid CMS-249 A X EC-413056 which was closely followed by CMS-249 A X SG-25, 249A X EC-601951 and CMS-302 A X EC-601951with oil yield kg/ha 806Kg/ha,802Kg/ha and 800 Kg/ha respectively against the national check hybrids LSFH-171, KBSH-53 and DRSH-1 which oil yield were recorded 687 Kg/ha,709 Kg/ha and 673 Kg/ha respectively. From this experiment, over the years of study in station hybrid Trial and multilocation Trial, the highest standard (Economic) heterosis was observed in sunflower hybrid CMS-249 A X EC-413056 (oil yield 836kg/ha) which oil yield (kg/ha) was recorded 18% higher against KBSH-53, 21% higher against LSFH-171 and 24 % higher against DRSH-1 respectively. The significant economic/ standard heterosis were also observed in sunflower hybrid CMS-249 A X SCG-25(oil yield 807kgha), CMS-249A XEC-601951(oil yield 802 kg/ha) and CMS302 A X EC-601951(Oil yield 800 kg/ha). The oil yield (kg/ha) of the these three sunflower hybrids were recorded 13.8% higher against KBSH-53, 17.5% higher against LSFH-171 and 20 % higher against DRSH-1 respectively, 13.1% KBS higher against H-53, 16.7% higher against LSFH-171 and 19.2 % higher against DRSH-1 respectively and 12.8 higher against KBSH-53, 16.4% higher against LSFH-171 and 19% higher against DRSH-1 respectively.

Key words **:** economic heterosis, hybrid breeding, sunflower, yield

Introduction

Sunflower (*Helianthus annuus* L., 2n = 34) an Asteraceae family plant is native to the temperate North America, which is the centre of diversity for this important edible oil-yielding species. Sunflower occupies the fourth position among vegetable oil seeds after soybean, oil palm and canola in the world. Sunflower is the one important source of vegetable oil in the world. Sunflower is grown worldwide, mostly as a source of vegetable oil and proteins and is one of the major crops around the world, which is cultivated on a surface of 21 million hectares. It is one of the three crop species along with soybean and rapeseed which account for approximately 78% of the world vegetable oil. Its seeds contain high oil content ranging from 35 to 40% with some types yielding upto 50%. Due to its low to moderate production requirements, high oil quality, protein content, and utilization of all plant parts, sunflower became an oil crop around the world during the end of the 19th century, when 'popular selection' was practiced in several parts of Russia to improve sunflower populations grown at that time. Sunflower cultivation plays a key role in edible oil production worldwide, represents an important alternative for crop rotation and provides intercropping and succession in producing regions. Edible oil is the basic requirement of the human body because it is very important for the escalation and improvement of body. There is need to focus on conventional as well as non-conventional oilseed crops to fill the gap between consumption and production. Sunflower is non-conventional crop introduced in our country in early seventy's. India is facing a shortage of edible oil in recent years. Sunflower has maximum potential for bridging the gap in the demand and production of edible oil in the country. In India, sunflower is cultivated in an area of 0.7 million ha with a total productivity of 0.50 million tones (Padmaiah *et.al.,* 2015) and with an average productivity of 713kg/ha (Anonymous, 2016) In West Bengal it is grown in an area of 12,500 ha in last *rabi* season (2015-16).

Most of the sunflower seed is imported in the country that is actually not bred for our environment. That's why; it gives low yield due to the adaptation problem (Kokhar *et al.,*2006). Oil content of sunflower kernel ranges from 48-53% whilst in seed from 28-35% (Reddy, 2006). Sunflower oil is premium oil due to its beam colour, taste, high smoke point, good nutritional quality, towering level of unsaturated fatty acids and lack of linolenic acid. It has the sturdy oxidative stability so it can be used as cooking oil. Sunflower is short duration crop (95-120 days) so; it fits in any cropping pattern of India. It also requires less agronomic practices for the better yield. But farmers are focusing on major crops instead of sunflower as an oilseed crop. Regrettably its production in India is very stumpy compared to its requirement. For the enhancement of oil production we need to increase seed yield & oil percentage of sunflower. Genetic variability is very crucial item in the breeding programs. Genetic similarities and differences existing in the genotypes are utilized efficiently as genetic resource in the breeding programs (Safavi *et. al.,* 2011). Seed yield is a quantitative character which is influenced by different traits. Association is determined between the seed yield and its related traits for the improvement of yield in sunflower. Development of hybrids is the primary objective of most sunflower breeding programs in the world.

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 (Fick and Miller, 1997). 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 Sunflowrer 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 8.0 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 (2014-15). 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 2013-14 with aimed to (i) Breeding and Evaluate the performance of the sunflower hybrids in respect to yield and yield component and (ii) 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 **Standard (economic**) heterotic combinations, and not to concentrate the study the Heterobeltiosis. In the very first year (2013-14), Three sets of hybrids (developed from Line X tester combination) were evaluated and next year, 2014-15, 32 superior hybrids were tested along with the three national checks and the next year, 2015-16, 18 superior sunflower hybrids which performance (seed&/ Oil yield) higher or at per with the national checks were subjected to study in the present experiment which was carried out during *rabi* season, 2015-16 and 2016-17 at research farm under AICRP Sunflower, Nimpith Centre. A total of 18 sunflower hybrids were evaluated including the three National check hybrids, KBSH-53, LSFH-171 and DRSH-1 in Randomized complete block design with three replications. The plot size was 4.5m x 3.0 m. In the 2nd year (2014-15), a total of 32 sunflower hybrids were tested in AICRP (Sunflower) research farm, Nimpith Centre, South 24 Parganas, West Bengal. In the next two years, 2015-16 and 2016-17 the best 18 sunflower hybrids were tested including the three National check hybrids, KBSH-53,LSFH-171 and DRSH-1 in "On station" trial at Nimpith centre and another three locations viz..at Research Farm, Institute of Agriculture Sciences, Calcutta University, Baruipur and Radhakantapur (AICRP-adopted Village) as Multilocation trial. The soil texture was clay loam in "On station" and "MLT" 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 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 weight(g) & hull content (%),volume weight (seed weight in gram per 100 ml) and oil content(%). 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.

Results and Discussion

In all, for economic heterosis, only six cross which manifested significant positive heterosis for all the three modes in all the three environments as well as expressed significant higher seed and oil yield (kg/ha) i.e. economic heterosis which were, CMS-249 A X EC-413056, 249 A X EC—601951, 249 A X ID-30, 249A X SCG-25, 302 A X EC-601951 and 234A XEC-279309.

Yield and yield components:

The significant contribution in the induction of earliness in the above crosses is from CMS 234 A and 302A. Raghavendra (2004), also reported negative heterosis for days flowering. These parents exhibited higher GCA effects for most of the important yield contributing traits in at least two environments and on the basis of pooled analysis. In addition to these EC 601951, and CMS 234A and CMS-302A also manifested high GCA effects for oil and hull content in at least two environments and on pooled basis. Hence, these were considered good combiners for yield and its component traits. Such type of good general combiner for economic trait were also reported by Gaurishankar

Table 1. Seed yield and yield attributing characters

Sl. No	Name of the Hybrid	Pl.Ht. (Cm)	HD.Dia. (cm)	Avg.Seed Yield (Kg/ha)	Gr. Filling%	100 Seed wt.(g)	Kernel Wt (g)	Husk Wt (g)	Hull Cont. (%)	**Vol. Wt (g/100cc)**	**Oil%**	**Oil yield (Kg/ha)**
1	234A X EC-201868	146.4	14.2	**1430.0**	85.0	5.5	3.5	2.0	35.6	44.0	36.5	522
2.	249A XGP-6-358	149.6	13.9	**1551.0**	88.0	4.9	2.9	2.0	41.0	38.5	38.0	589
3	**249 A X SCG-25**	156.5	14.3	**2134.0**	91.5	4.9	3.2	1.7	34.5	46.5	37.8	807
4	234A XR-271	149.7	14.2	**1897.5**	85.0	5.5	3.7	1.9	33.6	46.0	36.4	691
5.	**2A X ID-30**	151.4	14.5	**1772.5**	88.5	4.2	2.9	1.3	32.0	42.0	33.5	594
6	234A XEC-279309	147.9	14.8	**1842.5**	88.0	5.1	3.4	1.8	34.2	43.5	38.2	704
7	**249A X EC-413056**	144.9	14.2	**2035.0**	90.5	4.6	2.6	2.0	43.7	45.5	38.2	777
8	**234A XEC-279309**	153.7	14.4	**1776.5**	88.5	5.3	3.5	1.8	34.6	44.0	38.2	679
9	**249A X ID-30**	151.4	14.5	**2024.0**	88.5	5.9	3.9	2.0	34.6	38.0	38.5	779
10	**249A X EC-413056**	158.6	14.2	**2200.0**	88.0	4.8	3.1	1.7	37.2	38.0	**38.0**	836
11	**249A X EC-601620**	143.4	13.7	**1837.0**	91.0	4.6	3.2	1.4	30.7	41.5	38.2	702
12	249A XEC-625702	154.7	12.3	**1793.0**	91.5	5.0	2.9	2.1	41.4	39.5	35.6	638
13	2A X R-1-1	140.4	12.7	**1771.0**	90.5	3.7	1.9	1.8	48.1	35.3	33.5	593
14	302A XEC-623008	140.6	13.5	**1870.0**	89.0	3.7	2.3	1.4	38.3	41.5	37.5	701
15	**249A XEC-601951**	159.8	14.7	**2046.0**	92.5	5.1	3.4	1.8	34.5	38.0	39.2	802
16	**249A XR-107**	152.9	14.2	**1870.0**	89.5	6.3	3.6	2.6	42.0	37.5	35.4	662
17	**302A XEC-601951**	154.8	14.1	**2073.5**	89.0	4.3	2.9	1.5	33.5	38.0	38.6	800
18	10A X R-1-1	141.6	13.6	**1496.0**	86.5	4.9	3.2	1.7	35.0	41.0	36.8	551
19	P-2-7-1A XEC-602060	148.8	13.8	**1556.5**	91.5	4.1	2.7	1.4	33.9	40.5	37.2	579
20	**KBSH-53(Ch-1)**	160.0	14.4	**1886**	90.0	4.4	2.7	1.7	39.2	41.8	37.6	709
21	**LSFH-171 (Ch-2)**	163.8	15.0	**2052**	86.0	5.1	3.1	2.1	40.1	36.0	33.5	687
	DRSH-1	155.5	14.5	**1705**	91.0	5.3	3.5	1.8	33.4	41.0	39.5	673
	S.Em(±)	4.2	0.7	**59.6**	1.2	0.2	0.14	0.05	1.7	1.7	1.1	14.8
	LCD(P=0.05)	12.5	2.1	**178**	3.6	0.6	0.4	0.15	5.2	5.0	3.2	42.5
	CV(%)	8.6	7.2	**9.4**	6.8	6.4	5.8	5.4	8.2	6.8	7.8	8.6

et al. (2007) and Parmeshwarappa *et al.* (2008). The result also indicated that some parents besides above showing high GCA effects for important characters could be used in crossing programme depending upon the specific objectives.

The data for seed yield and other yield attributing traits for the test hybrids along with the checks are presented in Table-2 and table-3. Highly significant differences were observed for seed yield and other yield attributing traits among the test hybrids. Statistical analysis of the data on seed yield (Kg/ha) in MLT and in "On Station" station hybrid trial (average data from MLT & SHT over locations in Table-3) reveals that the highest seed yield of (2200 kg/ha) was recorded in the experimental sunflower hybrid CMS-249 A X EC-413056 which was closely followed by sunflower hybrid CMS-249 A X SG-25 and hybrid CMS-302 A X EC-601951with seed yield 2134kg/ha and 2073Kg/ha respectively. The best national check hybrid, i.e. LSFH-171was recorded seed yield of 2152 kg/ha and less seed yield were recorded in others two National check hybrids, in KBSH-53 and DRSH-1 with seed yield 1846 kg/ha and 1705 kg/ha respectively. The other sunflower hybrids like 249A x Ec601951 and CMS-249A x ID-30 also out yielded two national check KSH-53 and DRSH-1 with seed yield 2046 kg /ha, 2024 kg/ha respectively and Sunflower hybrid, 234A xEc-279309 also recorded the higher seed yield in comparison to DRSH-1 (1705kg

TABLE 2A. BEST ENTRY-2016-17 at AICRP-SUNFLOWER, NIMPITH
Seed yield and other yield attributing traits in AICRP-Nimpith Centre Developed Sunflower Hybrids at *rabi*-2016-17

Sl. No	Name of the Hybrid	Pl.Ht.	HD.Dia.	Seed Yield (Kg/ha)	Gr. Filling%	100 Seed wt.(g)	Kernel Wt (g)	Husk Wt (g)	Hull Cont. (%)	**Vol. Vol. Wt (g/100cc)**	**Oil%**	**Oil yield (Kg/ha)**
1	249 A X SCG-25	156.5	14.3	**2134**	91.5	4.9	3.2	1.7	34.5	46.5	37.8	807
2.	249A X EC-413056	148.9	14.2	**2200**	90.5	4.9	2.9	2.0	38.7	45.5	38.0	836
3	249A XID-30	151.4	14.5	**2024**	88.5	5.9	3.9	2.0	34.6	38.0	38.5	778
4	249A XEC-601951	159.8	14.7	**2046**	92.5	5.1	3.4	1.8	34.5	38.0	39.2	802
5.	302A XEC-601951	154.8	14.1	**2073**	89.0	4.3	2.9	1.5	33.5	38.0	38.6	800
6	234A XEC-279309	147.9	14.8	**1842**	88.0	5.1	3.4	1.8	34.2	43.5	38.2	704
	KBSH-53(Ch-1)	160.0	14.4	**1886**	90.0	4.6	2.9	1.7	39.2	41.8	37.6	709
	LSFH-171 (Ch-2)	163.8	15.0	**2152**	86.0	5.1	3.1	2.1	40.1	36.0	33.5	687
	DRSH-1 (Ch-3)	155.5	14.5	**1705**	91.0	5.3	3.5	1.8	33.4	41.5	39.5	673

TABLE 2. Economic Heterosis, Seed Yield and Oil Yield Improvement over Standard Chack-KBSH-53, LSFH-171 and DRSH-1

Sl. No	Name of the Hybrid	**Seed Yield (Kg/ha)**	**Over KBSH-53**	**Over LSFH-171**	**Over DRSH-1**	**Oil%**	**Oil yield (kg/ha)**	**Over KBSH-53 (%)**	**Over LSFH-171(%)**	**Over DRSH-1 (%)**	**Over all Improve-ment(%)**
1	249 A X SCG-25	**2134**	13.1	4.0	25.2	37.8	807	13.8	17.5	19.9	**17.1**
2.	249A X EC-413056	**2200**	7.9	7.2	29.0	38.0	836	17.9	21.7	24.2	**21.3**
3	249A XID-30	**2024**	7.3	-1.4	18.7	38.5	778	9.7	13.2	15.6	**12.8**
4	249A XEC-601951	**2046**	8.5	-0.3	20.0	39.2	802	13.1	16.7	19.2	**16.3**
5.	302A XEC-601951	**2073**	9.9	1.0	21.6	38.6	800	12.8	16.4	18.9	**16.0**
6	234A XEC-279309	**1842**	-2.3	-10.2	8.0	38.2	704	-0.7	2.5	4.6	**2.1**
	KBSH-53(Ch-1)	**1886**	-	-	-	37.6	709	0.0	3.2	5.3	-
	LSFH-171 (Ch-2)	**2152**	-	-	-	33.5	687	-3.1	0.0	2.1	-
	DRSH-1	**1705**	-	-	-	39.5	673	-5.1	-2.0	0.0	-

seed yield/ha) with seed yield 1846 kg /ha. This finding supported the conclusion of Ashoka *et al.* (2000). The Maximum oil (%) was recorded in the experimental hybrids like 249A XEC-601951 (39.2) and 302A X EC-601951 (38.6) against the national check hybrid, DRSH-1 with 39.2% oil. From the experiment and statistical analysis of the data on oil yield (Kg/ha) in "On Station" trial and MLT (average data from MLT over locations in Table-2 and table-3) reveals that highest oil yield of 836 kg/ha was recorded in the sunflower hybrid CMS-249A A X EC-413056 followed by CMS-249 A X SCG-25(oil yield 807kgha), CMS-249A XEC-601951(oil yield 802 kg/ha) and CMS302 A X EC-601951(Oil yield 800 kg/ ha) respectively. From the experiment it was reveals that in response to oil yield (kg/ha), the newly developed sunflower hybrids were significantly high oil yielder over the national check hybrids, i.e. KBSH-53, LSFH-171 and DRSH-1. The field observation reveals that, among the 18 sunflower hybrids under study, the sunflower hybrids developed by the AICRP-Sunflower, Nimpith Center viz. CMS-249A A X EC-413056, CMS-249 A X SCG-25, CMS-249A XEC-601951and CMS-302 A X EC-601951 significantly out yielded the best national check sunflower hybrid i.e. KBSH-53(709 kg oil / ha),LSFH-171(687 kg oil yield/ha) and DRSH-1(673 kg oil yield/ha) in respect to **oil yield** (kg/ha)by recording oil yield of 836 kg oil /ha, 807 kg oil /ha, 802 kg oil /ha and 800 kg oil/ha respectively. The findings have close proximity with the finding of Chandra *et.al* in 2013 where they reported that the seed yield and oil yield of sunflower can be increased by introduce of new parents.(Table-3).

Table 3. Seed Yield and Oil Yield(kg/ha) of New sunflower .

Name of the Hybrid	Seed Yield (kg/ha) 2015-16 SHT & MLT	2016-17 SHT& MLT	Over The years Seed Yield (Kg/ha)	Seed Yield (kg/ha) SHT-2015-16	MLT-2015-16	SHT-2016-17	MLT-2016-17	Oil Yield (kg/ha) Over the Years Oil yield (Kg/ha)	2015-16 SHT & MLT	2016-17 SHT& MLT
234A X EC-201868	1502	1355	**1430**	1543	1461	1388	1322	**522**	548	495
249A XGP-6-358	1629	1470	**1551**	1674	1584	1505	1435	**589**	619	559
249 A X SCG-25	2241	2022	**2134**	2303	2179	2071	1973	**807**	847	764
234A XR-271	1992	1798	**1898**	2047	1937	1841	1755	**691**	725	654
2A X ID-30	1860	1678	**1772**	1911	1809	1718	1638	**594**	623	562
234A XEC-279309	1935	1746	**1842**	1988	1882	1788	1704	**704**	739	667
249A X EC-413056	2137	1928	**2035**	2196	2078	1974	1882	**777**	816	736
234A XEC-279309	1865	1683	**1776**	1916	1814	1723	1643	**679**	712	643
249A X ID-30	2125	1918	**2024**	2183	2067	1964	1872	**779**	818	738
249A X EC-413056	2310	2085	**2200**	2374	2246	2135	2035	**836**	878	792
249A X EC-601620	1929	1741	**1837**	1982	1876	1783	1699	**702**	737	665
249A XEC-625702	1883	1699	**1793**	1935	1831	1740	1658	**638**	670	605
2A XR-1-1	1860	1678	**1771**	1911	1809	1718	1638	**593**	623	562
302A XEC-623008	1964	1772	**1870**	2018	1910	1815	1729	**701**	737	665
249A XEC-601951	2148	1939	**2046**	2207	2089	1986	1892	**802**	842	760
249A XR-107	1964	1772	**1870**	2018	1910	1815	1729	**662**	695	627
302A XEC-601951	2177	1965	**2074**	2237	2117	2012	1918	**800**	840	758
10A X R-1-1	1571	1417	**1496**	1614	1528	1451	1383	**551**	578	521
P-2-7-1A XEC-602060	1634	1475	**1556**	1679	1589	1510	1440	**579**	608	549
KBSH-53(Ch-1)	1980	1787	**1886**	2034	1926	1830	1744	**709**	744	672
LSFH-171 (Ch-2)	2155	1944	**2052**	2214	2096	1991	1897	**687**	722	651
DRSH-1	1790	1615	**1705**	1839	1740	1654	1576	**673**	707	638
S.Em(±)	**64.5**	**56.5**	**59.6**	55.8	48.8	42.5	40.7	**14.8**	15.7	13.1
LCD(P=0.05)	**192.4**	**171.2**	**178**	166.8	148.7	138.6	123.5	**42.5**	45.8	38.6
CV(%)	**9.6**	**9.1**	**9.4**	9.3	9.1	8.7	8.2	**8.6**	8.9	8.2

In this study oil yield of (836 kg/ha) was recorded in the experimental sunflower hybrid CMS-249 A X EC-413056 which was closely followed by sunflower hybrid CMS-249 A X SG-25, 249A X EC-601951 and hybrid CMS-302 A X EC-601951with seed yield kg/ha 806Kg/ha, 802Kg/ha and 800 Kg/ha respectively against the national check hybrids LSFH-171, KBSH-53 and DRSH-1 which seed yield were recorded 687 Kg/ha,709 Kg/ha and 673 Kg/ha respectively. From this experiment, over the years of study in station hybrid Trial and multilocation Trial, the highest standard (Economic) heterosis was observed in sunflower hybrid CMS-249 A X EC-413056 (oil yield 836kg/ha) which oil yield (kg/ha) was recorded 18% higher against KBSH-53, 21% higher against LSFH-171 and 24 % higher against DRSH-1 respectively. The significant economic/ standard heterosis were also observed in sunflower hybrid CMS-

249 A X SCG-25(oil yield 807kgha), CMS-249A XEC-601951(oil yield 802 kg/ha) and CMS302 A X EC-601951(Oil yield 800 kg/ha). The oil yield (kg/ha) of the these three sunflower hybrids were recorded 13.8% higher against KBSH-53, 17.5% higher against LSFH-171 and 20 % higher against DRSH-1 respectively, 13.1% KBS higher against H-53, 16.7% higher against LSFH-171 and 19.2 % higher against DRSH-1 respectively and 12.8 higher against KBSH-53, 16.4% higher against LSFH-171 and 19% higher against DRSH-1 respectively. The sunflower hybrid CMS-249A X ID-30(oil yield 778kg/ha) also out yielded the best three national check hybrids which oil yield also recorded 9.7% higher against KBSH-53, 13.2% higher against LSFH-171 and 15 % higher against DRSH-1 respectively. From this study it was observed that the sunflower hybrids viz.CMS-249 A X EC-413056, CMS-249 A X SG-25, 249A XEC-601951 and CMS-302 A X EC-601951 (Table-3) were the superior sunflower hybrids compared to the best national checks over the environments (over the years and over the locations). The findings was supported by Reddy *et.al*.2009 where he studied stability parameters of parents and F_1 hybrids of sunflower *(Helianthus annuus* L.) in different environments.

Conclusion :

From the study it may be concluded that the sunflower hybrids viz.CMS-249 A X EC-413056, CMS-249 A X SG-25, 249A XEC-601951 and CMS-302 A X EC-601951 may be promoted for AICRP Coordinated trial for further evaluating their performance in Eastern India due to their superiority over the best national check sunflower hybrids over the environments and over the years.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 9-17, 2018

Gene Actions for Cob Characters and Grain Yield in Quality Protein Maize (QPM) Inbreds Based on Hayman's Approach

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Received : 10.04.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

Gene actions in maize for five traits (cob length, cob diameter, number of grains per cob, 100 grain weight and grain yield per plant) were studied using Hayman's approach following 8x8 half diallel. Based on t^2 test and regression analysis of Wr,Vr it was found that additive dominance model was partially adequate for these traits. These traits were overwhelmingly controlled by overdominance gene action. The ratio of $H_2/4H_1$ was less than 0.25 for all traits suggesting asymmetrical distribution of positive and negative genes. There appeared to be equal spread of dominance and recessive alleles in parental lines for all five traits as ratio of $\sqrt{4DH_1} + F/\sqrt{4DH_1} - F$ did not differ significantly from unity. The value of h^2/H_2 indicated that at least one dominant gene group was in operation for all traits. For all these traits narrow sense heritability estimates was very low suggesting their poor response to selection. Four Quality Protein Maize inbred lines, DMR QPM 102, CML 170, DMR QPM 03-121 and DMR QPM 103 recorded high positive Fr values indicating major proportion of dominant genes in them. The inbred line CML 167 would likely to have maximum recessives genes for all these traits since it recorded high negative Fr values. Furthermore, the analysis suggested that inbred lines CML 511 and CML 539 possessed high proportion of recessive genes for cob length and diameter as well as grain yield per plant. Based on gene actions it was suggested that heterosis could be exploited in developing hybrids and maximum gain could be achieved through the maintenance of considerable heterozygosity coupled with selection in segregating generation to enhance recombinations which would facilitate breaking the undesirable linkage.

Key words **:** Additive dominance model, gene action, half diallel, inbreds, QPM

Introduction

Maize (Zea mays L.) is an important cereal ranking third in the world after rice and wheat. In India it is also an important cereal cultivated in area of 8.69 million ha having a production of 15.50 million tonnes (Directors review, 2016-17). The demand for maize is growing as food and poultry feed and in several industrial applications. Maize has a critical nutritional role to play because it is a major important staple food crop infact maize is widely fed to babies from 2-3 months to 15-24 months old and also to preschool children (3-5 years old) in several countries without protein supplements. However, normal maize has a major nutritional constraint as human food because its protein is deficient in Lysine and tryptophan, two essential amino acids which are important for both monogastric animals and human beings (Huang et al., 2004). Consequently, infants feed on normal maize suffer from malnutrition and develop diseases like Kwashiorkor. Hybrids of Quality protein maize (QPM) have a crucial role to play because QPM contains increased lysine and tryptophan concentrations and have a higher biological value than the normal maize. Information on the combining ability of QPM inbreds is crucial for the success of hybrid programmes. To achieve this it is highly essential to understand the nature of gene action involved for a specific trait to be improved. The choice of efficient breeding programme depends on the close knowledge of the type of gene action for components of productivity. Dominance gene action is desirable for developing hybrids and additive gene action implies that standard selection protocols would be effective enough in breeding about improving the character (Edwards et al., 1976). For such studies diallel analysis is a useful biometrical approach to understand the nature of gene action through which a plant breeder can identify the parents of best combining ability to produce productive progenies. Against this backdrop QPM inbreds would be invaluable to the hybrid programme. The present study is concerned with seven QPM inbreds and one normal maize inbred. The objectives were to i. study the additive dominance model using Hayman's approach, ii. estimate genetic components of variance and heritability and finally, iii. analyze inheritance pattern (additive vs dominance) for cob characters including grain yield in 8x8 half diallel crosses of maize inbreds.

Materials and Methods

Materials: Seven QPM inbreds and one normal were obtained from CIMMYT and DMR, India and their brief description is given in Table 1.

Generation of diallel crosses: All possible crosses were made among the selected 8 inbred lines using the half diallel mating system to produce 28 single cross hybrids including parents without the reciprocals during rabi, 2013/14 at the Experimental farm of University of Calcutta, Baruipur, South 24 Parganas, West Bengal (22.3597° N, 88.4318° E at an elevation of 9 m above sea level, Avg. temperature ranged 28-35°C maximum and 11-16°C minimum).

The raising: The 28 single cross hybrids and their eight parents were grown in randomized complete block (RCB) design with three replications for three consecutive seasons of 2014/15, 2015/16 and 2016/17 from Mid November to Mid April (Sowing to harvest). All the genotypes (F1 and parents) were planted in single rows of 2m length. The distance between plant to plant and row to row was maintained at 20cm and 60 cm, respectively. Recommended normal cultural practices were carried out throughout the experiment.

Observations and Data Collection: Observations were made on five randomly taken plants from each replication and data were recorded for ear traits such as cob length (base to tip of the cob), cob diameter (width of the cob minus husk at the middle), number of grains per cob, and 100 grain weight as well as grain yield/plant.

Statistical Analysis:

The eight parent half diallels (28 F1's + 8 parents) were pooled and combined across seasons. The pooled data were subjected to Analysis of variance (ANOVA) and Duncan's Multiple Range tests (DMRT) were used to test the significance of differences between means. The genetic analyses was performed following Hayman's and Mather's diallel approach with concept of D and H genetic components of variation for additive and dominance variances, respectively. (Jinks and Hayman, 1953; Hayman, 1954 a,1954 b; Jinks, 1956; Mather and Jinks, 1982J).

Assumptions and test of adequacy: The assumptions required to estimate genetic parameters using the diallel mating design are i. genes are independently distributed in the parents, ii. absence of epistasis, iii. absence of reciprocal effect, iv. absence of multiple allelism and v. diploid segregation and homozygosity of parents. To fulfill the assumptions the data were tested through two scaling tests i.e. regression analysis and t^2 test. This would help evaluate the adequacy of of the additive-dominance model for the data. If the t^2 is significant the additive-dominance model is not good fit meaning that presence of non-allelic interaction. According to Mather and Jinks (1982) regression coefficient is expected to be significantly different from zero and not from unity. Failure of this test means the presence of epistasis. Failure of these two tests completely invalidates the additive-dominance model. However, if one test fulfills the assumption the additive-dominance model is considered to be partially adequate.

TABLE 1. List and a brief description of inbred lines/parents used for 8x8 half diallel crossing programme

SL. No.	Inbred Lines/ Parents	TYPE	GRAIN COLOUR	SALIENT FEATURES	Source
P1	DMR QPM 102	QPM	YELLOW	Medium height, Early maturity, Flint	DMR
P2	CML 170	QPM	YELLOW	Short height, Early maturity, Semi flint	DMR
P3	DMR QPM 03-121	QPM	YELLOW	Short height, Early maturity, Semi flint	DMR
P4	DMR QPM 103	QPM	YELLOW	Medium height, Early maturity, Semi dent	DMR
P5	CML 509	QPM	WHITE	Tall height, Mid- altitude, Tropical, Medium maturity, flint	CIMMYT
P6	CML 511	QPM	WHITE	Tall height, Mid- altitude, Tropical, Medium maturity, flint	CIMMYT
P7	CML 539	Normal	WHITE	Medium height, Medium maturity, semi flint/ semi dent	CIMMYT
P8	CML 167	QPM	YELLOW	Tall height, Medium maturity, Semi flint	DMR

TABLE 2. Analysis of variance for ear traits in 8X8 Half Diallel cross

Sources of variation	**df**	**Mean Squares**				
		CL (cm)	**CD (cm)**	**G/C**	**GW (g)**	**GYP (g)**
Replications	**2**	12.1*	9.4***	85443.6***	48.5*	6981.7***
Genotypes (P+H)	**35**	9.3***	3.3***	19644.3***	38.6***	2095.2***
Parents (P)	**7**	3.8**	3.2**	18061.0***	15.8**	1243.1*
Hybrids (H)	**27**	9.3***	3.1***	20598.6***	40.7***	2241.5***
P Vs H	**1**	14.8*	7.4**	4961.4**	143.0***	4110.5**
Error	**70**	2.7	0.8	3300	10.8	459.6

***, ** and *** Significant at 0.05, 0.01 and 0.001 levels of probability, respectively**

Cob length = CL, Cob diameter = CD, Number of grains/cob = G/C, 100 Grain weight = GW and Grain yield/plant = GY/P

Estimation of Genetic components of variation: Genetic components of variation, their ratio with standard error and correlation coefficients were estimated using Windostat Version 9.2 (indostat services, Hyderabad). The following genetic components are estimated:

i. E (Environmental components of variation)

$$= \left(\frac{\text{Error SS+Replication SS}}{\text{df}}\right) \Big/ \text{No.of replication:}$$

ii. D (Additive genetic variance) = V0L0 - E, where V0L0 = Variance of parents and E = Environmental component of variation.

iii. H_1 (Dominance variance-component of variation due to dominant gene effect) = V0L0 - 4 $W0L0_1$ + $4V_1L_1$ – (3n-2) E/n, where W0L0= mean covariance between the parents and the array, V_1L_1 = mean variance of arrays and n= number of parents.

iv. H_2 (Symmetry or asymmetry of alleles) = H1 [1-(u-v) 2], where u and v are the proportions of positive and negative genes, in the parents.

v. F (Mean of Fr over array) = 2V0L0 - 4 $W0L0_1$ - 2(n-2) E/n, Fr is positive = proportion of dominance gene is excess than the recessive; Fr is negative = proportion of recessive gene is excess than the dominance. Fr (Covariance of additive and dominance effects in a single array) = 2(V0L0 - $W0L0_1$+ V_1L_1 - Wr-Vr) - 2(n-2)E/n

vi. h^2 (Dominance effect- as algebraic sum over all loci in heterozygous phase in all crosses) = $4(ML_1-ML_o)^2 - 4(n-1)E/n^2$. When frequency of dominant and recessive alleles is equal, then H1 = H2 = h^2. Significance of h^2 confirms that dominance is unidirectional.

The significance of each component was tested by t test at (n-2) degrees of freedom. The calculated value of t for each component was obtained by dividing each component by their respective standard error values.

The following genetic ratios were determined from these estimates:

i. $\sqrt{H_1/D}$: Average degree of dominance. When ratio becomes zero there is no dominance. If ratio value is – ratio = 1, it indicates complete dominance; 0 < ratio < 1, it indicates partial dominance; ratio value > 1, it indicates overdominance.

ii. $H_2/4H_1$: Proportion of genes with positive and negative effects in the parents.

if value of ratio – ratio = to 0.25, indicates symmetrical distribution of positive and negative genes; ratio < 0.25, indicates asymmetrical distribution of positive and negative genes.

iii. $\sqrt{4DH_1} + F / \sqrt{4DH_1} - F$: Proportion of dominant and recessive genes in the parents [K_D / K_r], where K denotes genes, D denotes dominance and r denotes recessiveness. If ratio value is – ratio >1, indicates an excess of dominant genes; ratio < 1, indicates more recessive genes; ratio = 1, indicates equal proportion of dominant and recessive genes.

iv. h^2/H_2: Number of gene groups/genes, which control the character and exhibit dominance.

v. r - Coefficient of correlation between the parental order of dominance (Wr+Vr) and parental measurement (Yr). Negative value of correlation coefficient (r) indicates dominant genes, while if its value is positive then recessive genes are responsible for the phenotypic expression of the trait.

vi. $h^2_{(ns)}$ - Heritability in narrow sense: The narrow-sense heritability is the ratio of additive genetic variance to the total phenotypic variance. It plays an important role in the selection of elite genotypes from the segregating population. The narrow sense heritability in F1 generation was calculated for each character according to Mather and Jinks (1982).

vii. $h^2_{(bs)}$ - Heritability in broad sense: The broad-sense heritability is the ratio of total genetic variance to total phenotypic variance.

Results and Discussion

Performance of Parents and F1's

Analysis of variance revealed that Mean sum of squares (MSS) due to genotypes, parents, hybrids and parents vs hybrids were highly significant for all traits (Table 2.).

Based on mean values Inbred lines CML 167, DMR QPM 102 and CML 509 performed better than others for majority of the characters and of them inbred line CML 167 stood out recording highest grain yield per plant, number of grains per cob including cob diameter. However, DMR QPM 103 displayed second largest number of grains with appreciably large cob diameter. Besides cob diameter for all other characters a significant increase was evident in mean performance of hybrids for different characters. This would also suggest that there was a larger genetic variability in F1 populations which was distinctly amplified in case of grains per cob and grain yield per plant in particular. With reference to single cross hybrids DMR QPM 103xCML539 (P4xP7), DMR QPM 102xCML 167 (P1xP8), DMR QPM 103x CML 509 (P4xP5), CML 170xDMR QPM 03-121 (P2xP3) and CML 509xCML 167 (P5xP8) were better performing hybrids. Of these hybrids except CML 170xDMR QPM 03-121 (P2xP3) either both parents or one of the parents maintained a record of high performance of cob characters. Only the cross combination of CML 170xDMR QPM 03-121 (P2xP3) exhibited a visible departure from this trend. Interestingly, the single cross hybrid involving DMR QPM 103xCML539 (P4xP7) recorded highest grain yield of 160 g per plant which was around 60% increase as compared to average grain yield over parental lines (Table 3). In other words it had the best genetic potential for high yield. It was further evident that grains per cob be it in parental lines or in cross combinations became the most important determining parameter for realizing higher grain yield per plant in maize. The importance of grains as major yield component is well recognized in maize (Khazaei *et al.*, 2010; Munawar *et al.*, 2013).

Diallel Analysis

Adequacy of model

Adequacy of additive dominance model was tested through two scaling tests t^2 and regression analysis (Table 4). For all traits t^2 was not significant. Thus t^2 test was good fit indicating that there were no non allelic interactions and the genes were independent in their action for random association. However, regression coefficient b was found to be significantly different from zero and from unity which did not fulfil the assumptions of additive dominance model. Hence, additive dominance model became partially adequate for all five traits. Zare et al. (2011) also reported partial adequacy of additive dominance model for few traits in maize. In cotton also for majority of the traits additive dominance model was partially adequate (Khan and Hassan, 2011)

Estimates of genetic components of variation and its ratios

For all traits D the additive component was not significant while H_1 and H_2 were significant demonstrating the importance of overdominance gene action for these traits. The average degree of dominance $(\sqrt{H1/D})$ was also greater than unity which confirmed all five traits were controlled by Overdominance. The estimates of F (mean Fr over arrays) where positive for all the traits which also implied overwhelming dominance effect of genes for these traits. Zhara (2011) and Kumar et al. (2012) also reported similar trend for grain yield in maize. The ratio of $H_2/4H_1$ (genes with +/- effects) was less than 0.25 for all traits suggesting asymmetrical distribution of positive and negative genes. Quite analogous results were reported by Kumar et al. (1999) and Kumar et al. (2012) for grain yield and by Sarac and Nedelea (2013a) for ear length in maize inbreds. The ratio of $\sqrt{4DH_1} + F/\sqrt{4DH_1} - F$ did not show departure from unity suggesting equal spread of dominance and recessive alleles in parents for all traits. The value of h^2/H_2 indicated that atleast one dominant gene group is in operation for all traits. This ratio underestimates the number of genes and gives no exact information about group of genes exhibiting a little or no dominance. Hence, greater dependency cannot be placed on this ratio. The estimates of broad sense heritability varied from 75% to 86% among the traits but narrow sense heritability estimates ranged from 10 to 24% indicating their poor sensitivity/response to selection in segregating generation.

TABLE 3. Means of traits of the 8 parental lines and the 28 F1 Hybrids

	CL (cm)	CD (cm)	G/C	GW (g)	GYP (g)
Parents/Inbreds					
P1	15.6^{c-j}	14.22^{abc}	245.43^{cd}	30.85^{i-m}	85.59^{c-f}
P2	11.1^{a}	13.75^{b-e}	245.14^{bc}	20.40^{a}	54.83^{a}
P3	12.1^{a}	12.97^{a}	211.43^{bc}	25.86^{bc}	58.26^{a}
P4	11.8^{ab}	14.15^{b-f}	274.23^{de}	23.03^{b}	74.18^{bcd}
P5	13.9^{bd}	15.20^{a-d}	206.15^{a}	34.56^{n-p}	69.10^{abc}
P6	12.2^{a}	14.94^{abc}	234.13^{ab}	28.98^{cde}	85.10^{cde}
P7	10.4^{a}	12.70^{ab}	130.44^{a}	32.08^{f-i}	47.79^{ab}
P8	14.8^{h-l}	15.66^{f-m}	351.63^{k-l}	24.23^{def}	103.42^{i-l}
Mean	12.7	14.20	237.32	27.50	72.28
Min	10.4	12.70	130.44	20.40	47.79
Max	15.6	15.66	351.63	34.56	103.42
Crosses/F1					
P1xP2	15.14^{c-j}	12.91^{c-g}	353.12^{dg}	28.00^{e-h}	95.66^{f-j}
P1xP3	14.11^{c-i}	13.29^{d-h}	359.53^{dg}	31.33^{i-m}	104.83^{d-h}
P1xP4	14.59^{c-j}	13.20^{c-h}	352.15^{dg}	32.73^{k-n}	119.43^{jkl}
P1xP5	14.72^{c-j}	14.19^{h-m}	346.33^{dg}	30.36^{h-l}	113.73^{i-l}
P1xP6	15.75^{h-l}	14.11^{h-m}	391.04^{f-k}	31.89^{i-n}	123.96^{l}
P1xP7	17.27^{k-m}	14.47^{i-n}	386.27^{f-j}	32.72^{k-n}	123.74^{kl}
P1xP8	17.52^{l-m}	15.07^{mn}	438.59^{j-k}	31.96^{i-n}	149.76^{m}
P2xP3	18.19^{m}	14.83^{mn}	543.50^{m}	28.73^{e-h}	149.71^{m}
P2xP4	13.76^{c-f}	14.27^{h-n}	408.37^{g-k}	26.47^{def}	101.67^{f-k}
P2xP5	15.35^{c-j}	14.60^{k-n}	339.38^{df}	31.73^{i-n}	111.55^{h-l}
P2xP6	15.49^{e-k}	14.23^{h-n}	403.62^{f-k}	29.78^{g-j}	117.70^{jkl}
P2xP7	13.80^{c-g}	13.30^{d-h}	372.38^{e-i}	26.71^{def}	94.84^{f-i}
P2xP8	15.92^{i-l}	14.54^{j-n}	497.90^{lm}	26.93^{d-g}	119.26^{i-l}
P3xP4	13.65^{cde}	13.55^{f-l}	408.71^{g-k}	27.66^{e-h}	112.98^{i-l}
P3xP5	14.60^{c-j}	13.58^{f-l}	359.58^{dg}	29.69^{ghi}	102.27^{f-k}
P3xP6	13.55^{bcd}	13.37^{e-j}	368.26^{e-h}	26.79^{def}	119.63^{i-l}
P3xP7	15.62^{g-k}	14.67^{lmn}	394.93^{f-k}	32.62^{j-n}	116.61^{i-l}
P3xP8	15.90^{i-l}	14.19^{h-m}	435.06^{ijk}	24.40^{bcd}	113.89^{g-l}
P4xP5	15.64^{g-k}	14.93^{mn}	430.52^{h-k}	34.58^{nop}	149.93^{m}
P4xP6	15.55^{f-k}	14.21^{h-m}	430.55^{h-k}	30.13^{h-k}	107.87^{f-l}
P4xP7	16.42^{j-l}	15.37^{n}	503.25^{lm}	33.60^{m-p}	160.13^{m}
P4xP8	13.95^{c-h}	13.95^{f-m}	391.87^{f-k}	29.10^{f-i}	90.16^{d-g}
P5xP6	15.15^{c-j}	14.54^{j-n}	362.00^{dg}	35.86^{op}	126.84^{l}
P5xP7	15.84^{i-l}	13.32^{d-i}	350.77^{dg}	36.11^{p}	124.84^{kl}
P5xP8	16.70^{h-l}	14.63^{f-m}	455.16^{kl}	30.51^{def}	134.14^{i-l}
P6xP7	14.87^{c-j}	15.12^{mn}	393.34^{f-k}	33.26^{l-o}	125.85^{l}
P6xP8	17.28^{k-m}	14.32^{h-n}	438.13^{jk}	31.64^{i-m}	122.20^{l}
P7xP8	13.98^{c-h}	13.45^{e-k}	397.85^{f-k}	27.90^{e-h}	96.61^{e-i}
Mean	15.37	14.15	404.01	30.47	118.92
Min	13.55	12.91	339.38	24.40	90.16
Max	18.19	15.37	543.50	36.11	160.13

Cob length = CL, Cob diameter = CD, Number of grains/cob = G/C, 100 Grain weight = GW and Grain yield/plant = GY/P

DMRT was used to compare inbreds and their hybrids at P$\leq$ 0.05, where values followed by the same letter in a column are not significantly different.

TABLE 4. Additive-Dominance model for various trait in 8x8 F1 Half diallel cross

Traits	T^2 test	Regression analysis (t value of b) b0, b1	Conclusion
CL (cm)	11.834	b0= -2.25** b1= 5.97**	Partially adequate
CD (cm)	5.803	b0= -2.49** b1=4.16**	Partially adequate
G/C	26.61	b0= -4.64** b1=8.74**	Partially adequate
GW (g)	4.13	b0= -0.27 b1=4.95**	Partially adequate
GYP (g)	27.36	b0= -3.06** b1=9.54**	Partially adequate

**** Significant at 0.01 levels of probability, respectively**
Cob length = CL, Cob diameter = CD, Number of grains/cob = G/C, 100 Grain weight = GW and Grain yield/plant = GY/P

TABLE 5. Estimates of genetic components of variation and its ratios for ear traits and grain yield in 8x8 F1 Half diallel cross of Maize

Components/ratios	CL (cm)	CD (cm)	G/C	GW (g)	GYP (g)
E	0.98*±0.47	0.35*±0.13	1860.6±1095.26	3.95±2.39	213.58±113.15
D	1.82±1.41	0.71±0.38	4159.72±3285.77	1.33±7.18	200.78±339.45
H_1	11.26*±3.25	3.15*±0.86	24969.94*±7553.49	47.98*±16.50	2342.20*±780.34
H_2	9.07*±2.83	2.58*±0.75	21641.73*±6571.54	39.82*±14.36	1904.41*±678.89
F	2.86±3.34	0.63±0.89	5821.04±7763.97	4.95±16.96	258.17±802.09
h^2	2.00±1.89	1.06*±0.50	-0.04±4407.15	21.74*±9.63	580.94±455.30
$\sqrt{H1/D}$	2.49	2.11	2.45	6.01	3.42
$H_2/4H_1$	0.20	0.20	0.22	0.21	0.20
$\sqrt{4DH_1}+F/\sqrt{4DH_1}-F$	1.04	1.07	1.00	1.00	1.00
h^2 / H_2	0.22	0.41	0.00	0.55	0.31
h^2(ns)	15.10	24.30	10.30	14.00	21.60
h^2(bs)	75.00	77.80	86.00	75.90	80.90
Coefficient of correlation (r) between $Wr + Vr$ and	0.676	0.713	0.877	0.111	0.781

***, ** Significant at 0.05 and 0.01 levels of probability, respectively(±) = Standard error values**
Cob length = CL, Cob diameter = CD, Number of grains/cob = G/C, 100 Grain weight = GW and Grain yield/plant = GY/P

Significant positive correlation coefficients between Wr+Vr and Yr (Parental means) for all traits excluding 100 grain weight suggested that parents with recessive genes were responsible for depressed manifestation of these traits in F1 generation. The covariance of additive vs dominance effect in parental genotypes for ear traits and grain yield per plant in F1 generation (Table 6) revealed that parental inbred lines DMR QPM 102, CML 170, DMR QPM 03-121 and DMR QPM 103 recorded high positive Fr values indicating the major proportion of dominant genes in them. Inbred line CML 170 appeared to possess maximum dominant genes as it displayed maximum positive Fr values in almost all traits including grain yield. Significantly in all five traits inbred line CML 167 recorded high negative Fr values and it would likely to have maximum recessive genes for these traits. Inbred line CML 511 and CML 539 also displayed large negative Fr values for all traits except grains per cob and 100 grain weight, respectively. Hence both the parents had high proportion of recessive genes for cob length, cob diameter and grain yield per plant.

TABLE 6. Covariance of dominance and additive effects (Fr values for traits)

Inbreds/Parents	CL (cm)	CD (cm)	G/ C	GW (g)	GYP (g)
P1	6.07	2.43	11218.15	23.43	1083.48
P2	9.29	2.67	20787.70	24.41	1868.98
P3	7.73	2.02	15046.48	16.87	1294.99
P4	9.80	2.06	20907.87	18.26	1417.06
P5	0.96	0.61	13412.84	-34.01	375.39
P6	-0.57	-1.53	805.96	-8.18	-1104.06
P7	-6.93	-0.88	-5366.64	10.65	-550.56
P8	-3.52	-2.31	-30244.00	-11.84	-2319.93
Total	22.85	5.06	46568.36	39.58	2065.35
Mean	2.86	0.63	5821.05	4.95	258.17

Cob length = CL, Cob diameter = CD, Number of grains/cob = G/C, 100 Grain weight = GW and Grain yield/plant = GY/P

Breeding Approach

The results revealed pre dominance of non additive gene action in the inheritance of the traits under study. There is thus a limited scope for improvement of these traits by selection. As overdominance (non – additive gene action) are responsible for the control of these traits reflected by the analysis. The later generation selection likely to be more effective. Heterosis could be exploited in developing hybrids. Furthermore, the study by and large indicates that the rapid gain under the recurrent selection cycle will not be very profitable. Maximum gain could be achieved through the maintenance of considerable heterozygosity coupled with selection in segregating generation to enhance recombinations which may facilitate in breaking undesirable linkage. This would ensure transgressive segregations to accumulate and express maximum number of potentially functional genes for the improvement of the trait. Hopefully, this would lead to the production of stable and widely adapted genotypes.

Acknowledgement

International maize and wheat improvement centre (CIMMYT), Hyderabad and Directorate of Maize research (DMR), New Delhi are duly acknowledged for providing the seed material of inbred lines. Thanks to the Department of science and technology, Government of India, for providing Inspire Fellowship to the first author.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 19-30, 2018

Heterosis and Combining Ability Study for Seed Yield, Oil Content and Yield Attributing Characters in Sunflower (*Helianthus Annuus* L.)

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Received : 04.05.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

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, plant height and head diameter,100seed weight(g),leaf Area Index(LAI),no of seeds per head, seed filling % and oil content(%) were studied in the sunflower hybrids developed by the line x tester method. The female inbred lines were introduced from DOR, Hyderabad and from other AICRP centers , while the male restorer inbreds with good combining abilities were used as testers in the form of fertility restorers. F_1 hybrids were obtained by crossing each tester with each female inbred. The inbred lines and their F_1hybrids differed significantly in their mean values of the traits under the present study. Heterosis values for seed yield per plant were positive and highly significant relative to both the parental mean (31.4-154%). Significantly less heterosis was recorded in the case of plant height relative to parental mean (-7.5-94.0%). With head diameter, the heterotic effect ranged from (-21.0 to 90%) (parental mean), days to 50 %Flowering (-9.2-19.6%),for 100 seed weight(g) (-17.1-30.02%), for hill cont(%)(-17.0 - 13.2%), for volume weight(-8.5 – 9.7%),for grain filling (0.4 - 14.6%) and for oil yield (kg/ha) (34 -154.0%) respectively. Heterosis studies revealed that the best cross combination for semi-dwarf plant height coupled with good seed yield per plant and high oil content were observed in P-89-1A X EC-601751(100days maturity and seed yield 2450kg /ha) and CMS-10A X EC-601725(100days maturity and seed yield 2280kg /ha) respectively. The best specific combinations for seed yield were CMS-852 AX RHA-138-2 (2680 kg/ha,107 days maturity), CMS-853 AX EC-623027 (seed yield 2672kg/ha and 105 days maturity), CMS-853 AX EC-623023 (2536kg/ha and 105 days maturity) in comparison to the national check hybrids, i.e. KBSH-53 (seed yield 2212kg/ha and 114 days maturity) and DRSH-1(seed yield 2126kg/ha and 108 days maturity. It was also observed that the **GCA** was higher for seed yield among the female (CMS) lines in CMS-852A, CMS-853A, PET-89-1A and among the restorers(R)/male lines, EC-601971(mono), EC623023and EC601725 respectively. Out of the CMS lines for early maturity and semi-dwarfness, the best general combiners were CMS 103A and CMS-10A and the restorer line for the same traits, the best general combiners were EC-601878, EC-601751 and EC-623016 respectively. The results of this study may be used for the development of new high yielding and stable sunflower hybrids based on the hybridization between the best combiner.

Key words **:** combining ability, heterosis, sunflower, yield

Introduction

Sunflower (*Helianthus annuus* L., 2n = 34) an Asteraceae family plant is native to the temperate North America, which is the centre of diversity for this important edible oil-yielding species. Sunflower occupies the fourth position among vegetable oil seeds after soybean, oil palm and canola in the world. Sunflower is the one important source of vegetable oil in the world. Sunflower is grown worldwide, mostly as a source of vegetable oil and proteins and is one of the major crops around the world, which is cultivated on a surface of 21 million hectares. It is one of the three crop species along with soybean and rapeseed which account for approximately 78% of the world vegetable oil. Its seeds contain high oil content ranging from 35 to 40% with some types yielding upto 50%. Due to its low to moderate production requirements, high oil quality, protein content, and utilization of all plant parts, sunflower became an oil crop around the world during the end of the 19th century, when 'popular selection' was practiced in several parts of Russia to improve sunflower populations grown at that time. Sunflower cultivation plays a key role in edible oil production worldwide, represents an important alternative for crop rotation and provides intercropping and succession in producing regions.

Edible oil is the basic requirement of the human body because it is very important for the escalation and improvement of body. There is need to focus on conventional as well as non-conventional oilseed crops to fill the gap between consumption and production. Sunflower is non-conventional crop introduced in our country in early seventy's. India is facing a shortage of edible oil in recent years. Sunflower has maximum potential for bridging the gap in the demand and production of edible oil in the country. In India, sunflower is cultivated in an area of 0.7 million ha with a total productivity of 0.50 million tones (Padmaiah *et.al.,* 2015) and with an average productivity of 713kg/ ha (Anonymous, 2016) In West Bengal it is grown in an area of 12,500 ha in last *rabi* season (2015-16).

Most of the sunflower seed is imported in the country that is actually not bred for our environment. That's why; it gives low yield due to the adaptation problem (Kokhar *et al.,* 2006). Oil content of sunflower kernel ranges from 48-53% whilst in seed from 28-35% (Reddy, 2009). Sunflower oil is premium oil due to its beam colour, taste, high smoke point, good nutritional quality, towering level of unsaturated fatty acids and lack of linolenic acid. It has the sturdy oxidative stability so it can be used as cooking oil. Sunflower is short duration crop (95-120 days), therefore; it fits in any cropping pattern of India. It also requires less agronomic practices for the better yield. But farmers are focusing on major crops instead of sunflower as an oilseed crop. Regrettably its production in India is very stumpy compared to its requirement. For the enhancement of oil production we need to increase seed yield & oil percentage of sunflower. Genetic variability is very crucial item in the breeding programs. Genetic similarities and differences existing in the genotypes are utilized efficiently as genetic resource in the breeding programs (Safavi *et. al.,* 2011). Seed yield is a quantitative character which is influenced by different traits. Association is determined between the seed yield and its related traits for the improvement of yield in sunflower. Development of hybrids is the primary objective of most sunflower breeding programs in the world.

After the discovery of the cytoplasamic male sterility (CMS) lines (Leclercq in 1969) and fertility restorer genes by Kinman in 1970 which shifted the interest from population breeding to heterosis breeding. Heterosis of sunflower 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.

TABLE 1A. Analysis of variance (Mean squares)

Source of variation	d.f.	Days. to 50% flowering	Plant height	Head Diameter	Autogamy %	100 seed weight	No. of Filled seeds/ head	Seed yield / plant	Hull content %	Oil content %	Oil yield (Kg/ha)
Replication	1	0.96	7.25	0.58	4.77	0.28	10.85	9.57	1.45	2.35	1.45
Genotypes	61	**25.68****	**38.68****	**45.25****	**25.26****	**16.48****	**28.42****	**1062.5****	**24.62****	**32.62****	**48.11****
Parents	13	14.26**	19.41**	24.82**	26.72**	9.81*	25.2**	488.62**	11.78*	9.95*	9.25*
Line (L)	7	9.52**	14.72**	20.56**	21.58**	9.42*	46.5**	362.28**	11.45*	9.28*	9.12*
Tester(T)	5	8.26**	12.41**	16.82**	18.72**	7.81*	20.58**	245.62**	8.78*	7.95*	7.06*
P vs C	2	0.48	3.28	1.66	2.32	0.25	2.36	2.75	1.62	1.24	1.45
Hybrids(L xT)	35	**15.82****	**23.61****	**25.87****	**45.62****	**11.52***	**47.66****	**952.51****	**19.82****	**18.6***	**17.48****
Error	47	0.45	5.75	0.66	11.08	0.25	28.25	1.25	1.28	0.95	1.16

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

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 rest pert of the world including India. Sunflower hybrid breeding has thus played a provital 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 yieldIn India, the sunflower is grown on about 8.0 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 12,500 ha in last *rabi* season (2015-16). 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.

The study of combining ability is useful in testing of hybrid combinations and in choice of the desirable parents for use in the heterosis breeding. One of the techniques, which was widely used to extract the Information about the potentiality of the parental lines and the gene action governing the inheritance of traits is line X tester (L x T) analysis (Kmpthorne 1957). With a view to identify the lines with good combining ability and to identify the good specific cross combination for further exploitation, the present investigation was undertaken in the 2014-15 and 2015-16**.** 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.

Materials and Methods

The experiment was carried out during December 2014-15 and 2015-16 under AICRP Sunflower, Nimpith Centre of RAKVK Research Farm, South 24 Parganas, West Bengal The soil texture was clay loam in “On station” and “MLT” plots. Three irrigations were provided during the cropping period. A total of 48 sunflower hybrids developed (2014 and 2015 Off season/ *Kharif* season) at AICRP-Sunflower, Nimpith along with parents were evaluated centre along with the three national check hybrids, KBSH-53, LSFH-171and DRSH-1 were evaluated in this trial in a randomized block design with two replications in a plot size of 4.5m x 3.0m.. The soil texture was clay loam in “On station” and “MLT” 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 (%), No. of filled grain and unfilled grain per head, volume weight (g/100cc) and the seed yield/ plant. 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.

The present study was aimed to (i) Study the Heterosis for yield component in sunflower (*Helianthus annuus* L). (ii) Study the combining ability in relation to heterosis in sunflower to evaluate the superior sunflower hybrids to identify the superior **cross combination /sunflower hybrids** in respect to yield and yield component suitable for growing *rabi* season in West Bengal agro-climatic condition.

TABLE 2. Combining ability effects of parents for yield and yield contributing characters.

Name of the parent	Plant height	Head Diameter	Days. to 50% flowering	Seed yield/ plant	100 seed weight	**No. of Filled seeds/head**	Autogamy % (Gr. Filling%)	Hull Cont.(%)	Vol. Wt. (g/100cc)	Oil Cont. %
CMS-850A	-6.25**	-0.22*	-1.82**	- 6.08*	-1.28*	3.25	0.35	-0.56*	-0.55*	-0.55*
CMS-852A	8.65**	0.66**	-0.61*	13.27**	1.22*	16.25**	0.32	0.45*	0.57*	-0.58*
CMS-10A	11.45**	0.45**	-0.55*	5.42	-1.08*	11.65**	0.41	0.45*	-0.48*	-0.65*
CMS-853A	14.45**	0.81**	0.41**	14.42**	1.62*	18.75**	0.32	0.41*	0.71*	-0.71*
P-89-1A	9.56**	0.52**	-0.35	10.55**	-1.16*	12.65**	0.71*	0.49*	0.35*	-0.55*
CMS-103A	-9.87**	-0.26*	-2.31**	-7.42*	-1.56*	3.45*	0.83*	-0.78*	-0.38*	-0.48*
P-2-7-1A	9.02**	0.46**	-0.29	10.51**	-1.02*	14.81**	0.65	0.41*	0.47	-0.56*
CMS-207A	7.12*	0.36**	-0.31	8.28*	-1.16*	12.58**	0.37	0.41*	-0.41*	-0.55*
S.Em(±)	**2.62**	**0.14**	**0.12**	**3.48**	**0.05**	**4.67**	**0.25**	**0.27**	**0.31**	**0.31**
EC-601878	3.41*	0.81 **	-0.72*	5.08*	-1.18*	11.51**	0.73*	-0.25*	-0.47*	0.39*
EC-623023	8.85**	0.89**	1.17**	10.08**	-1.18*	13.18**	-0.25	0.32*	0.55*	-0.37*
EC-623016	8.25**	0.49**	-1.14*	6.27**	-1.42**	7.68	0.65*	-0.35*	-1.06**	-1.25**
EC-623027	11.25**	1.58**	1.54**	14.27**	1.22**	17.44**	0.35	0.25*	1.21**	-0.38**
EC-601751	8.21**	1.17**	-0.72*	10.08**	0.75*	12.25*	-0.38	0.36*	-0.55*	-0.55*
EC-601725	6.28**	1.09**	-0.55*	14.55**	-1.28*	10.61**	-0.27	0.25*	0.57*	-1.26**
EC-623021	12.25**	1.60**	0.64*	11.23**	-1.02*	11.86**	-0.45	-0.40	-1.05**	-1.05**
S.Em(±)	**4.28**	**0.21**	**0.38**	**1.28**	**0.07**	**3.28**	**0.36**	**0.56**	**0.41**	**0.36**

TABLE 2A. Performance of parents for yield and yield contributing characters.

Name of the parent	**Pl. Ht(cm)**	**Hd. Dia. (cm)**	**50% Flow.**	**Seed Yield (kg/ha)**	**100 seed wt.(g)**	**Hull. Cont. (g)**	**No .of filled grains/ Hd.**	**Gr. Filling %**	**Vol. Wt (g/100cc)**	**Oil%**	**Oil Yield (kg/ha)**
CMS-853A	118.6	11.5	67.9	1385	5.7	30.2	298	83.3	42.8	36.2	501
CMS-852A	123.5	11.8	65.6	1140	5.0	32.1	280	86.8	42.2	35.6	406
CMS-850A	116.0	12.8	66.0	1090	4.9	28.9	286	90.2	42.0	35.4	386
CMS-10A	141.9	12.4	69.4	1225	5.3	31.4	340	87.1	42.1	34.0	417
CMS-103A	129.3	12.3	65.0	1035	5.3	26.5	321	87.8	45.4	36.2	375
PET-89-1A	107.8	10.5	71.0	1100	4.9	29.3	408	84.0	45.4	35.2	387
CMS-207A	136.0	12.6	68.8	1210	4.6	31.8	478	88.0	40.4	35.4	428
PET-2-7-1A	131.8	13.2	70.4	1150	5.5	33.1	364	86.9	43.7	35.2	405
EC-601878	87.4	11.6	66.3	770	4.9	29.6	286	87.9	42.9	42.5	327
EC-623023	95.8	7.5	71.3	825	5.3	29.1	283	85.2	43.0	38.2	315
EC-623016	86.2	6.4	69.8	690	5.1	29.0	235	86.3	41.5	41.5	286
EC-623027 (M)	104.8	9.9	71.5	1020	5.6	26.0	393	72.5	45.3	38.9	397
EC-601751	95.2	9.7	64.3	770	5.3	30.3	264	86.5	44.0	42.6	328
EC-601725	84.2	9.8	70.5	880	5.2	32.7	308	83.0	44.6	41.8	368
EC-601751	91.2	9.0	62.0	720	5.4	30.0	256	85.5	43.0	42.0	318
EC-623021	87.4	8.6	64.0	780	5.0	29.5	262	87.5	42.0	42.5	342

Results and Discussion

Identification of cytoplasmic male sterility sources leads to the exploitation of hybrid vigour and commercial hybrid seed production in sunflower became easier. Sunflower is a highly cross pollinated nature; hence it offers tremendous scope for commercial exploitation of heterosis using cyto-restorer system (Gangappa *et. al.*, 1997). The first important step for the commercial exploitation of heterosis is to know its magnitude and extent. The magnitude of heterosis provides a basis for genetic diversity and guide for the choice of desirable parents for developing superior F_1 hybrids so as to exploit hybrid vigor and/ or for building gene pools to be employed in breeding programme.

The heterosis studies revealed that the Heterosis values for seed yield per plant were positive and highly significant relative to both the parental mean (31.4-154%). Significantly less heterosis was recorded in the case of plant height relative to parental mean (-7.5-94.0%). With head diameter, the heterotic effect ranged from (-21.0 to 90%) (parental mean), days to 50 %Flowering (-9.2-19.6%), for 100 seed weight(g) (17.1-30.02%), for hill cont (%) (-17.0 - 13.2%), for volume weight (-8.5 - 9.7%), for grain filling (0.4 - 14.6%) and for oil yield (kg/ha) (34 -154.0%) respectively. A total of 11 crosses exhibited significant better parent heterosis, for days to 50 % flowering. The significant contribution in the induction of earliness in the above crosses is from CMS 850A,103A and CMS-10A similar report was found by Raghavendra (2004). 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 no cross showed significant negative mid parent heterosis for plant height.

Head diameter is 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.*852A 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. Heterosis for seed filling percentage revealed that mid parent heterosis ranged from 0.4 to14.6%, (Table 4).The F1,viz. **CMS-853 A X EC-623027(M)**, PET-89-1A X EC-601878, 852A X EC-601718 and CMS-207AX EC-623016 showed significant and positive mid parent heterosis for the said trait. The *per ce* performance of most of these hybrids was significantly superior to highest yielding check LSFH 171. Gangappa *et al.* (1997) also observed higher magnitude of heterosis for filled seeds 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 -8.6 to 6.4%. Only 2 sunflower hybrids, *viz.,*CMS-10 AX EC-623023 and CMS-10 AX EC-623027 showed significant positive mid parent heterosis for the same trait. For oil yield (kg/ha) *per ce* performance of most of these hybrids was significantly superior and showed significant positive mid parent heterosis for the same trait. The higher mid parent heterosis observed for the same trait in PET-89-1A X EC-601916 followed by CMS-852A X EC-601751, CMS -853 A X EC623023, CMS-850 A X EC-601878, P-2-7-1A X EC-601751, CMS 852 AX EC-623021 **CMS-10A X EC-601725** and CMS-852 A X EC-601725 respectively.

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 observed in 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. The best specific combinations for seed yield were CMS-853 AX Ec-623027 (2462 kg/ha, 107 days maturity, and oil Yield 881 kg/ ha), CMS-853 AX EC-623023 (seed yield 2428kg/ha and 105 days maturity and 861 kg oil/ha respectively),CMS-852 AX EC-601751 (2328kg/ha and 105 days maturity and 840 kg oil/ha) respectively.

Low hull content in seed is having direct relation to increase the oil content percent. Among 48 hybrids studied, the desirable negative significant mid parent heterosis was manifested by F1 viz., CMS-10A X EC-623023 followed by CMS-207AX EC-623016 and 853 A x Ec-601725PET-89-1A X EC-601878CM-103A X EC-601878, PET-89-1A X EC-601916, CMS-852AX EC-601751 and CMS-103A X EC-623023 respectively. The parental lines *viz.* CMS-852A, CMS-103 A, PET-89-1A with significant GCA effects 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 v in F1s viz., CMS-103 A X EC-601878 followed byPET-89-1A X EC-601878 and PET-2-7-1A X EC-601878 respectively. All the three sunflower hybrids were high oil percentage and significantly superior over the LSFH-171 (Table-3 and Table-4).

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 v in F1s viz., PE-2-7-1A X EC-623016 (30% heterosis over mid parent), followed by CMS-853 A X EC-623027, CMS-103 A X EC-601718, 207A x -601718, CMS-852 A X EC-601725, CMS-853 A X EC-623023 CMS-207A X EC-601878 and **CMS -10A X EC-623021, CMS -10A X EC-623016** respectively(table-4). The parental lines *viz.* CMS-853A, CMS-207 A, PET-89-1A and CMS-10A and EC-601718, with significant GCA effects have contributed for desirable significant positive heterosis among the above hybrids for high 100 seed weight.

Significant genotypic differences were existed for all the agronomic traits. The analysis of variance shows significant differences among the genotypes for all the above said characters studied. The gene action governing different traits were inferred from combining ability. The variance due to specific combining ability was higher for all the traits studied. The σ 2D values were also found to be higher than σ 2A for all the traits study. Predominance of dominance genetic variance of all the traits except plant height indicated the influence of non-additive gene action as reported by Gourisankar *et. al.* (2007) and Satishchandra *et. al.,*2010. The data pertaining to seed yield and other yield attributing traits for these test hybrids along with the checks are presented in Table 3.

This indicated significant contribution of lines, testers towards GCA and line x tester interaction towards SCA. General combining ability (GCA) provides estimates of additive gene action while specific combining ability (SCA) provides estimates of non-additive gene action (Sprague and Tatum, 1942). Highly significant variances due to lines x environments and lines x testers x environments suggested that lines and hybrids were highly influenced by environments. Two testers viz. EC-601725 and EC-601751 exhibited higher *gca* effects for most of the traits studied (Head Diameter, No. of filled seeds/head, oil %), therefore, these parents can be considered as the good combiners For hull content, CMS 103A and CMS-850A among testers, and among lines EC-601878 and Ec-623016 exhibited significant negative GCA effects therefore, these parents can be considered as the good combiners for low hull content (table-3). 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 and positive GCA effects, therefore, these parents can be considered as the good combiners for high oil content .Very few crosses displayed significant positive SCA effects for volume weight among them CMS-103 A X EC-601878, PET-89-1A X EC-601878, CMS-850A X EC-623016, PET-2-7-1A X EC-601878, PET-89-1A X EC-601751 and CMS-10A X EC-601725 are found promising. For 100 seed weight CMS 852A and CMS-853A and EC-623023 and Ec-623027 showed positive and significant GCA effects. Thus these parents could be adjudged good general combiners for 100-seed weight.

Six parents, CMS-853A & CMS-852A and EC-623027(M), EC-601751, EC-623023 & EC-601725 had significant positive gca effect for seed yield and some

TABLE 3. Performance of specific cross combination(Sunflower hybrids for yield and yield attributing characters)

Sl. No	Hybrid combination	Pl. Ht (cm)	Hd. Dia. (cm)	50% Flow.	Seed yield (kg/ ha)	100 seed wt.(g)	Hull Cont. (%)	No. of Filled grain/ Hd.	Gr. Fill. %	Vol. Wt (g/ 100 cc)	Oil%	Oil Yld. (Kg/ha)
1.	CMS-853 A X EC-623027	194.5	16.4	73.0	**2462**	6.2	32.3	766	87.0	42.8	35.8	881
2	CMS -853 A X EC623023	192.5	16.0	75.5	**2428**	6.0	30.0	812	87.5	43.0	35.6	864
3	CMS-853 AX EC 623021	15.7 144.0	74.5	**2292**	5.0	28.0	922	87.0	43.7	36.4	834	
4	CMS-853A X EC-601878	145.0	15.5	71.5	2075	5.6	25.0	674	86.5	45.3	37.4	776
5	CMS-853A X EC-601725	182.5	17.4	75.5	**2278**	4.8	33.3	916	87.0	40.0	35.2	802
6	CMS-853A X EC-623016	160.5	15.0	72.0	2072	5.6	32.1	813	87.5	43.8	37.2	770
7.	CMS-852A X EC-623027	185.0	15.1	76.0	**2270**	4.9	30.0	916	92.0	40.0	35.8	814
8	CMS-852A X EC-623023	180.0	16.1	76.0	2328	4.6	34.8	1021	88.5	43.2	36.1	840
9.	CMS 852 AX EC-623021	189.0	15.4	77.5	**2272**	5.0	30.0	888	91.0	40.0	35.8	813
10.	CMS-852AX EC-601751	170.0	15.8	74.5	**2284**	4.8	31.3	930	90.0	41.6	36.4	831
11	CMS-852 A X EC-601725	155.0	16.7	70.5	2072	5.6	32.1	813	87.5	43.8	37.2	771
12	852A X EC-623016	175.5	15.3	73.0	**2306**	5.9	25.4	741	88.5	42.7	35.8	826
13	CMS-850A X EC-601751	133.0	15.4	69.0	1861	5.1	27.5	663	91.5	42.6	36.8	685
14	CMS-850 A X EC-601878	92.5	9.6	65.0	1500	5.0	28.0	565	94.0	39.7	39.2	588
15	CMS-850A X EC-623016	122.5	13.3	64.0	1472	4.5	31.1	595	91.0	43.6	38.4	565
16	CMS-103 A X EC-601878	134.5	11.8	66.0	1733	5.8	23.8	536	90.5	48.5	38.4	665
17	CMS-103A X EC-623023	124.0	12.7	64.0	1340	4.8	29.2	507	90.0	42.2	37.2	498
18	CMS-103A X EC-601751	137.5	10.5	64.5	1232	4.7	30.0	532	91.0	43.4	38.9	486
19	P-2-7-1A X EC-601878	137.5	11.5	64.5	1340	4.5	31.1	582	90.0	45.6	38.7	518
20	P-2-7-1A X EC-601751	177.5	15.8	76.0	**2340**	5.6	32.1	818	87.5	42.6	35.2	824
21	P-2-7-1A X EC-623016	155.5	14.9	70.0	**1878**	6.9	33.8	495	90.0	42.4	37.8	710
22	P-2-7-1A X EC-601725	145.5	15.7	68.0	**2192**	5.5	32.7	758	88.5	43.5	37.6	824
23	P-2-7-1A X EC-623027	193.0	16.4	73.0	2094	5.2	34.6	767	89.0	43.2	37.0	775
24	CMS -207A X EC-623023\	142.5	14.7	73.0	2194	4.4	29.5	907	88.0	39.9	36.4	799
25	**CMS-207A X EC-601878**	115.0	13.5	67.0	1431	5.3	32.1	491	90.5	39.2	38.5	551
26	CMS207AX EC-601725	172.5	14.8	71.5	**2017**	4.8	33.3	764	86.0	40.0	36.8	742
27	CMS207AX EC-623021	169.0	14.4	70.5	**1886**	5.0	34.0	715	90.0	38.0	37.5	707
28	CMS-207AX EC-623027	142.5	14.0	63.5	**1567**	4.7	32.8	606	92.0	39.6	39.0	611
29	CMS-207AX EC-623016	123.0	14.0	66.5	1447	4.3	32.6	612	92.0	40.2	38.5	557

30	**PET-89-1A X EC-623027**	**191.5**	**14.7**	**73.5**	**2218**	**4.5**	**31.1**	**982**	**88.0**	**45.1**	**35.6**	**790**
31	**PET-89-1A X EC-601878**	**123.0**	**12.0**	**68.5**	**1444**	**5.0**	**26.0**	**525**	**91.5**	**45.2**	**38.8**	**560**
32	**PET-89-1A X 154.0 EC-601751**	**16.1**	**71.0**	**2244**	**5.2**	**30.8**	**844**	**85.5**	**45.9**	**37.2**	**835**	
33	**PET-89-1A X** EC-623016	136.5	13.9	67.0	1611	5.1	33.3	767	90.0	41.0	37.5	604
34	**PET-89-1A X** EC-601725	148.5	15.0	73.0	1960	4.6	31.8	762	89.0	39.7	36.8	711
35.	CMS-10A X EC-601751	142.5	15.0	73.5	1967	4.4	31.8	813	87.0	39.6	36.4	716
36.	CMS-10 AX EC-623023	144.0	14.7	64.0	**1380**	4.8	29.2	523	92.0	42.2	38.6	533
37.	CMS-10 AX EC-623016	145.5	15.0	68.0	**1792**	5.5	32.7	625	87.5	41.5	38.2	685
38.	**CMS-10A X EC-601725**	156.5	18.3	70.5	**2240**	5.2	32.7	818	86.0	44.6	37.6	842
39.	**CMS-10 AX EC-601878**	119.0	11.8	64.5	1306	5.0	30.0	612	92.0	40.3	38.2	499
40.	**CMS -10A X EC-623021**	142.5	14.8	71.5	1722	5.5	30.9	569	88.0	40.8	36.5	629
	KBSH-44	185.0	15.6	80	**2224**	5.1	36.5	793	86.5	36.0	28.6	636
	DRSH-1	175.0	15.1	78	**1916**	5.5	32.0	633	90.0	40.5	39.2	736
	LSFH-171	181.0	15.7	80	**2260**	5.1	35.0	806	87.5	36.5	31.0	701
	G. Mean	**152.2**	**15.1**	**69.9**	**1864**	**5.1**	**32.0**	**710.2**	**88.1**	**41.2**	**36.5**	**711**
	S.Em(±)	**2.3**	**0.6**	**1.1**	**21.4**	**0.2**	**0.5**	**20.3**	**0.6**	**0.4**	**0.22**	**28.2**
	C.D.(P=0.005)	**6.8**	**1.7**	**3.4**	**61.8**	**0.6**	**1.4**	**60.4**	**1.8**	**1.1**	**0.68**	**84.5**
	C.V.(%)	**9.2**	**5.1**	**6.8**	**9.6**	**5.8**	**8.2**	**9.2**	**7.5**	**7.1**	**8.2**	**9.4**

other yield components like head diameter, 100 seed weight and volume weight (g/100cc). On the basis of analysis these parents recorded significant and positive GCA effects for seed yield. Thus these genotypes appeared to possess high concentration of additive genes for seed yield and component traits. Most of these parents also possessed high *per se* performance for seed yield as well as its important component traits. The studies revealed that the best cross combination for semi-dwarf plant height coupled with good seed yield per plant and high oil content are 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 the 48 hybrids, CMS-853 AX EC-623027 (2462 kg/ha, 107 days maturity, and oil yield 881 kg/ ha, 100 seed weight 6.2g), CMS-853 AX EC-623023 (seed yield 2428kg/ ha,105days maturity,861 kg oil/ha,100 seed weight 6.2g), CMS-852 AX EC-623016 (2306kg/ha,105 days maturity, 840 kg oil/ha and 100 seed weight 5.9g) possessed superiority for seed yield as well as high 100 seed weight and high volume weight. These crosses involved at least one parent with high GCA effects and had high seed yield at *per se* performance. Recently high heterotic hybrids for seed yield were also reported by Chandra *et al.* (2013), Thombare *et al.* (2007).

From the field experiment, it was also observed that CMS-852A, CMS-853A & PET-89-1A possessed superior **GCA** effects for seed yield among the female (CMS) line in and EC601751(mono), EC623023 and EC601725 possessed superior **GCA** effects for seed yield among the restorer lines. Among the CMS lines, for early maturity and semi-dwarfness, CMS 103A and CMS-10A possessed superior **GCA** effects the among the restorer lines EC-601878, EC-601751 and EC-623016 possessed superior **GCA** effects for the same traits.

The best specific combination for seed yield and other yield attributing traits like 100 seed weight, fresh head diameter and volume weight(g/100cc) are CMS-853 AX EC-623027(mono),CMS-853 AX EC-623023, CMS-852 AX EC-623016 CMS 852 AX EC-623021, PET-2-7-1A XEC-601751 and CMS-10A X EC-601725 respectively (Table-3).

From the field experiments it was observed that the difference were significant among lines, testers and lines tester interaction for head diameter and seed filling percentage, Testers exhibited the highest proportional contributions for above characters. The estimates of SCA and GCA variances were highly influenced by highly significant mean square due lines x environments, tester x environments and lines x testers x environments variances in seed filling percentage, while for head diameter, significant interaction between lines x environments and lines x testers x environments variances revealed that testers and hybrids were influenced by environments. The magnitude of estimated component of GCA and SCA variances revealed greater importance of GCA for head diameter, while of SCA for seed filling percentage. Similar to present findings, head diameter was observed to be under the influence of additive effects by Makanda *et al*. (2012). Patil *et al*. (2012), Jondhale, *et al*. (2012) highlighted the importance and predominance of non-additive effects in for the same traits.

Oil content recorded significant mean squares due to lines, testers as well as line x tester with high magnitude of variance for lines and testers as compared to L x T on the basis of pooled analysis. This indicated significant contribution of lines, testers towards GCA and line x tester interaction towards SCA. Highly significant interaction between line x environments, testers x environments and line x testers x environments suggested that lines, testers and hybrids were influenced by environments. The similar type of findings also reported by Patil *et al*. (2012), Jondhale, *et al*. (2012).

Seed yield, the final expression of above component traits, was found to record high significant mean square for lines, testers and line x tester interaction. The significant mean squares indicated significant contribution of lines and testers towards general combining ability variance component for the trait. Whereas significant mean square for line x tester indicates the significant contribution of crosses for specific combining ability variance component. Significant L x T proved that variation among hybrid combination was considerably higher. Significant interaction between lines x environments and lines x testers x environments suggested that lines and hybrids were highly influenced by environments. On the basis of analysis, SCA: GCA ratio variances indicated that the most of the total genetic variation for seed yield was resulted in by the non-additive gene effects. The importance and predominance of non-additive or dominance effects for seed yield in sunflower was also highlighted by many earlier workers like Permeshwarappa *et al.* (2008), Karasu *et al*. (2010), Patil *et al*. (2012), Jondhale *et al*. (2012).

Conclusion

The studies revealed that the best cross combination for semi-dwarf plant height coupled with good seed yield per plant and high oil content are 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 the 48 hybrids, CMS-853 AX EC-623027 (2462 kg/ha, 107 days maturity, and oil yield 881 kg/ ha, 100 seed weight 6.2g), CMS-853 AX EC-623023 (seed yield 2428kg/ ha,105days maturity,861 kg oil/ha,100 seed weight 6.2g), CMS-852 AX EC-623016 (2306kg/ha,105 days maturity, 840 kg oil/ha and 100 seed weight 5.9g) possessed superiority for seed yield as well as high 100 seed weight and high volume weight. These crosses involved at least one parent with high GCA effects and had high seed yield at *per se* performance. Six parents, CMS-853A & CMS-852A and EC-623027(M), EC-601751, EC-623023 & EC-601725 had significant positive GCA effect for seed yield and some other yield components like head diameter, 100 seed weight and volume weight (g/100cc). On the basis of analysis these parents recorded significant and positive GCA effects for seed yield. Thus these genotypes appeared to

TABLE 4. Heterosis(h^2) for the yield attributing traits

Hybrid combination	Pl. Ht (cm)	Hd. Dia.	50% Flow.	Seed yield (kg/ha)	100 seed wt.(g)	Hull Cont. (%)	No. of Filled grain/Hd	Gr. Fill. %	Vol. Wt (g/100	Oil%	Oil Yld. (Kg/ha)	PDI of *S. rolsii* (%)
	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%	h^2%
CMS-853 A X EC-623027(M)	94.5	53	4.7	105	9.7	14.9	121.7	10.7	-2.9	-4.5	108.2	22.8
CMS -853 A X EC623023	92.5	78	9.6	134	11.1	1.4	204.7	3.2	1.9	-8.5	142.4	44.9
CMS-853 AX EC 623021	44.0	65	7.0	107	-9.1	-5.7	217.4	3.2	1.9	-2.2	126.2	17.5
CMS-853 AX EC-601778	44.0	66	6.0	98	4.0	-6.1	168.6	3.4	2.1	-2.4	112.5	17.0
CMS-853A X EC-601725	92.5	63	9.1	101	-12.7	5.7	202.3	4.6	-8.5	-9.7	95.9	6.7
CMS-853A X EC-623016	67.2	58	6.6	92	4.0	-6.1	128.6	3.8	2.5	-2.1	88.5	17.0
CMS-852A X EC-623027	89.0	71	19.6	137	3.6	-2.6	126.2	4.7	-3.5	-7.1	121.7	-3.2
CMS-852A X EC-623023	89.0	71	19.6	141	11.6	-0.8	162.7	4.7	-3.2	-7.0	128.7	-3.5
CMS 852 AX EC-623021	89.0	71	19.6	137	3.6	-2.6	136.7	4.0	-4.0	-7.4	116.7	-3.8
CMS-852A X EC-601778	68.2	62	17.6	128	5.2	-0.8	162.7	4.7	-3.2	-7.0	128.7	-3.5
CMS-852AX EC-601751	70.0	46	14.6	139	-7.7	0.3	241.9	3.8	-3.5	-6.9	143.3	-17.6
CMS-852 A X EC-601725	55.0	55	3.5	105	9.8	-0.9	176.5	3.1	0.9	-3.9	99.2	-10.3
852A X EC-623016	75.5	90	7.8	152	15.7	-17.0	187.8	2.2	1.9	-7.3	148.6	-9.7
CMS-850 A X EC-601878	-7.5	-21	-1.8	61	2.0	-4.4	97.6	5.5	-6.6	0.5	64.9	**-25.6**
CMS-850A X EC-601751	33.0	36	5.8	100	0.0	-7.1	141.1	3.5	-0.9	-5.6	91.9	-8.3
CMS-850A X EC-623016	22.5	39	-5.7	65	-10.0	7.2	128.4	3.1	4.3	-0.3	68.2	**-39.4**
CMS-103A X EC-623023	24.0	28	-6.2	44	-9.4	5.0	67.9	4.0	-4.5	0.0	44.3	7.7
CMS-103 A X EC-601878	34.5	-2	0.5	92	15.3	-15.3	76.6	3.0	9.7*	-2.5	89.5	-12.5
CMS-103A X EC-601751	37.8	-3	0.7	31	-11.4	5.0	62.1	5.0	-5.5	-0.2	41.3	7.9
PET-89-1A X EC-623027	94.5	53	4.7	136	4.5	5.2	56.1	3.3	3.7	-7.0	145.1	**-45.1**
PET-89-1A X EC-601878	23.0	8	-0.3	54	2.0	-11.9	51.3	6.4	**8.3***	-0.3	56.9	**-37.0**
PET-89-1A X EC-601751	54.0	59	5.0	140	2.0	3.4	151.2	0.4	2.7	-4.4	151.2	**-38.3**
PET-89-1A X EC-601725	37.5	53	4.2	121	4.4	5.2	54.1	3.4	3.7	-6.0	141.1	**-41.1**
PET-89-1A X EC-623016	91.5	73	4.4	148	-10.0	6.5	205.4	3.3	3.7	-7.3	157.1	**-55.1**
PET-2-7-1A X EC-623027	93.5	55	4.7	96.2	2.6	11.2	136.7	8.6	-2.9	-4.5	108.2	22.8
P-2-7-1A X	77.5	38	12.8	144	3.7	1.3	160.5	0.9	-2.9	-9.5	142.0	-17.5
PET-2-7-1A X EC-601725	45.5	37	0.9	128	1.9	3.2	141.4	2.1	-0.9	-3.3	135.2	-20.0

PET-2-7-1A X EC-623016	55.5	52	-0.1	104	30.2	8.7	65.3	3.9	-0.5	-1.6	105.5	-27.0
(P-2-7-1A X EC-601878)	93.0	32	6.7	118	0.0	10.2	136.0	1.8	-0.2	-4.9	121.9	**-38.6**
CMS-207A X EC-623027	42.5	24	-9.5	41	-7.8	13.5	39.2	14.6	-7.7	4.8	48.1	4.8
CMS -207A X EC-623023	42.5	46	4.1	116	-12.0	-3.3	138.4	1.6	-4.3	-1.1	115.1	4.4
CMS207AX EC-623021	69.0	36	6.2	90	4.2	10.7	93.2	2.5	-7.8	-3.8	91.7	-7.3
CMS-207A X EC-601878	15.0	12	-0.9	45	10.4	4.6	28.5	2.8	-6.0	-1.3	46.0	**-26.1**
CMS-207AX EC-601725	72.5	32	2.6	93	-2.0	3.1	94.4	0.6	-5.9	-4.7	86.4	-4.5
CMS-207AX EC-623016	23.0	47	-4.0	52	-12.2	7.2	71.7	5.5	-2.0	0.0	56.0	**-33.3**
CMS-10A X EC-623023	42.5	50	4.4	92	-17.0	5.0	161.0	0.9	-7.0	0.8	95.6	-28.8
CMS -10A X EC-623021	42.5	41	7.2	72	5.8	1.3	89.0	0.8	-3.1	-4.7	65.7	**-30.9**
CMS-10A X EC-601878	19.0	-2	-5.0	31	-2.0	-1.6	95.5	5.1	-5.2	-0.3	34.1	**-33.3**
CMS-10A X EC-601725	56.5	65	0.7	113	-1.9	1.9	152.5	1.1	2.8	-0.8	124.2	**-34.5**
CMS-10 AX EC-623016	45.5	60	-2.3	87	5.8	8.3	117.4	0.9	-0.7	1.1	105.7	**-40.0**

possess high concentration of additive genes for seed yield and component traits therefore, these parents can be **considered** as the **good combiners** for **heterosis breeding programme in Sunflower**. CMS 852A and CMS-853A testers and EC-623027 showed positive significant and positive GCA effects 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.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 31-34, 2018

Effect of Graded Doses of Zinc on the Changes of Biological Properties in an Acid and Neutral Soil

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Received : 04.05.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

Laboratory experiment were conducted in an acid and neutral soil to study the changes in biological properties in an acid and neutral soil affected by different level of zinc application either in combination with lime or organic matter. In the laboratory study the results show that the colony forming unit of total viable bacteria and fungi due to zn application has been found to be counteracted by the application of lime at its full lime requirement of the soil suggesting a stimulating effect of lime on the viable bacterial population in an acid soil. The results further pointed out that the combined application of all levels of Zn and organic matter counteracted the magnitude of such decrease in bacterial population explaining that organic matter provides energy to the microbes especially bacteria as well as modifies soil reaction.

Key Words: interaction, lime, organic matter, soil biological properties, zinc

Introduction

Rice *(Oryza sativa)* is the stable food of more than 60 percent of the world's population by virtue of the extent and variety of uses and its adaptability to a wider range of climate edaphic and cultural condition. At present in West Bengal, 6.15 m ha of lands are under rice cultivation (Estimate of area production and productivity of principal crops, 1999-2000, Govt. of West Bengal). The total production of rice in West Bengal is 13.759 m lakh tons and productivity is 2237 kg ha. But unfortunately the rice yield in these soils of West Bengal is consistently fluctuating in spite of applying recommended levels of N.P and K fertilizers. Zinc is one of the important essential micro-nutrients required for growth development and yield of most crops especially rice grown in low land condition. As much as around 40% of soil samples analyzed throughout all districts of West Bengal have been found to be deficient in zinc. The problem seems to be more acute for rice as around half of the total rice area found to be severely affected by Zn deficiency since rice is growth mostly on submerged soils where availability of Zn is affected a diversely. Zinc is an indispensable micro-nutrient for proper plant growth and development (Das and Saha 1999). Singh and Abrol, 1986 reported that on an average 50% of the Indian soils are deficient in zinc.

Materials and Method

Soil Sample used in the present experiment was collected from a rice field in the Manbazar block, District- Purulia, West Bengal. The soil was content PH 5.60 and Zn content 0.92 ppm and also soil sample was collected from a rice field in the University farm, in check farm at Kalyani, District- Nadia West Bengal. We soil were content PH 7.00 and Zn content 0.35ppm. Both the soil sample collected from a depth of 0-15 cm, air dried, powdered and passed through a 20 mesh sieve.

Experimental details in acid soil:

Treatments	Description of treatments
T_1	Only soil (control)
T_2	Soil + Zn@ 20 mg kg $^{-1}$ as $ZnSO_4.7H_2O$ (soil weight Basis)
T_3	Soil + Full lime requirement + Zn@ 20 mg kg $^{-1}$ as $znSO_4.7H_2O$
T_4	Soil + Zn@ 40mgkg^{-1} as $ZnSO_4$.7H2O
T_5	Soil + full lime requirement + Zn@ 40mg kg^{-1} as $ZnSO_4.7H_2O$
T_6	Soil + Zn@ 60mg kg^{-1} as Zn $SO^4.7H_2O$
T_7	Soil + Full lime requirement + Zn@ 60mg kg^{-1} as $ZnSo_4.7H_2O$
T_8	Soil + Zn@ 80mg kg^{-1} as Zn $SO_4.7H_2O$
T_9	Soil + Full lime requirement + Zn@ 80mg kg^{-1} as $ZnSo_4.7H_2O$

Experimental details in neutral soil:

Treatments	Description of treatments
T_1	Only soil (control)
T_2	Soil + Zn@ 20 mg kg $^{-1}$ as $ZnSO_4.7H_2O$ (soil weight Basis)
T_3	Soil + organic matter at 1%+ Zn@ 20 mg kg $^{-1}$ as $ZnSO_4.7H_2O$
T_4	Soil + Zn@ 40mgkg^{-1} as $ZnSO_4$.7H2O
T_5	Soil + organic matter at 1%+ Zn@ 40 mg kg $^{-1}$ as $ZnSO_4.7H_2O$
T_6	Soil + Zn@ 60mg kg^{-1} as Zn $SO_4.7H_2O$
T_7	Soil + organic matter at 1%+ Zn@ 60 mg kg $^{-1}$ as $ZnSO_4.7H_2O$
T_8	Soil + Zn@ 80mg kg^{-1} as Zn $SO_4.7H_2O$
T_9	Soil + organic matter at 1%+ Zn@ 80 mg kg $^{-1}$ as $ZnSO_4.7H_2O$

Viable count of the micro-organisms

The enumeration of the microbial population was done on agar plates containing appropriate media following serial dilution technique and pour plate method Pramer and Schmidt, 1965. Plates were incubated at 30^{0}c. The counts were taken at 5th days of incubation. The results were reported as number of cells per gram for soil. For counting tolal number of viable bacteria Thornton's agar medium and martin's rose Bengal streptomycin agar medium for fungi was used for counting.

Results and Discussion

1. Changes in colony forming unit of total viable bacteria in soil.

i. Total viable bacteria in an acid soil: -

Comparing the results of different treatments, it was recorded that the amount of viable bacteria in normal acid soil (untreated with zinc and lime) has been found highest (85.30X10^7 CFU/g soil) compared to other treatment at 20 days of incubation. The amount of bacteria was recorded lowest (39.13X10^7 CFU/g soil) in the treatment T_8 where the highest level of Zn at 80 mg/kg as Zn So_4 .7H_2O was applied followed by the treatment T_6 (43.73X10^7 CFU/g soil) receiving Zn at 60mg/kg as Zn $So_4.7H_2O$ at 40 days of incubation. Such decrees due to zinc application has been reported by Gogolev, Wilke (1997), civic, karaca (2006) also reported similarly where total bacterial population was recorded significantly lower in soils amended with Zn. However, the trend of changes in the amount of colony forming bacteria at 40 days of incubation was in the following order.

$$T_1>T_3>T_5>T_7>T_9>T_2>T_4>T_8$$

ii. Viable bacteria in neutral soil: -

The results (Table 1) show that the amount of bacteria has been found to be increased initially up to 20 days of incubation and there after the amount of the same decreases irrespective of treatments. Such changes, however varied with treatments, being highest (82.26x10^7 CFU/g soil) and lowest (46.15x10^7 CFU/ g soil) in the treatments T_1 and T_8 respectively at 40

TABLE 1. Periodic changes in colony forming unit (CFU) of total viable bacteria (X10^7/g soil) in an **acid and neutral soil with the application of lime, organic matter and zincs**

Treatments	Days After Incubation(acid soil)					Days after Incubation(neutral soil)				
	10 days	20 days	30 days	40 days	Mean	10 days	20 days	30 days	40 days	Mean
T_1	76.25	85.32	73.54	66.39	75.38	92.32	107.12	86.43	82.26	92.03
T_2	56.19	59.72	51.62	47.44	53.74	64.53	69.65	61.86	58.37	63.60
T_3	72.12	75.33	68.37	54.56	67.60	87.19	97.27	84.42	76.58	86.37
T_4	52.93	55.17	48.39	45.58	50.52	61.24	65.17	57.63	52.15	59.05
T_5	69.72	71.52	65.36	53.47	65.02	84.03	93.23	81.44	72.68	82.86
T_6	48.86	51.27	46.38	43.73	47.56	58.12	63.18	54.26	49.86	56.36
T_7	66.76	68.48	61.18	51.12	61.98	81.47	89.52	78.76	70.59	80.09
T_8	44.64	49.56	42.25	39.13	43.90	53.52	59.83	51.13	46.15	52.66
T_9	61.96	65.12	57.19	49.55	58.46	78.08	86.37	71.74	68.18	76.09
SE(m)	0.27	0.30	0.27	0.04		0.57	0.44	0.40	0.52	
LSD (0.05)	1.10	1.22	1.11	0.15		2.34	1.79	1.63	2.11	

days of incubation. Such lowest value due to application of highest level of Zn might be due adverse and toxic effect of Zn on bacterial proliferation moderating the permeability of bacterial cell membranes (Gogolev, Wilke;1997). The results further pointed out that the combined application of all levels of Zn and organic matter counteracted the magnitude of such decrease in bacterial population explaining that organic matter provides energy to the microbes especially bacteria as well as modifies soil reaction. Iqbal et al (2005) reported that the less of microbial diversity is evident as they move towards higher concentration of heavy metals especially Zn in soils.

Neutral Soil:

With regards to the changes in the acting of fungi in normal neutral soil (Table 2) it was observed similar pattern of the changes with that of fungi acting in acid soil with exception of the amount of insoluble Value where much higher value were recorded irrespective of treatments. However, the higher activities of fungi next to control treatments might be due to the application of combined application of organic matter and Zinc. The application of Zn at its higher level (80 mg/kg) significantly decreased the acting of fungi which might be due to toxic effect of heavy metal Zn on fungi interfering with metabolic activity.

Conclusion:

It was concluded that the activity of total viable bacteria and fungi have been found to be suppressed with the applications of Zn. However, such depressed activity has been somewhat reduced with the application of lime in case of acid soil and with organic matter in case of neutral soil.

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Table 2. Periodic changes in colony forming unit (CFU) of fungi (X10^2/g soil) in an acid & neutral soil with the application of lime, organic matter and zinc.

Treatments	Days After Incubation(acid soil)					Days after Incubation(neutral soil)				
	10 days	20 days	30 days	40 days	Mean	10 days	20 days	30 days	40 days	Mean
T_1	12.24	16.52	11.19	9.02	12.24	19.16	24.37	17.62	12.76	18.48
T_2	9.32	14.12	7.64	6.53	9.40	12.02	15.14	9.04	7.12	10.83
T_3	16.37	19.92	11.17	9.19	14.16	18.42	22.18	16.26	11.03	16.97
T_4	8.04	12.34	6.23	5.44	8.01	9.05	133.32	8.47	6.64	9.37
T_5	12.56	17.13	9.45	8.67	11.95	16.36	19.06	15.19	10.26	15.22
T_6	6.02	9.74	5.14	4.29	6.30	8.07	12.17	7.37	5.52	8.28
T_7	11.34	16.27	8.36	7.54	10.88	15.72	18.95	13.12	9.43	14.31
T_8	5.62	8.73	4.09	3.16	5.40	7.33	11.02	6.34	4.48	7.29
T_9	9.67	15.28	7.46	6.39	9.70	14.26	17.04	12.34	8.18	12.96
SE(m)	0.03	0.03	0.03	0.03		0.16	0.18	0.07	0.03	
LSD (0.05)	0.11	0.12	0.10	0.12		0.67	0.72	0.29	0.11	

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 35-40, 2018

Influence of Toxic Concentration of Zn and Cd on the Changes in Soil Ecology of Rhizosphere Growing Rice (*Oryza Sativa* L)

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Received : 04.05.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

The greenhouse experiment on rice (Cv. IET- 4687) were conducted in an alfisol and Inceptisol to study the influence of toxic concentrations of Zn and Cd on the changes in soil ecology of rice Rhizosphere affected by different levels of Zinc and cadmium application. The results suggest an antagonistic effect between Zn and Cd with regard to the Zn content in rice shoot. The application of Cd reduced the amount of Zn content in soil, being reduced a greater magnitude with level of Cd application at 60 mg/kg soil. The mean number of seed/panicle was found to be decreased with the separate application of Zn and Cd, being lowest decrease 133.02 and 132.67 with Zn and Cd at 80 mg/kg respectively. Such decrease has been found to be further enhanced in the treatment, when Zn and Cd was applied combinedly, being maximum decrease (120.92) in the Zn_2 Cd_2 treatment combination. The similar trend of changes for 1000 seed weight to that of number of seed/panicle in rice plant was followed the highest 1000 seed weight (17.44 gm) was recorded in Zn_1 Cd_1 treatment combination where Zn at 60 mg/kg and Cd at zero mg/kg was applied combinedly.

Key Words: cadmium, interaction, lime, organic matter, rice, soil ecology, zinc

Introduction

Rice (*Oryza sativa* 2) is the stable food of more than 60 percent of the world's population by virtue of the extent and variety of uses and its adaptability to a wider range of climate adaphic and cultural condition.

At present in West Bengal, 6.15 m ha of lands are under rice cultivation. (Estimate of area production and productivity of principal crops, 1999-2000, Govt. of West Bengal). The total production of rice in West Bengal is 13.759 m lakh tons and productivity is 2237 kg ha^{-1}. But unfortunately the rice yield in these soils of West Bengal is consistently fluctuating inspite of applying recommended levels of N.P and K fertilizers.

Most of the works have so far been conducted on cadmium is the laboratory as incubation studies as well as in the greenhouse taking wheat, maize oat etc. as test crops. Very few studies have been conducted on low land rice and so in the present investigation rice has been taken as a test crops. So the application of Zn fertilizer may interact with the cadmium and thereby modify the Cadmium concentration in soil as well as its uptake by the rice plant to a less phytotoxic level.

Soil reduction due to flooding results in changes in the P^H, E^H, specific conductance, sorption-desorption, ion-exchange and exchange equilibria, which in turn greatly influence the availability of plant nutrients, uptake and utilization by Wet land rice (Ponnamperuma, 1984 a; Das *et.al.*2004). When soils are submerged the concentration of most nutrient elements in soils increases, but the availability of Zn to plant decreases (Das and Mandal, 1988; Mandal *et. al.* 1993). The adsorption of Zn on hydrous Oxides of iron and manganese in the oxygenated rhizosphere of rice root of probably an important factor in decreasing the concentration and mobility of Zn in the rhizosphere of flood rice. Zinc deficiency is usually more prevalent in rice soils with a high P^H and high content of organic matter or when organic manures are applied (Dobermann and Fairhurst, 2000).

Materials and Methods

A greenhouse experiment was conducted during winter season at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The soil was clay loam with P^H 7.6, and Zn and Cd content of soil was 0.35 ppm and 0.08 ppm respectively.

Twenty seven porcelain pots, each of 10-liter capacity was filled with 5 kg of air dried sieved (2mm) soil. The above treatment combination for the greenhouse experiment were applied replication wise to all the pots and mixed thoroughly with the soil. Then the treated soils were puddle by adding demineralized water. Thirty days old rice seedlings (IET-4687) were transplanted in each of the pots. During the course of the experiment the soils were maintained under water logged condition with 5 ± 0.5 cm of water on top of the soil surface demineralized water was used throughout the period of experiment. Soil and plant samples were collected periodically for the analysis of Cd and Zn. Then the plants were allowed to grow up to maturity and harvested carefully along with the roots. The plants were then separated into three components viz root, straw and grain and each of them was washed thoroughly under running tap water, followed by very dilute acid, distilled water and finally by glass distilled water, dried in an oven at $60^0 \pm 5^0$C to a constant weight and the dry matter yield were recorded, sample for the chemical analysis were prepared by cutting the straw and roots into small pieces and grinding them as well as the rice grain with the help of a grinder made of stainless steel.

Results and Discussion

Changes in Zn an Cd content in rice shoot.

The results for changes in Zn and Cd content in rice shoot due to interaction effect between Zn and Cd is presented in Table -1 and Table - 2.

The amount of Zn content in rice shoot has been found to be increased with the separate application of both Zn and Cd, being more increase with Zn application. As regard to the interaction effect between Zn and Cd, the amount of Zn content in rice shoot has been found to be further increase, being highest increase in Zn_2 Cd_2 treatment combination where Zn and Cd was applied combinedly at their highest level. The results suggest an antagonistic effect between them with regard to the Zn content in rice shoot. As regard Cd content in rice shoot due to interaction effect between cd and Zn, the similar trend of changes to that of Zn content of rice shoot was observed.

Experimental Details

Treatments	Description of treatments
T_1	No Zn and no Cd (control)
T_2	No Zn and Cd @60 gm kg^{-1} as $CdSO_4$
T_3	No Zn and Cd @ 80 mg kg^{-1} as $CdSO_4$
T_4	Zn @ 60 mg kg^{-1} as $ZnSO_4$. $7H_2$ O and no Cd.
T_5	Zn @ 60 mg kg^{-1} as $ZnSO_4$ $7H_2O$ and Cd @60 mg kg^{-1} as Cd SO_4
T_6	Zn @60 mg kg^{-1} as $ZnSO_4$.$7H_2O$ and Cd @80 mg kg^{-1} as $CdSO_4$
T_7	Zn @ 80 mg kg^{-1} as $ZnSO_4$.$7H_2O$ and no Cd
T_8	Zn @80 mg kg^{-1} as $ZnSO_4$. $7H_2O$ and Cd @60 mg kg^{-1} as $CdSO_4$
T_9	Zn @ 80 mg kg^{-1} as $ZnSO_4$. $7H_2O$ and Cd @ 80 mg kg^{-1} as $CdSO_4$

Table 1. Influence of toxic concentration of Zn and Cd application on the changes in Zn content (mg/kg) in rice shoot

Treatments	Days After Transplanting 20 Days				40 Days				60 Days			
	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean
Zn_0	6.29	7.23	7.56	7.03	6.52	8.44	8.63	7.86	6.93	8.85	9.18	8.32
Zn_1	10.17	12.46	14.63	12.42	12.29	14.28	16.13	14.23	13.87	15.98	18.62	16.16
Zn_2	17.36	18.49	20.25	18.70	19.24	20.76	22.12	20.71	21.34	22.32	24.39	22.68
Mean	11.27	12.73	14.15	12.72	12.68	14.49	15.63	14.27	14.05	15.72	17.4	15.72
SE (m)	2.615				3.264				3.835			
LSD (0.05)	NS				NS				NS			

Table 2. Influence of toxic concentration of Zn and Cd application on the changes in Cd content (mg/kg) in rice shoot

Treatments	Days After Transplanting 20 Days				40 Days				60 Days			
	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean
Zn_0	1.02	17.23	19.12	12.46	1.29	18.56	21.47	13.77	1.53	20.32	23.14	15.03
Zn_1	6.74	12.53	13.19	10.82	8.39	14.86	15.38	12.88	9.65	16.73	18.12	14.83
Zn_2	7.44	14.52	16.54	12.83	9.04	16.25	18.36	14.55	10.29	18.34	20.18	16.27
Mean	5.07	14.76	16.28	12.04	6.24	16.56	18.40	13.73	7.16	18.46	20.51	15.38
SE (m)	1.933				2.370				2.877			
LSD (0.05)	7.867				9.648				11.713			

Table 3. Influence of toxic concentration of Zn and Cd application on the changes in Zn content (mg/kg) in rice soil.

Days After Transplanting

Treatments	15 Days				30 Days				45 Days				60 Days			
	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean
Zn_0	0.92	1.02	1.19	1.04	0.76	0.93	1.07	0.92	0.54	0.81	0.94	0.76	0.42	0.53	0.75	0.57
Zn_1	5.34	3.58	3.72	4.21	4.56	2.25	2.47	3.09	3.19	1.16	1.38	1.91	2.32	0.92	0.98	1.41
Zn_2	6.43	4.29	4.56	5.09	5.12	3.18	3.29	86	3.54	2.43	2.56	2.84	2.49	1.24	1.28	1.67
Mean	4.23	2.96	3.16	3.45	3.48	2.12	2.28	2.63	2.42	1.47	1.63	1.84	1.74	0.90	1.00	1.21
SE (m)	24.771				1.563				0.013				0.111			
LSD (0.05)	NS				4.645				0.053				0.453			

Table 4. Influence of toxic concentration of Zn and Cd application on the changes in Cd content (mg/kg) in rice soil

Days After Transplanting

Treatments	15 Days				30 Days				45 Days				60 Days			
	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean
Zn_0	0.07	5.32	7.64	4.34	0.03	3.86	5.49	3.13	0.01	2.57	3.85	2.14	Trace	1.35	2.36	1.24
Zn_1	0.52	3.29	3.48	2.43	0.44	2.72	2.98	2.05	0.32	1.37	1.87	1.19	0.24	1.09	1.18	0.84
Zn_2	0.64	4.12	4.36	3.04	0.49	3.42	3.64	2.52	0.34	2.29	2.48	1.70	0.28	1.16	1.27	0.90
Mean	0.41	4.24	5.16	3.27	0.32	3.33	4.04	2.56	0.22	2.08	2.73	1.68	0.18	1.20	1.60	0.99
SE (m)	0.014				0.017				0.013				0.014			
LSD (0.05)	0.056				0.070				0.053				0.057			

TABLE 5. Influence of toxic concentration of Zn and Cd application on the changes in thousand seed weight (gm) and number of seed/panicle in rice plant

Treatments	No. of seed/panicle				1000 seed weight (gm)			
	Cd_0	Cd_1	Cd_2	Mean	Cd_0	Cd_1	Cd_2	Mean
Zn_0	152.36	141.12	137.83	143.77	12.17	10.88	9.98	11.01
Zn_1	159.52	145.39	139.27	148.06	17.44	11.67	10.84	13.32
Zn_2	154.48	123.66	120.92	133.02	16.86	8.76	7.93	11.18
Mean	155.45	136.72	132.67	141.62	15.49	10.44	9.58	11.84
SE (m)		0.465				0.119		
LSD (0.05)		1.895				0.483		

Changes in Zn Content in Soil:

The results (Table - 3) showed that the amount of Zn content in soil has been found to be decreased with the progress of crop growth irrespective of treatments. The magnitude of Zn content in soil, however, varied with treatment combination. The application of Cd reduced the amount of Zn content in soil, being reduced a greater magnitude with level of Cd application at 60 mg/kg soil. With regard to the application of Zn the amount increased with an increasing rate of Zn application of Zn the amount increased with an increasing rate of Zn application. The magnitude of such increase, however, was recorded much lower at the latter period of rice growth, which might be due to the depletion of Zn by the crop.

As regard to the interaction effect between Zn and Cd it was observed that the amount of Zn content has been found to reduce to a greater extent with Zn_1 $Cd\text{-}_1$ treatment combination where Zn and Cd both was applied as 60mg/kg soil combinedly. Such decrease amount might be due to the competition between same adsorption site on to the soil. Therefore, the result suggests that the relationship between Cd and Zn was found antagonistic with regard to the Zn content in soil.

Changes in Cd content in soil

The results (Table - 4) showed that amount of Cd content in soil has been found to be increased with increasing amount of Cd application in soil. The magnitude such increase, however, gradually decrease with the progress of crop growth. The decrease of Cd content was much higher with application of Cd at 60 mg/kg of soil. With regarded to the application of Zn the amount of Cd content was also found a decrease, being maximum decrease with the application of Zn at 60 mg/kg in soil.

With regard to the interaction between Zn and Cd it was found that the amount of Cd content in soil consistently greater decrease with Zn_1Cd_1, treatment combination, compared $Zn_2Cd_{2,}$ treatment. The results also suggest that the amount of Cd content in soil has been found to be decreased where Zn was applied along with Cd enhance the relationship between them was found antagonistic.

Changes in number of seed/panicle and seed weight in rice plant

The results (Table - 5) showed that the mean number of seed/panicle was found decrease with the separate application of Zn and Cd, being lowest decrease (133.02 and 132.67) with Zn and Cd at 80 mg/kg respectively. Such decrease has been found to be further enhance in the treatment, when Zn and Cd was applied combinedly, being maximum decrease (120.92) in the Zn_2 $Cd_{2,}$ treatment combination.

The similar trend to changes for 1000 seeds weight to that of number of seed/panicle in rice plant was followed the highest 1000 seed weight (17.44gm) was recorded in Zn_1 Cd_0 treatment combination where Zn at 60 mg/kg and Cd at Zero mg/kg applied combinedly. However, following trend was recorded as – Cd_0 Zn_1> Cd_0Zn_1>Cd_0 Zn_0> Cd_1 Zn_1>Cd_1 Zn_0>Cd_2 Zn_1>Cd_2 Zn_0>Cd_1 Zn_2>Cd_2 Zn_2

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 41-46, 2018

Relative Performance of Pigeonpea Varieties at Different Dates of Sowing During Pre-*Rabi* Season

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Received : 18.06.2018 **Accepted : 04.07.2018** **Published : 18.07.2018**

Abstract

Pigeonpea always face challenges from natural calamities, aberrant weather condition, severe attack of pod borer complex and competitive remunerative rainfed crops during *kharif* season. The need for horizontal expansion of pigeonpea encouraged for searching of new niche. Hence efforts have been made for standardization of package technology for pre-*rabi* pigeonpea. A Field experiment was conducted over three years (2011-12, 2012-13 and 2014-15) at the Centre for Pulses Research (OUAT), Berhampur-761001 to optimise the date of sowing and find suitable cultivars of Pigeonpea under upland maize-pigeonpea cropping system with limited irrigation. Altogether 12 treatment combinations comprising four varieties of Pigeonpea, viz. UPAS-120, Manak(H-77-216) , Laxmi(ICPL 85063) and CO-6 with three dates of sowing viz. 15th September, 30th September and 15th October were taken in Split Plot Design with three replications. The data revealed that among varieties Manak performed best and recorded maximum number of fruiting branches/plant (9.07), pods/plant(75.52), seeds/pod(3.37) and ultimately the highest pigeonpea grain yield (1074.58 kg/ha). Significant variation was observed in growth and yield attributes with varying dates of sowing. Early sowing in 15th Sept. was found most suitable with highest plant height (114.06cm), number of fruiting branches/plant (10.23), pods/plant(91.24), seeds/pod(3.48) and also the maximum pigeonpea grain yield (1383.47 kg/ha). However, the combination of these two ie, when variety Manak sown in 15th Sept. gave the highest grain yield (1517.55kg/ha) ,TDMP(3930.45kg/ha) and Harvest Index(38.61%). Economics of all treatment combinations was calculated on per hectare basis. Maximum net profit (Rs.42,182/-) with B:C ratio(3.11) were obtained when variety Manak sown in 15th September. In general, reduction in plant height was observed with pre-*rabi* sown pigeonpea crop as compared to *kharif* crop with delayed date of sowing, which might be due to agronomic dwarfing.

Key words: pre-*rabi* pigeonpea, agronomic dwarfing, harvest index, net return, B:C ratio

Introduction

Pulses, due to their inherent capability to fix atmospheric nitrogen and many micro- nutrients, have an important role for soil and human health. Rapid stride in population growth coupled with diversion of cultivable land for non-agricultural purpose, result in a progressive decline in the per capita availability of pulses, which is a matter of great concern for nutritional security. Pulses can play an important role in sustaining intensive agriculture by improving physical, chemical and biological properties of soil. Being nutrient efficient and sustainable, these are considered excellent crops for diversification in cereal based cropping system. Pigeonpea (*Cajanus cajan* L.) is one of the most ancient and versatile grain legume crop in India with 90% of global production and grown across the country under diverse agro-ecosystem. It is generally grown as *Kharif* crop and the national productivity remain stagnant at around 700kg/ha as compared to its potential yield of 1500-3000kg/ha . Aberrant weather condition is one of the most important factor responsible for this gap. Pigeonpea always face challenges from natural calamities, vagaries of monsoon, severe attack of pod borer complex and competitive remunerative rainfed crops such as composite/ hybrid maize, sweet corn, cowpea etc. during *kharif* season. The need for horizontal expansion of pigeonpea encouraged for searching of new niche. Pigeonpea can be grown as *rabi* crop in areas with mild and short winter (Roy Sharma et. al. ,1980). Puste and Jana (1990) recommended September sowing of pigeonpea in West Bengal. Venugopal and Rao (1999) recommended September sowing of rabi pigeonpea in Andhra Pradesh. Panda et.al. (2003) studied on the effect of NK fertilization on performance of yambean- pigeonpea intercropping system during pre-*rabi* and its residual effect on succeeding mungbean in West Bengal. Babu and Kalra (1989) studied nutrient management of rabi pigeonpea in Maharastra. Kanwar (1981) indicated the importance of early maturing pigeonpea for post-monsoon sowing. Mahalakshmi et. al. (2011) reported the positive response of *rabi* pigeonpea to drip irrigation. Hence effort has been made to find out optimum time of sowing and suitable variety for pre-*rabi* pigeonpea under upland maize- pigeonpea cropping system with limited irrigation.

Materials and Methods

A field experiment was conducted over three consecutive years (2011-12,2012-13 & 2014-15) at the Centre for Pulses Research ,OUA T, Berhampur-761001 which comes under East and South Eastern Coastal Plain zone of Odisha to optimise the date of sowing and find suitable varieties of Pigeonpea under upland maize- pigeonpea cropping system with limited irrigation. However, due to very severe cyclonic storm (VSCS), Phylin on 13th October 2013, the trial for 2013-14 was vitiated and not taken into account. Altogether 12 treatment combinations comprising four varieties of Pigeonpea, viz. UPAS-120, Manak (H-77-216) , Laxmi (ICPL 85063) and CO-6 were taken with three dates of sowing viz. 15 September, 30 September and 15 October in Split plot design with three replications, after harvest of composite maize (var. Navjot) sown during 1st week of July for green cob purpose. Dates of sowing was placed in main plot and varieties in sub- plot. Crop was sown at 45 X 15cm spacing during each year (2011-12,2012-13 &2014-15). Recommended package of practice for *kharif* crop was followed in pre- *rabi* crop. The soil was sandy loam with pH 6.2, low Organic Carbon (0.43 %) , medium available Phosphorus (21.67kg/ha) and high available potassium (292kg/ha). The crop received 127.3mm, 432 mm & 311mm rainfall (12, 22 &20 rainy days) during 37th standard week(10-16 Sept.) to 8th standard week(19-25 Feb) of 2011-12, 2012-13 &2014-15 respectively. Dry spell was observed from 29th Oct. to 23rd Dec. 2011; 15th Oct.2012 to 11th Feb2013 and 29th Oct. to 23th Dec. 2014. The crop was sown under residual soil moisture condition and two irrigations were given at critical stages of growth . Observations on plant height, yield attributes , grain yield, *bhusa* yield, stick yield were taken at harvest and analysed as per statistical procedure described by Panse and Sukhatme (1985). Economics of the treatment combinations were calculated and compared for economic feasibility.

Results and Discussion

Plant height :

Data depicted in Table-1& 2 revealed that Pigeonpea plant become more dwarf with delayed dates of sowing. In general plant height of pigeonpea during *rabi* season found to be shorter than that of the *kharif* crop. Significant variation was observed in plant height of Pigeonpea at different sowing dates and the highest (114.06cm) was recorded when the crop sown on 15th Sept., which was in fact 45% higher than the crop sown after one month i:e:, on 15th Oct.(78.82cm). The drastic reduction in plant height due to delayed sowing date i:e: agronomic dwarfing was observed. However, the variation in plant height within varieties in same date of sowing or different dates and pooled over three years was not significant. Nevertheless, the interaction effect of date of sowing and variety on plant height varied significantly and the tallest plants (117.27cm) were found with variety Manak sown on September 15th.

Yield attributes:

Various yield attributes of pigeonpea varieties at different dates of sowing were taken at harvest and placed in table-1&2. Number of primary fruiting branches showed significant variation due to different dates of sowing. The highest number of fruiting branches per plant (10.23) was recorded with 15th

Sept. sown crop, which was significantly superior to those recorded with 30th Sept.(7.7) and 15th Oct. (6.71) sowing .Branching reduced to a tune of 34% with delayed date of sowing from 15th Sept. to 15th October . Number of primary fruiting branches per plant did not vary much with different varieties. But, numerically more branches per plant (9.07) were registered with variety Manak (H-77-216).

The number of pods / plant followed the same trend as that of fruiting branches. The maximum number of pod / plant (91.24) was obtained from 15th September sown crop which reduced drastically with delayed sowing and the lowest value (49.49) was recorded with crop sown on October 15th. It is observed that the number of pod/plant increased to a tune of 84% if the *rabi* pigeonpea sown one month earlier in September 15 instead of 15th October under upland ecosystem with limited irrigation. The number of pods per plant was found significantly superior (75.52) with V2 (Manak) than that with V4 i:e:, CO-6 (59.83), but at par with other two varieties i:e:, UPAS-120 (69.03) and Laxmi (67.96). (Table-1).

The variation with the number of seeds/ pod recorded at different dates of sowing as well as different varieties were statistically at par. However, the maximum values (3.48 & 3.37) were obtained with the 15th September sown crop & variety Manak respectively (Table-1).

Interaction effects of date of sowing and variety for different yield attributes were also calculated and found significant for number of primary fruiting branches per plant and number of pods per plant, but the variation was insignificant for number of seeds/ pod (Table-2). Nevertheless, the treatment combination D1V2 (Manak sown on 15th September) has recorded maximum number of fruiting branches per plant (11.47), number of pods per plant (103.55) and number of seeds per pod (3.69).

Yield :

Conspicuous variation in Pigeonpea grain yield was observed at different dates of sowing (Table-1). Significantly highest grain yield (1383.47 kg/ha) was obtained from Sept. 15 sown crop which is 129 % higher as compared to that obtained from the crop sown on 15th October(604.33 kg/ha). Among varieties, Manak performed best and recorded maximum yield(1074.58 kg/ha) and significantly superior to CO-6 (878.58kg/ ha) , but at par as compared to UPAS-120 (995kg/ha) and Laxmi (942.99kg/ha). Highest bhusa yield(608.46kg/ha), stick yield (1591.64 kg/ha) and total dry matter production (3583.57kg/ha) were obtained from September 15th sown crop, which was significantly superior to other dates of sowing. Among varieties, Manak performed better than others (Table-2). Interaction effect was also found significant (Table-2) and the maximum grain yield (1517.55 kg/ha) was recorded with Manak sown on 15th September. The *bhusa* yield, stick yield and total dry matter production (TDMP) followed the same trend as grain yield and the maximum values (667.72, 1745.18 & 3930.45 kg/ ha respectively) being recorded with Manak sown on 15th September.

Harvest Index (HI) :

Harvest Index was calculated on proportion of grain yield to biological yield ie, total dry matter production of above ground parts on percentage basis to find out the dry matter partitioning to grain as influenced by dates of sowing and cultivars of pigeonpea during pre-*rabi* season (Table-1). Among dates of sowing, the maximum value (38.61%) was computed with September 15th sown crop and among varieties, Manak was found superior (37.53%). Considering the treatment combination, the maximum harvest index (38.61%) was computed with Manak sown on 15th September (Table-2).

Economics :

Economics for each treatment combination was computed and presented in Table-3. The gross return was calculated by summing the return from grain yield and stick yield. The highest gross return (Rs. 62,182/ha), net return (Rs 42,182/ha) and B:C ratio (3.11) was obtained from Manak sown on 15th September. Profit decreased with delayed sowing and the lowest net return (Rs.1250/ha) and B:C ratio (1.06) was recorded with variety CO-6 sown on October 15th.

Table 1. Growth, yield attributes and yield of Pigeonpea varieties at different dates of sowing under pre-*rabi* condition. (pooled data of three years)

Treatment	Plant height (cm)	Branches /plant	Pods /plant	Seeds /pod	Seed Yield (kg/ha)	Bhusa yield (kg/ha)	Stick yield (kg/ha)	TDMP (kg/ha)	HI
D1	114.06	10.23	91.24	3.48	1383.47	608.46	1591.64	3583.57	38.61
D2	94.58	7.70	63.33	3.24	930.56	443.23	1118.72	2492.51	37.33
D3	78.82	6.71	49.49	2.81	604.33	322.52	736.19	1663.04	36.34
S Em (±)	4.81	0.64	6.87		67.98	29.83	74.57	172.38	
CD at 5%	18.86	2.51	26.93	NS	266.86	117.23	293.06	677.15	
V1	92.48	8.16	69.03	3.16	995.00	483.43	1175.91	2654.34	37.49
V2	94.56	9.07	75.52	3.37	1074.58	507.29	1281.46	2863.33	37.53
V3	98.77	7.79	67.96	3.11	942.99	454.43	1096.58	2525	37.35
V4	97.48	7.86	59.83	3.07	878.58	436.29	1032.96	2347.83	37.42
S Em(±)			3.16		61.46	30.73	68.72	160.91	
CD at 5%	NS	NS	9.39	NS	182.62	91.28	204.09	477.99	

D1:September 15, D2: September 30, D3: October 15,
V1: UPAS120, V2:Manak, V3:CO-6, V4: Laxmi ,

Table 2. Growth, yield attributes and seed yield of Pigeonpea cultivars at different dates of sowing under pre-*rabi* condition. (pooled data of three years)

Treatment	Plant height (cm)	Branches /plant	Pods /plant	Seeds /pod	Seed Yield (kg/ha)	Bhusa yield (kg/ha)	Stick yield (kg/ha)	TDMP (kg/ha)	HI
D1V1	108.32	9.97	88.77	3.44	1376.99	605.87	1583.54	3566.4	38.61
D1V2	**117.27**	**11.47**	**103.55**	**3.69**	**1517.55**	**667.72**	**1745.18**	**3930.45**	**38.61**
D1V3	111.99	9.5	90.1	3.45	1345.34	591.95	1547.14	3484.43	38.61
D1V4	117.24	9.97	82.54	3.35	1294	578.36	1488.10	3360.46	38.51
D2V1	85.94	7.27	64.99	3.15	942.52	448.64	1131.02	2522.18	37.37
D2V2	89.72	8.64	71.17	3.54	1046.04	497.91	1275.25	2819.2	37.10
D2V3	108.37	7.6	63.09	3.17	909.94	443.13	1091.93	2445	37.22
D2V4	94.3	7.3	54.05	3.1	823.74	398.11	988.49	2210.34	37.27
D3V1	83.17	7.17	53.34	2.88	665.5	355.16	811.91	1832.57	36.32
D3V2	76.68	7.09	51.83	2.87	660.15	352.48	825.38	1838.01	35.92
D3V3	75.94	6.28	50.69	2.72	573.69	326.35	699.90	1599.94	35.86
D3V4	79.5	6.3	42.89	2.77	517.99	306.61	631.95	1456.55	35.56
S Em	8.67	0.79	5.11	-	91.36	43.24	101.16	226.38	
CD at 5%	26.71	2.43	15.76	NS	281.39	133.18	311.57	698.17	

D1-SEPT.15, D2- SEPT.30, D3- OCT.15, V1- UPAS120, V2-MANAK, V3-CO-6, V4- LAXMI

TABLE 3. Economics of Pigeonpea cultivars at different dates of sowing under pre-rabi condition. (pooled data of three years)

Treatment	Grain Yield (kg/ha)	Stick yield (kg/ha)	Cost of cultivation (Rs./ha)	Return (Rs./ha) From grain (Rs./ha)	Return (Rs./ha) From Stick (Rs./ha)	Gross Return (Rs./ha)	Net return (Rs./ha)	B:C Ratio
D1V1	1376.99	1583.54	20,000	55313.69	1108.48	56422	36422	2.82
D1V2	**1517.55**	**1745.18**	**20,000**	**60959.98**	**1221.63**	**62182**	**42182**	**3.11**
D1V3	1345.34	1547.14	20,000	54042.31	1083.00	55125	35125	2.76
D1V4	1294	1488.10	20,000	51979.98	1041.67	53022	33022	2.65
D2V1	942.52	1131.02	20,000	37861.03	791.71	38653	18653	1.93
D2V2	1046.04	1275.25	20,000	42019.43	892.68	42912	22912	2.15
D2V3	909.94	1091.93	20,000	36552.29	764.35	37317	17317	1.87
D2V4	823.74	988.49	20,000	33089.64	691.94	33782	13782	1.69
D3V1	665.5	811.91	20,000	26733.14	568.34	27301	7301	1.37
D3V2	660.15	825.38	20,000	26518.23	577.77	27096	7096	1.35
D3V3	573.69	699.90	20,000	23045.13	489.93	23535	3535	1.18
D3V4	517.99	631.95	20,000	20807.66	442.37	21250	1250	1.06

D1,September 15, D2, September 30, D3, October 15, V1, UPAS120, V2,Manak, V3,CO-6, V4, Laxmi ,
Pigeonpea seed Rs 38.50 per kg for 2011-13 and Rs.43.50/kg for 2014-15 (Average Rs.40.17/kg).
Pigeonpea stick yield Rs.70.00 /q for three years (2011-13 & 2014-15)

Conclusion

Agronomic dwarfing (dwarfed plant height with delayed sowing towards shorter day length), shortening of maturity period and synchronous maturity were noticed with pre-*rabi* sowing of pigeonpea irrespective of varieties. The highest grain yield , harvest index , net return and B:C ratio was observed in each genotypes of Pigeonpea sown on 15th Sept. The results corroborate with the findings of Reddy et.al. 2015 at Andhra Pradesh. Among varieties, Manak performed the best followed by UPAS-120 and Laxmi. It can be concluded that pigeonpea variety Manak should be recommended for sowing during mid-September after kharif maize, under upland maize- pigeonpea cropping system with limited irrigation for farmers of East and South Eastern Coastal Plain zone of Odisha for high profitability.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 47-51, 2018

Kharif Greengram – Drilled *Rabi* Fennel + Cauliflower (1:1) : A Promising Cropping System of North Gujarat Condition

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Received : 04.05.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

A field experiment was conducted during 2011-2012 to 2015-16 at Centre for Research on IFS, SDAU, S.K.Nagar, to evaluate the productivity, profitability and improving soil health, among eight cropping systems with three replication under randomized block design. Result revealed that *kharif* green gram – *rabi* Fennel + Cauliflower cropping system recorded significantly the highest pearl millet equivalent yield (21311 Kg/ha), highest net realization (Rs. 2,56,918/ha), highest benefit cost ratio (3.06), maximum employment generation (374 man days/year), highest nutrient productivity (74.8 kg/kg), water productivity (31.33 kg/ha) and then rest of other cropping systems.

***Key words*:** Pearl millet equivalent yield, gross return, net return, water productivity, nutrient productivity, system productivity, system profitability

Introduction

Diversification of cropping system is necessary to get higher yield and returns to maintain the soil health, preserve the environment and meet the daily requirement of human and animals (Samui *et al*., 2004). Depending on just one crop can have great consequences and leave small-scale farmers open to unnecessary hazards. A slump in the market value for a particular crop could greatly reduce the income of the monoculture producers. Other factors, such as the weather or pests could destroy a large part of the crop, leaving the farmer in ruins. On the other hand, farmers with diversified production can avoid these risks, provide their families with a healthy diet and derive a whole series of other benefits. Choice of component crop in the cropping system representing the specific agro-ecological region needs to be suitably maneuvered to harvest the synergism among them toward efficient utilization of resource base and increase overall productivity and profitability. Crop diversification means growing a variety of crops in an area, not just one.

Since last decades world is facing bad effect of climate change, in our part also farmers and scientists are facing and observing good and bad effect on climate change. In some part of North Gujarat like Kutch region total rainfall has increase within short time while in some part of semi arid region rainfall and cold pattern is change under some circumstances. Farmers are seeking alternative crops having higher price and resistance to changing environment. Marginal and small farmers are interested in integrated farming systems having resources conservation and having the efficient utility of farm waste and organic manure. Some cropping systems are newly emerging and it is necessary to taste their economical viability and sustainability against present cropping systems therefore present experiment is form different diversification cropping systems in such a manner it can suite in integrated farming system model.

Materials and Methods

A field experiment was conducted in randomized block design, replicated three times at All

India Coordinated Research Project on Integrated Farming Systems, S. D. Agricultural University, Sardarkrushinagar, Gujarat, India, during 2010-11 to 2015-16, to develop a suitable cropping system by introducing pulse/oilseed/fodder into a groundnut-potato-pearl millet based cropping system as a second or third crop. The experimental soil was loamy sand in texture, alkaline in reaction (pH 7.6), 0.30 %, organic carbon, 195 kg/ha available nitrogen and 15.92 and 198 kg/ha P and K, respectively. The region predominantly humid and diurnal and seasonal variations in temperature remain in a narrow range. The 08 different cropping systems, namely viz. T_1: Pearl millet-Mustard- Fallow; T_2: green gram + sun hemp-castor-green gram; T_3: Green gram + cowpea-castor-f. sorghum; T_4: Green gram + sunhemp-castor-bitter gourd; T_5: Bt. cotton + Sunhemp-castor-Bitter gourd; T_6: Green gram-fennel+ cauliflower-fellow; T_7: Green gram-mustard + lucerne-Lucerne cont.; T_8: Bt. Cotton + green gram-castor-castor cont. in randomized block design with three replications.

Nitrogen, P and K were supplied through urea and di-ammonium phosphate, respectively as per the recommended dose of respective crops. Common application of FYM @10 t/ha was applied during kharif season for all the treatments. Green gram were incorporated in to soil after picking the pods at harvests. Economic yields of the component crops were converted to pearl millet equivalent yield (PEY), taking into account the prevailing farm gate price (Rs./kg) of crop produce. The productivity of different cropping systems was compared by calculating their economic pearl millet equivalent yield (PEY). System productivity was calculated as the ratio of kg PEY/ha to total crop duration of the system in days. For the available nutrient status of the soil, after completion of a crop sequence, representative soil samples were collected and analyzed for organic carbon, available nitrogen, phosphorus and potassium. The cost of cultivation, calculated on existing input cost and economic value of different crop produce, based on market price (Table 1). Gross returns were computed by considering prevailing market price of the produce. Net return was calculated by subtracting cost of cultivation from gross value of the produce, including by product value. The benefit : cost ratio (BCR) was worked out dividing net return by the cost of cultivation. The data on yield of crops and dry matter production of crops under cropping system and economics were recorded and subjected to statistical analysis. No severe pests and diseases were observed during the crop growth; however, necessary plant protection measures were taken on need basis. Optimum plant population was maintained for different crops. Growth and yield parameters were recorded at harvest of the crop. Seed and stover yields/ ha were worked out based on yields record in each plot.

Results and Discussion

The results of different experiments conducted on cropping system diversification and\ or intensification during 2011-12 to 2015-16 at Centre for Research on Integrated Farming Systems to achieve the objectives of Identification of sustainable and profitable cropping sequences to suit the specific needs of north Gujarat agro-climatic zone are presented as under. An experiment was conducted during *kharif, rabi* and summer seasons of 2011-12 to 2015-2016 at Sardarkrushinagar to identify need based crop sequences to suit resources available and needs of arid eco-system of North Gujarat. Eight different cropping systems were tested during the study period. The crop yields obtained are converted into pearl millet equivalent yield by considering the prevailing market price of different crops.

Yield and economics

The results presented in table 1 indicated that crop sequence green gram – Fennel + Cauliflower recorded significantly the highest Pearl millet equivalent yield during all the years of experimentations as well in pooled. In case of pooled data, crop sequence green gram – Fennel + Cauliflower recorded significantly the highest Pearl millet equivalent yield by recording 21311 Kg/ha while predominate cropping sequence i.e. pearl millet- Mustard performed very poor by recording lowest Pearl millet equivalent yield (8,158 Kg/ha). The results presented in table 1 indicated that crop sequence green gram – Fennel + Cauliflower recorded significantly the highest gross realization during all the

Table 1. Pearl millet equivalent yield, gross return, net return, BCR, nutrient productivity and water productivity as influenced by different cropping sequences (mean of Pooled)

Tr.	Cropping systems Kharif	Rabi	Summer	PMEY (Kg/ha)	Gross return (Rs/ha)	Net return(Rs/ha)	BCR	Pooled (2010-11 to 2015-16) Nutrient productivity (Kg/kg)	Water productivity (Kg/ha-mm)
T_1	Pearl millet	Mustard	Fallow	8158	130527	59238	0.83	28.6	23.31
T_2	Gr. gram + Sunhemp - Castor	Castor continue	Green gram	15092	241466	124021	1.06	42.2	17.35
T_3	Green gram + Cowpea (F) (2:1) - Castor	Castor continue	F. Sorghum + F. cowpea (3:1)	13357	213716	103394	0.94	32.0	16.29
T_4	Gr. gram + Sannhemp-Castor	Castor continue	Bottle gourd	14870	237925	124085	1.09	41.6	15.49
T_5	Bt Cotton + Sannhemp -Castor	Cotton-Castor	Bitter gourd	16701	267222	138310	1.07	33.1	17.40
T_6	Gr. gram	Fennel + Cauliflower	Fennel continue	21311	340983	256918	3.06	74.8	31.33
T_7	Gr. gram	Mustard + Lucerne	Lucerne continue	12413	198615	160814	4.25	55.2	25.86
T_8	Bt Cotton + Gr. gram	Castor	Castor continue	16646	266331	145752	1.21	37.4	23.31
		S.Em.±		495	7923	7923			
		CD		1502	24031	24031			
		CV (%)		5.78	5.78	9.86			
		Y x T		NS	NS	NS			

Sale price (/kg)-Pearl millet-16,green gram-60,castor-31, mustard-37,cauliflower-10, fennel-40, cotton-45, bottle gourd-20, bittel gourd-20, F.sorghum-4, f.cowpea-4

Table 2. Average total uptake (kg/ha) of major nutrients

Tr. No.	*Kharif* N	*Kharif* P	*Kharif* K	*Rabi* N	*Rabi* P	*Rabi* K	Summer N	Summer P	Summer K	Sequence N	Sequence P	Sequence K
T_1	89.3	20.0	70.9	100.9	33.0	41.2	0.0	0.0	0.0	190.2	53.0	112.1
T_2	118.4	17.8	64.0	79.3	12.0	32.6	62.5	14.2	42.8	260.2	44.0	140.1
T_3	161.1	26.8	93.0	71.4	9.1	28.8	56.8	18.6	77.2	289.2	54.5	198.9
T_4	124.9	19.3	70.0	72.5	10.0	29.7	22.6	7.1	20.6	220.0	36.4	120.2
T_5	197.8	32.3	111.0	68.8	10.5	30.6	14.1	4.1	12.2	280.5	46.9	153.3
T_6	58.5	8.6	39.0	108.9	38.8	91.5	34.7	9.3	25.0	201.9	56.7	155.5
T_7	56.7	8.1	36.0	114.5	30.4	49.0	19.9	3.7	14.4	191.0	42.2	99.8
T_8	158.1	22.6	82.0	67.9	11.3	26.4	49.4	9.1	28.7	275.3	43.0	136.6

Table 3. Soil fertility status at the end of year: 2015-16

Treatment	Available nutrients (kg/ha) N	P	K	Organic Carbon (%)	pH	EC (dS/m)	Bulk Density (g /cc)	Water Holding Capacity (%)
T_1	204	17.58	216	3.27	7.68	0.153	1.45	28.53
T_2	218	20.20	232	3.68	7.51	0.145	1.47	28.21
T_3	218	20.56	212	3.29	7.52	0.170	1.46	28.68
T_4	214	19.87	227	3.47	7.66	0.165	1.49	28.32
T_5	228	19.51	210	3.67	7.55	0.163	1.48	28.12
T_6	205	19.56	190	3.34	7.71	0.159	1.49	28.83
T_7	207	18.42	215	3.39	7.63	0.137	1.44	29.35
T_8	223	17.02	227	3.45	7.55	0.152	1.45	27.29
Initial status	**195**	**15.92**	**198**	**3.30**	**7.60**	**0.140**	**1.48**	**26.56**

years of experimentations as well as in pooled. In case of pooled data, crop sequence green gram – Fennel + Cauliflower recorded significantly the highest Net realization by recording 2,56,918 while predominate cropping sequence i.e. Pearl millet- Mustard performed very poor by recording lowest (59,238 Rs/ha) net realization. The results presented in table 1 indicated that crop sequence green gram – Fennel + Cauliflower recorded significantly the highest benefit cost ratio in pooled. In case of pooled data, crop sequence T_6: green gram – Fennel + Cauliflower recorded significantly the highest benefit cost ratio (3.06).

As far as nutrient productivity is concerned, green gram – Fennel + Cauliflower recorded the highest value (74.8 kg nutrient). The nutrient productivity of existing cropping sequence viz., pearl millet-mustard recorded the lowest value and it was 28.6 kg grain/kg nutrient. Among different cropping systems, maximum water productivity (31.33 Kg/ha-mm**)** observed under green gram – Fennel + Cauliflower cropping system which was followed by green gram-mustard + lucerne cropping system (25.86 Kg/ha-mm). This results are in agreement with the findings of Rajkumara *et al.* (2014).

Nutrient uptake

The uptakes of major crop nutrients of different crop sequences are presented in Table 2. The maximum sequence total uptake of N (289.2 kg/ha) and K (198.9 kg/ha) was noted with treatment cropping system Greengram + Cowpea (F) (2:1) – Castor - Sorghum (F) + Cowpea (F) (3:1). Whereas, P (56.7 kg/ha) was recorded with cropping system T_6 : Greengram - Fennel + Cauliflower). Cropping system pearlmillet-Mustard recorded the minimum sequence total uptake of N (190.2 kg/ha), sequence minimum total uptake of P (36.4 kg/ha) was recorded with cropping system Greengram (G+R) + Sannhemp (2:1) - Castor - Summer Bottle gourd. Whereas minimum total uptake of K (99.8 kg/ha) was recorded in Greengram - Mustard + Lucern.

Soil fertility status

The data presented in Table- 3 indicated that the highest content values of available N (228 kg/ha) was noted in cropping system T_5: Bt Cotton + Sunhemp (1:2) - Castor + Bitter gourd and available phosphorus (20.56 kg/ha) was noted in cropping system T_3 : Green gram (G+R) + Cowpea (F) (2:1) – Castor- Fodder Sorghum + Fodder cowpea (3:1) While available potassium (232 kg/ha) and organic carbon (3.68 g/kg) were noted highest in cropping system Green gram (G+R) + Sann hemp (2:1)- Castor- Green gram. Minimum Bulk Density value (1.44 g/cc) and Maximum Water Holding Capacity (29.35 %) recorded in Green gram- Mustard + Lucerne (Seed production) - Lucerne continue. Status of available N, P, K, Organic Carbon Content and Water Holding Capacity (%) improved than their initial status.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 53-62, 2018

Character Association and Path Coefficient Analysis for Nut Yield and Component Traits in Cashew (*Anacardium Occidentale* L.)

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Received : 21.02.2018 **Accepted : 04.06.2018** **Published : 18.07.2018**

Abstract

Relationships between cashew nut yield and twenty agronomic traits comprising eleven advance cashew genotypes were studied during 2014-15 fruiting seasons. All yield contributing traits had shown significant positive correlation with nut yield except flowering duration, sex ratio, nut length, nut breadth, apple weight, harvest duration and shelling percent. Plant height, canopy spread, canopy area, flowering laterals m^{-2}, number of nuts $panicle^{-1}$ and number of nuts m^{-2} could be considered as major yield contributing traits as evidenced from their strength of significant positive association with nut yield $plant^{-1}$. Path coefficient analysis indicated that selection for nut yield would be more effective through the choice of characters like plant height, trunk girth, canopy spread (in both direction East-West and North-South direction), canopy area, total laterals m^{-2}, flowering laterals m^{-2}, number of nuts $panicle^{-1}$, nut weight and number of nuts m^{-2}. It was also observed that the magnitude of association between a particular set remains same at both genotypic and phenotypic level. This indicates that the magnitude of association between a particular set was not affected by the environmental factors.

Introduction

Cashew is an important tropical fruit crop that originated from South American countries like Bolivia, Brazil, Ecuador and Peru (Valvilov, 1951 and Behrens, 1998) and is widely cultivated in tropical regions of the world. Major producers of cashew nuts are India, Tanzania, Mozambique, Nigeria, Guinea-Bissau and Kenya (Aliyu and Awopetu, 2007). India is the largest producer of cashew nut in the world contributing 29% to global cashewnut production (Malhotra *et al.*, 2016). However, productivity of cashew in India continues to be low (650 kg ha^{-1}) due to cultivation of inferior, indigenous clones under marginal lands. One of the primary objectives of cashew breeder is to increase the nut yield. Before yield improvements can be realized, the breeder needs to identify the causes of variability in nut yield in any given environment. Since fluctuation in environment generally affects yield primarily through its components, many researchers have analyzed yield through its components (Ishaq *et al.,* 2000; Esan and Omolaja, 2002). Grafius (1960) suggested that individual yield components may contribute valuable information in breeding for yield. The correlation among traits depending on the genetic composition of the test materials, characters studied, previous selection history and the test environment under which the breeding materials are tested. Correlation analysis reveals the direction and magnitude of the relationship between any given pair of traits without regards to cause/effect relationship. The study of path analysis (a standardized partial regression analysis) is also important in that, it partitions the total correlation coefficients with nut yield into various direct and indirect effects. Therefore, an attempt has been made to estimate the correlation and path coefficients of agronomic traits to formulate an effective breeding programme in cashew.

Materials and Methods

A multi location trial was laid out during the year 2003 at Cashew Research Station, Ranasighpur, Bhubaneswar, Odisha using clonal planting materials of eleven diverse cashew genotypes collected from different co-operating centres of All India Coordinated Research Project on Cashew, India. The grafts were raised using the scion materials and were planted at a spacing of 7.5 m x 7.5 m following Randomized Block Design (RBD) having four plants per treatment replicated thrice. Recommended package of practices were adopted uniformly to raise a good crop. The present study was undertaken during the fruiting season 2014-15 of 12 years old cashew plants. Observations on vegetative, yield and yield attributing traits were recorded wherever applicable, as per the standard descriptor of cashew (Swamy *et. al.,* 1998). Statistical procedures were followed for analysis of variance and covariance (Singh and Choudhury, 1985). The simple correlation coefficients for each pair of characters were computed and the path co-efficient (direct and indirect effects) were calculated as per Dewey and Lu (1959).

Results and Discussion

The correlation coefficients provide useful information for choice of characters in a selection program. There were all together 105 sets of estimates both for genotypic and phenotypic correlation (Table 1a and b).

The genotypic correlation recorded highest positive significant association (0.962) between canopy spread in North-South direction and canopy area while the lowest positive significant association (0.379) was found between plant height and nut weight. The highest negative significant association (-0.697) was observed between nut weight and harvesting duration whereas, the lowest negative significant association (-0.378) was observed between harvesting duration and nut yield. The correlation at phenotypic level recorded highest positive significant association (0.997) between canopy spread in East-West direction and canopy area whereas lowest positive significant association (0.381) was found between flowering laterals and sex ratio. Highest negative significant association (-0.764) was observed between nut weight and harvest duration. The lowest negative significant association (-0.396) was observed between sex ratio and nut weight. It was also observed that the magnitude of association between a particular set remains same at both genotypic and phenotypic level. This indicates that the magnitude of association between a particular set was not affected by the environmental factors.

Association among yield component traits

Plant height was significantly positively correlated with trunk girth, canopy spread in East-West and North-South direction and canopy area while it was significantly negatively correlated with harvesting duration and shelling % both at phenotypic and genotypic level. Similarly, trunk girth was significantly positively correlated with canopy spread (East-West and North-South direction), canopy area, flowering laterals, nuts panicle^{-1} and nuts m^{-2} both at phenotypic and genotypic level. It exhibited significant negative correlation with harvesting duration. Canopy spread in East-West direction exhibited significant positive association with canopy spread in North-South direction, flowering laterals, nut weight, nuts m^{-2} at both genotypic and phenotypic level. It recorded non significant positive association with flowering duration, nuts panicle^{-1}, apple weight and non significant negative association with sex ratio, harvest duration and shelling %. Canopy spread in North-South showed significant positive association with plant height, trunk girth, canopy spread in East-West direction, flowering laterals, nut weight and nuts m^{-2} at both the level of significance. The association of canopy spread in North-South direction was positive (non significant) with nuts panicle^{-1} and apple weight while its association was negative (non significant) with flowering duration, sex ratio, harvest duration and shelling %. The association of canopy area with different vegetative and yield attributing traits showed similar trends as that of canopy spread in both (East-West and North-South) directions. Many researchers (Nayar, *et al.* 1981, Manoj *et al.* 1994, Reddy *et al.*1996 and Lenka *et al.* 2001) reported similar correlation between different vegetative and reproductive traits of cashew.

Panicle length recorded either positive or negative correlation (non significant) with all the vegetative and reproductive characters while panicle breadth recorded significant negative correlation with characters like total lateral m^{-2}, flowering laterals m^{-2}, nut length, nut breadth, nut weight, number of nuts m^{-2}, apple weight, shelling % at both levels of significance(phenotypic and genotypic level) (Table 1a & b).

Both at phenotypic and genotypic levels flowering laterals m^{-2} exhibited positive significant association with total laterals m^{-2}, sex ratio, nuts panicle^{-1}, nut weight , nuts m^{-2} and shelling %. At genotypic level flowering laterals exhibited significant positive association with total laterals m^{-2}, nuts panicle^{-1} and nuts m^{-2} while its association with flowering duration and harvest duration was negative but non significant. Total laterals m^{-2} recorded significant positive association with nuts panicle^{-1}, nut weight and nuts m^{-2} both at phenotypic and genotypic level. Flowering duration recorded significantly positive association with harvesting duration while it recorded significantly negative association with nut length, nut breadth, nut weight and apple weight both at phenotypic and genotypic level. Sex ratio showed significant positive association with nuts panicle^{-1}, harvest duration and shelling % both at phenotypic and genotypic level. It showed negative association with nut length and breadth, nut weight and apple weight. Sena *et al.*(1994), Reddy *et al.*(1996) and Lenka *et al.* (2001) and Murthy (2005) also reported similar association between flowering traits of cashew.

Nut length recorded significantly positive correlation with nut breadth, nut weight and apple weight while nut breadth exhibited significant positive correlation with harvest duration, nuts panicle^{-1}, nut weight and apple weight at both level of significance(genotypic and phenotypic level). Nut length as well as breadth was significantly negatively correlated with harvest duration at genotypic level. Nuts panicle^{-1} showed significant positive association with trunk girth, flowering laterals, sex ratio and negative association with apple weight.

Nut weight showed significant positive association with all the characters except panicle breadth, flowering duration and harvesting duration with which it exhibited significantly negative association at genotypic level. Similar trend was observed at phenotypic level except for the character panicle breadth, with which it exhibited significant negative correlation. Nuts m^{-2} showed significant positive association with trunk girth, canopy spread both in East-West and North-South directions, canopy area, flowering laterals m^{-2} , total laterals m^{-2} and nut weight. It showed negative association with panicle length, flowering duration and harvest duration. Apple weight showed significant positive association with nut length, nut breadth and nut weight. With rest of the characters it was either positively or negatively associated. Shelling % showed significant positive association with sex ratio only. It was significantly negatively correlated with plant height and panicle breadth at both phenotypic and genotypic level.

Association of nut yield with component traits

Vegetative and flowering traits like with plant height, trunk girth, canopy spread both in East-West and North-South direction, canopy area, flowering laterals, nuts panicle^{-1}, nut weight and nuts m^{-2} were significantly positively correlated with nut yield both at genotypic and phenotypic levels. Positive but non significant correlation was observed with sex ratio, apple weight, nut length and breadth. Flowering duration and flowering harvest were negatively correlated with nut yield. Though the direction of both genotypic and phenotypic correlation is same, the phenotypic correlation is of higher magnitude as compared to genotypic correlation in all the cases. Parameswaran *et al.* (1984) and Rao *et al.* (2002) and Aliyu (2006) reported that nut panicle^{-1}, number of nuts tree $^{-1}$ and number of hermaphrodite flowers panicle^{-1} were positively correlated with nut yield and could be used as primary components for improving yield.

Path coefficient analysis

The association between yield and its 19 component traits was further subjected to path analysis

Table 1 (a). Phenotypic correlation of twenty agronomic traits of cashew

Characters	PH	TG	CS(E-W)	CS(N-S)	CA	PL	PB	FL	TL	FD	SR	NL	NB	HD	N/P	NW	N/M²	AW	S%	NY
PH	**1.000**	0.968**	0.973**	0.915**	0.969**	0.135	0.062	0.291	0.320	-0.096	-0.164	0.417*	-0.172	-0.493*	0.244	0.376	0.346	0.285	-0.438*	0.489*
TG		**1.000**	0.951**	0.889**	0.950**	0.048	-0.070	0.473*	0.482*	-0.076	0.012	0.356	-0.214	-0.468*	0.479*	0.374	0.564**	0.084	-0.236	0.670**
CS(E-W)			**1.000**	0.957**	0.997**	0.015	0.009	0.418*	0.413*	0.114	-0.151	0.274	-0.230	-0.443*	0.285	0.394*	0.509*	0.169	-0.289	0.644**
CS(N-S)				**1.000**	0.996**	-0.021	0.053	0.454*	0.453*	-0.002	-0.297	0.270	-0.167	-0.435*	0.123	0.434*	0.569**	0.186	-0.337	0.675**
CA					**1.000**	-0.035	0.031	0.413*	0.412*	0.011	-0.263	0.312	-0.219	-0.491*	0.193	0.423*	0.581**	0.178	-0.362	0.666**
PL						**1.000**	0.381	0.034	0.086	-0.083	0.190	0.095	-0.311	0.336	0.254	-0.052	-0.392	-0.041	-0.210	-0.154
PB							**1.000**	-0.564**	-0.541**	0.312	-0.319	-0.452*	-0.733**	0.291	-0.157	-0.547**	-0.688**	-0.410*	-0.526**	-0.436*
FL								**1.000**	0.997**	-0.082	0.381*	0.126	0.160	-0.145	0.531**	0.384*	0.774**	0.050	0.395*	0.849**
TL									**1.000**	-0.189	0.347	0.237	0.213	-0.196	0.520**	0.441*	0.715**	0.151	0.337	0.858**
FD										**1.000**	0.189	-0.666**	-0.640**	0.489*	0.150	-0.452*	-0.066	-0.476*	0.169	-0.041
SR											**1.000**	-0.188	-0.199	0.638**	0.827**	-0.396*	0.093	-0.504*	0.580**	0.076
NL												**1.000**	0.727**	0.612**	-0.087	0.808**	0.334	0.777**	-0.088	0.361
NB													**1.000**	0.485*	-0.426*	0.735**	0.215	0.848**	0.347	0.155
HD														**1.000**	0.225	-0.764**	-0.397*	-0.740**	0.262	-0.452*
N/P															**1.000**	0.224	0.349	-0.543**	0.418*	0.436*
NW																**1.000**	0.517**	0.860**	0.187	0.591**
N/M²																	**1.000**	0.039	0.266	0.891**
AW																		**1.000**	-0.111	0.191
S %																			**1.000**	0.283
NY																				**1.000**

*** Significant at 5% level**

**** Significant at 1% level**

PH :Plant height(m), TG: Trunk girth(cm), CS(E-W)(m): Canopy spread(East-West), CS(N-S)(m): Canopy spread (North-South), CA(m^2): Canopy area, PL:Panicle length(cm), PB: Panicle breadth(cm), FL: Flowering lateral m^{-2}, TL: Total lateral m^{-2}, FD: Flowering duration(days), SR: Sex ratio, NL: Nut length(cm), NB: Nut breadth(cm), HD:Harvesting duration(days), N/P:Nuts panicle^{-1}, NW: Nut weight(g), N/M^2: Number of nuts m^{-2}, AW: Apple weight(g), S%:Shelling percentage, NY- Nut yield plant^{-1}(kg)

Table 1 (b). Genotypic correlation of twenty agronomic traits of cashew

Characters	PH	TG	CS(E-W)	CS(N-S)	CA	PL	PB	FL	TL	FD	SR	NL	NB	HD	N/P	NW	N/M²	AW	S%	NY
PH	**1.000**	0.871**	0.891**	0.820**	0.831**	0.037	0.038	0.211	0.252	-0.104	-0.135	0.397	-0.119	-0.383*	0.202	0.379*	0.236	0.218	-0.398*	0.432*
TG		**1.000**	0.938**	0.879**	0.896**	0.051	-0.061	0.447*	0.446*	-0.073	-0.012	0.309	-0.197	-0.413*	0.416*	0.365	0.488*	0.073	-0.179	0.661**
CS(E-W)			**1.000**	0.938**	0.943**	0.005	0.012	0.395*	0.393*	0.121	-0.146	0.262	-0.211	-0.371	0.227	0.395*	0.456*	0.165	-0.260	0.633**
CS(N-S)				**1.000**	0.962**	-0.016	0.045	0.452*	0.440*	-0.002	-0.277	0.220	-0.143	-0.356	0.117	0.408*	0.488*	0.173	-0.281	0.667**
CA					**1.000**	-0.011	0.007	0.402*	0.390*	0.038	-0.252	0.231	-0.145	-0.394*	0.133	0.391*	0.512*	0.143	-0.348	0.633**
PL						**1.000**	0.260	0.025	0.097	-0.075	0.124	0.069	-0.308	0.212	0.098	-0.051	-0.204	-0.101	-0.005	-0.110
PB							**1.000**	-0.518	-0.502*	0.287	-0.272	-0.434*	-0.651**	0.272	-0.146	-0.502*	-0.460*	-0.331	-0.401*	-0.392*
FL								**1.000**	0.961**	-0.072	0.364	0.109	0.120	-0.106	0.482*	0.338	0.606**	0.044	0.343	0.817**
TL									**1.000**	-0.165	0.344	0.228	0.191	-0.218	0.484*	0.412*	0.577**	0.125	0.315	0.823**
FD										**1.000**	0.193	-0.578**	-0.563**	0.383*	0.133	-0.417*	-0.034	-0.429*	0.082	-0.026
SR											**1.000**	-0.150	-0.182	0.530**	0.764**	-0.364	0.041	-0.464*	0.459*	0.076
NL												**1.000**	0.571**	-0.542**	-0.075	0.762**	0.234	0.688**	-0.069	0.303
NB													**1.000**	-0.453*	-0.340	0.680**	0.146	0.698**	0.134	0.136
HD														**1.000**	0.214	-0.697**	-0.218	-0.592**	0.201	-0.378*
N/P															**1.000**	-0.217	0.226	-0.462*	0.329	0.390**
NW																**1.000**	0.404*	0.792**	0.085	0.561**
N/M²																	**1.000**	0.028	0.152	0.772**
AW																		**1.000**	-0.121	0.159
S %																			**1.000**	0.221
NY																				**1.000**

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

to partition into direct and indirect effect of the component traits on nut yield both at phenotypic and genotypic level (Table 2 a and b).

Path coefficient analysis at phenotypic level (Table 2a) revealed that the pattern of direct and indirect effects was of different magnitude and direction in many cases. At phenotypic level trunk girth had the highest positive direct effect (0.7927) on nut yield followed by flowering duration (0.4002), total laterals (0.3670), flowering laterals (0.3270), nut weight (0.3044), panicle breadth (0.1997), nut length (0.1940), nuts m^{-2} (0.1876), nut breadth (0.1455), harvest duration (0.1130), nuts panicle^{-1} (0.0795), canopy spread in North-South direction (0.0591) and shelling % (0.0380). Whereas, the highest negative direct effect was recorded for canopy spread in East-West direction (-0.5829) followed by sex ratio (-0.2986), apple weight (-0.1545), panicle length (-0.1314), canopy area (-0.1132) and plant height (-0.0112). Trunk girth had the highest positive direct effect (0.7927) on nut yield where as the correlation between the two characters was 0.670. The high magnitude of correlation coefficient was due to the positive indirect effect via flowering laterals and nut weight. Flowering duration had direct and positive effect (r=0.4002) on nut yield but the magnitude of correlation between the two was negative (-0.041). The positive direct effect was nullified by the negative indirect effect by most of the characters. The association of nuts m^{-2} with cashew nut yield was significantly highest (r = 0.891), but its direct effect on yield was found to be small (0.1876). This small direct effect was enhanced by positive indirect effect via characters like trunk girth, flowering laterals, total laterals, nut weight, canopy spread in North-South direction, panicle length, nut length, nut breadth, nuts panicle^{-1} and shelling %. In such situations, the indirect causal factors are to be considered simultaneously for selection. The phenotypic path coefficients was significantly positive for total laterals (0.858), flowering laterals (0.849), canopy spread in North-South (0.675), canopy area (0.666), canopy spread in East-West (0.644), nut weight (0.591), plant height (0.489) and nuts panicle^{-1} (0.436). A low to moderate level of direct positive effect on nut yield was observed for panicle breadth, nut length, nut breadth, harvesting duration, nuts panicle^{-1}, canopy spread in North-South direction and shelling %. The correlation coefficient for these characters was almost equal to their direct effect, the correlation explained true relationship and a direct selection through these traits will be effective. The phenotypic correlation between panicle breadth and yield was negative (r= -0.436), but the direct effect was found to be positive (0.1997) due to the nullifying effects of other characters. A negative correlation was also observed between yield and flowering duration (r= -0.041) and harvest duration (r = - 0.452), but their direct effect on seed yield was positive due to the nullifying effects of other characters. A negative correlation was found between panicle length and yield (r = - 0.154) where as a low degree of negative direct effect (-0.1314) was observed for this character on yield. The low degree of negative direct effect was due to nullifying effects of positive direct effect via other characters.

It is evident from both direct and indirect effects of the characters at phenotypic level that trunk girth, total laterals, flowering laterals, nut weight and nuts m^{-2} would be of more value while selecting for yield. Also the indirect causal factors should be considered simultaneously for selection of yield. A direct selection for yield through total laterals will be more effective. Aliyu (2006) found the relationships between cashew nut yield and different yield attributing characters and observed strong significant correlation among these traits.

At genotypic level (Table 2b) maximum direct effect on nut yield was exerted by trunk girth (1.2058) followed by total laterals (0.8027), flowering duration (0.7723), nut length (0.6747), panicle breath (0.5079), nut breadth (0.4373), flowering laterals (0.2941), nuts m^{-2} (0.1932), harvest duration (0.1393), nuts panicle^{-1} (0.1079), shelling % (0.0863), canopy spread (0.0122) and plant height (0.0012), whereas negative effect was caused by canopy spread in East-West direction (-0.9350) followed by sex ratio (-0.6038), canopy spread in North-South (-0.2490), panicle length (-0.2417), nut weight (-0.2171) and apple weight (-0.1346). The highest direct positive effect on yield at genotypic level was exhibited by trunk girth (1.2058)

TABLE 2(a): Phenotypic path co-efficient analysis of twenty agronomic traits of cashew

Characters	PH	TG	CS(E-W)	CS(N-S)	CA	PL	PB	FL	TL	FD	SR	NL	NB	HD	N/P	NW	N/M^2	AW	S%	NY
PH	**-0.0112**	0.6946	-0.5124	0.0485	-0.0941	-0.0049	0.0076	0.0690	0.0925	-0.0415	0.0402	0.0770	-0.0173	-0.0433	0.0161	0.1153	0.0443	-0.0337	-0.0152	**0.489***
TG	-0.0099	**0.7927**	-0.5483	0.0522	-0.1015	-0.0054	-0.0118	0.1468	0.1716	-0.0307	0.0081	0.0608	-0.0280	-0.0481	0.0326	0.1124	0.0909	-0.0129	-0.0073	**0.670****
CS(E-W)	-0.0099	0.7456	**-0.5829**	0.0554	-0.1068	-0.0003	-0.0028	0.1353	0.1500	0.0570	0.0406	0.0470	-0.0302	-0.0425	0.0195	0.1195	0.0874	-0.0244	-0.0089	**0.644****
CS(N-S)	-0.0092	0.6993	-0.5456	**0.0591**	-0.1089	0.0021	0.0090	0.1478	0.1614	0.0007	0.0826	0.0426	-0.0208	-0.0402	0.0093	0.1241	0.0915	-0.0267	-0.0107	**0.675****
CA	-0.0094	0.7110	-0.5498	0.0569	**-0.1132**	0.0014	0.0014	0.1314	0.1431	0.0152	0.0754	0.0448	-0.0211	-0.0446	0.0106	0.1190	0.0960	-0.0220	-0.0133	**0.666****
PL	-0.0004	0.0324	-0.0013	-0.0009	0.0012	**-0.1314**	0.0519	0.0081	0.0358	-0.0300	-0.0370	0.0133	-0.0448	0.0239	0.0078	-0.0155	-0.0382	0.0156	-0.0002	**-0.154**
PB	-0.0004	-0.0468	0.0083	0.0027	-0.0008	-0.0341	**0.1997**	-0.1695	-0.1844	0.1150	0.0813	-0.0842	-0.0947	0.0308	-0.0116	-0.1529	-0.0862	0.0512	-0.0153	**-0.436***
FT	-0.0024	0.3559	-0.2412	0.0267	-0.0455	-0.0033	-0.1035	**0.3270**	0.3528	-0.0288	-0.1087	0.0212	0.0174	-0.0120	0.0383	0.1029	0.1137	-0.0068	0.0131	**0.849****
TL	-0.0028	0.3706	-0.2383	0.0260	-0.0442	-0.0128	-0.1003	0.3143	**0.3670**	-0.0661	-0.1027	0.0443	0.0278	-0.0246	0.0385	0.1255	0.1082	-0.0193	0.0120	**0.858****
FD	0.0012	-0.0609	-0.0829	0.0001	-0.0043	0.0098	0.0574	-0.0236	-0.0607	**0.4002**	-0.0576	-0.1122	-0.0820	0.0433	0.0106	-0.1271	-0.0064	0.0663	0.0031	**-0.041**
SR	0.0015	-0.0214	0.0792	-0.0164	0.0286	-0.0163	-0.0544	0.1191	0.1262	0.0772	**-0.2986**	-0.0291	-0.0265	0.0599	0.0608	-0.1108	0.0077	0.0717	0.0175	**0.076**
NL	-0.0045	0.2484	-0.1413	0.0130	-0.0261	-0.0090	-0.0866	0.0358	0.0838	-0.2315	0.0448	**0.1940**	0.0831	-0.0612	-0.0060	0.2320	0.0438	-0.1062	-0.0026	**0.361**
NB	0.0013	-0.1526	0.1210	-0.0085	0.0164	0.0405	-0.1299	0.0392	0.0701	-0.2254	0.0543	0.1107	**0.1455**	-0.0513	-0.0270	0.2069	0.0273	-0.1078	0.0051	**0.155**
HD	0.0043	-0.3372	0.2191	-0.0210	0.0447	-0.0278	0.0544	-0.0348	-0.0799	0.1532	-0.1582	-0.1051	-0.0660	**0.1130**	0.0170	-0.2123	-0.0409	0.0914	0.0077	**-0.452***
N/P	-0.0023	0.3251	-0.1428	0.0070	-0.0151	-0.0129	-0.0292	0.1576	0.1775	0.0533	-0.2282	-0.0146	-0.0495	0.0242	**0.0795**	-0.0661	0.0425	0.0714	0.0125	**0.436***
NW	-0.0043	0.2927	-0.2289	0.0241	-0.0443	0.0067	-0.1003	0.1105	0.1513	-0.1671	0.1087	0.1479	0.0989	-0.0788	-0.0173	**0.3044**	0.0759	-0.1224	0.0032	**0.591****
N/M^2	-0.0027	0.3842	-0.2717	0.0289	-0.0579	0.0268	-0.0918	0.1983	0.2118	-0.0136	-0.0122	0.0453	0.0212	-0.0246	0.0180	0.1231	**0.1876**	-0.0044	0.0058	**0.891****
AW	-0.0025	0.0664	-0.0919	0.0102	-0.0161	0.0133	-0.0661	0.0144	0.0458	-0.1717	0.1385	0.1334	0.1015	-0.0669	-0.0368	0.2412	0.0053	**-0.1545**	-0.0046	**0.191**
S %	0.0045	-0.1518	0.1356	-0.0166	0.0394	0.0006	-0.0801	0.1123	0.1155	0.0327	-0.1369	-0.0133	0.0195	0.0228	0.0262	0.0259	0.0284	0.0187	**0.0380**	**0.283**

Residual effect: 0.0499 *** Significant at 5% level** **** Significant at 1% level**

TABLE 2(b). Genotypic path coefficient analysis of twenty agronomic traits of cashew

Characters	PH	TG	CS(E-W)	CS(N-S)	CA	PL	PB	FL	TL	FD	SR	NL	NB	HD	N/P	NW	N/M²	AW	S%	NY
PH	**0.0012**	1.1670	-0.9023	-0.2277	0.0118	-0.0327	0.0313	0.0857	0.2570	-0.0742	0.0991	0.2811	-0.0752	-0.0687	0.0264	-0.0816	0.0668	-0.0384	-0.0377	**0.432***
TG	0.0011	**1.2058**	-0.8845	-0.2219	0.0116	-0.0107	-0.0338	0.1386	0.3873	-0.0604	0.0154	0.2392	-0.0914	-0.0676	0.0505	-0.0824	0.1083	-0.0129	-0.0210	**0.661****
CS(E-W)	0.0011	1.1407	**-0.9350**	-0.2354	0.0120	0.0026	-0.0076	0.1265	0.3387	0.1052	0.0844	0.1818	-0.0981	-0.0627	0.0309	-0.0870	0.1015	-0.0236	-0.0239	**0.633****
CS(N-S)	0.0011	1.0747	-0.8839	**-0.2490**	0.0121	0.0050	0.0267	0.1336	0.3637	-0.0015	0.1684	0.1824	-0.0729	-0.0607	0.0132	-0.0942	0.1100	-0.0251	-0.0290	**0.667****
CA	0.0011	1.1489	-0.9247	-0.2479	**0.0122**	0.0086	0.0159	0.1215	0.3308	0.0087	0.1588	0.2105	-0.0959	-0.0684	0.0208	-0.0918	0.1123	-0.0239	-0.0312	**0.633****
PL	0.0002	0.0534	0.0101	0.0052	-0.0004	**-0.2417**	0.1938	0.0101	0.0692	-0.0643	-0.1146	0.0641	-0.1361	0.0468	0.0274	0.0114	-0.0757	0.0056	-0.0181	**-0.110**
PB	0.0001	-0.0802	0.0139	-0.0131	0.0004	-0.0922	**0.5079**	-0.1658	-0.4347	0.2407	0.1928	-0.3051	-0.3203	0.0405	-0.0169	0.1188	-0.1329	0.0552	-0.0453	**-0.392***
FT	0.0003	0.5681	-0.4022	-0.1131	0.0050	-0.0083	-0.2864	**0.2941**	0.8002	-0.0635	-0.2303	0.0849	0.0699	-0.0202	0.0572	-0.0835	0.1497	-0.0068	0.0341	**0.817****
TL	0.0004	0.5817	-0.3944	-0.1128	0.0050	-0.0208	-0.2750	0.2932	**0.8027**	-0.1459	-0.2094	0.1601	0.0930	-0.0273	0.0561	-0.0958	0.1382	-0.0203	0.0290	**0.823****
FD	-0.0001	-0.0944	-0.1274	0.0005	0.0001	0.0201	0.1583	-0.0242	-0.1516	**0.7723**	-0.1141	-0.4493	-0.2797	0.0682	0.0161	0.0982	-0.0128	0.0641	0.0146	**-0.026**
SR	-0.0002	-0.0308	0.1306	0.0695	-0.0032	-0.0459	-0.1622	0.1122	0.2784	0.1460	**-0.6038**	-0.1268	-0.0871	0.0888	0.0892	0.0860	0.0180	0.0678	0.0499	**0.076**
NL	0.0005	0.4275	-0.2519	-0.0673	0.0038	-0.0229	-0.2297	0.0370	0.1905	-0.5143	0.1135	**0.6747**	0.3177	-0.0853	-0.0094	-0.1754	0.0646	-0.1046	-0.0075	**0.303**
NB	-0.0002	-0.2521	0.2098	0.0415	-0.0027	0.0752	-0.3720	0.0470	0.1707	-0.4939	0.1203	0.4902	**0.4373**	-0.0675	-0.0460	-0.1596	0.0416	-0.1142	0.0299	**0.136**
HD	-0.0006	-0.5846	0.4210	0.1084	-0.0060	-0.0811	0.1476	-0.0427	-0.1574	0.3780	-0.3850	-0.4130	-0.2119	**0.1393**	0.0243	0.1659	-0.0768	0.0996	0.0226	**-0.378***
N/P	0.0003	0.5642	-0.2681	-0.0306	0.0024	-0.0613	-0.0798	0.1561	0.4172	0.1155	-0.4993	-0.0589	-0.1864	0.0314	**0.1079**	0.0486	0.0675	0.0730	0.0361	**0.390****
NW	0.0004	0.4579	-0.3747	-0.1080	0.0051	0.0127	-0.2780	0.1130	0.3540	-0.3493	0.2392	0.5449	0.3214	-0.1065	-0.0242	**-0.2171**	0.1000	-0.1158	0.0161	**0.561****
N/M²	0.0004	0.6756	-0.4911	-0.1418	0.0071	0.0947	-0.3493	0.2278	0.5740	-0.0513	-0.0561	0.2256	0.0942	-0.0554	0.0377	-0.1123	**0.1932**	-0.0052	0.0230	**0.772****
AW	0.0003	0.1152	-0.1642	-0.0464	0.0022	0.0100	-0.2083	0.0148	0.1210	-0.3677	0.3041	0.5244	0.3710	-0.1031	-0.0585	-0.1868	0.0075	**-0.1346**	-0.0096	**0.159**
S %	-0.0005	-0.2929	0.2594	0.0838	-0.0044	0.0507	-0.2668	0.1162	0.2702	0.1303	-0.3495	-0.0590	0.1516	0.0365	0.0451	-0.0405	0.0515	0.0150	**0.0863**	**0.221**

Residual effect: 0.0542 *** Significant at 5% level** **** Significant at 1% level**

where as its correlation with nut yield was found to be high (r= 0.661) and positive. The higher magnitude of correlation coefficient was due to the positive indirect effect via plant height, canopy spread, flowering laterals, total laterals, sex ratio, nut length, nuts panicle^{-1} and nuts m^{-2}. Next to trunk girth, total laterals m^{-2} recorded higher positive direct effect (0.8027) of on nut yield whereas, its correlation with yield was found to be highest (r = 0.823). However, the higher magnitude of correlation coefficient was due to positive indirect effect via other characters such as trunk girth, flowering laterals, nut length, nut breadth, nuts panicle^{-1} and nuts m^{-2} and shelling %. The effect via rest of the characters was negligible. Flowering duration recorded positive direct effect on nut yield (0.7723), whereas, its correlation with yield was negative (r= -0.026). The positive direct effect was nullified by the negative indirect effects via other characters. The direct effect of flowering duration, nut length, panicle breadth, nut breadth, flowering laterals, nuts m^{-2}, harvest duration, nuts panicle^{-1}, shelling %, canopy spread and plant height were positive whereas, the correlation coefficient of these characters with nut yield was found to be -0.026, -0.303, - 0.392, 0.136, 0.817, 0.772, -0.378, 0.390, 0.221, 0.633 and 0.432 respectively. The vegetative and reproductive traits such as nuts m^{-2}, canopy spread (both in East-West and North-South direction), canopy area, nuts panicle^{-1} and nuts m^{-2} had higher magnitude of correlation coefficient than direct effects because the positive direct effect was enhanced by positive indirect effects via other characters. The highest negative direct effect at genotypic level on yield was exhibited by East-West (-0.9350). It showed a moderate positive correlation with yield (0.633) because of positive indirect effect by trunk girth, flowering laterals, total laterals, flowering duration, nut length and nuts m^{-2} . The direct effect of canopy spread in North - South direction, panicle length, sex ratio, nut weight and nuts m^{-2} was negative and found to be -0.2490, -0.2417, -0.6038, -0.2171 & -0.1346 respectively. The correlation coefficients of panicle length character with yield was negative (r = 0.110), while for rest of the characters was positive. The negative effect was nullified by positive indirect effect via other characters. Anitha *et al.* (1991) and Samal *et al.*(2003) reported similar positive direct effect of vegetative and yield attributing traits on nut yield of cashew.

Conclusion

The results of both correlation coefficient and path coefficient analyses at phenotypic and genotypic level revealed that the characters like trunk girth, flowering laterals and total laterals, canopy spread(both in East-West and North-South direction), nuts panicle^{-1} and nuts m^{-2} would be of more value for genetic improvement for nut yield in cashew.

Acknowledgement

The authors are grateful to Director, Directorate of Cashew Research (DCR), Puttur, Karnataka for providing financial assistance and Orissa University of Agriculture & Technology, Bhubaneswar, Odisha for providing facilities to conduct the experiment.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 63-67, 2018

Charge Characteristics in Some Soils of West Bengal

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Received : 04.06.2018 **Accepted : 30.06.2018** **Published : 18.07.2018**

Abstract

The distribution of charges in some soils of West Bengal was studied by direct measurement of adsorption of ions in presence of varying concentration of electrolytes. The results showed that soil surface charge was varied with soil , organic matter and iron/ aluminium contents. However, the magnitude of charge variation have been found with the variation of functional groups present in the organic matter, Fe/Al blocked exchange sites and composition as well as content of clay. Organic matter amount of iron and aluminium content strongly influenced the charge variation in such soils.

Keywords : clay, iron and aluminium oxides, organic matter, soil charge

Introduction

Soils that have predominantly pH-dependent charge properties are highly weathered soils of the tropics and young volcanic ash soils. It is a basic tenet of soil chemistry that the surfaces of the solid phases in soils bear electric charge, the sign and magnitude of which may depend on the pH value of the soil solution (Sposito, 1977). The transport of indifferent anions through some acid tropical and subtropical soils classified as Alfisols, Ultisols, and Oxisols (Soil Survey Staff, 1975) is retarded because these variable charge soils develop appreciable positive charge on amphoteric mineral surfaces (Bellini *et al.,* 1996). The positive charge surfaces is balanced by an equivalent amount of indifferent anions adsorbed in the outer sphere and diffuse layers on soil particles, and their sum is defined as the counter ion charge, or the anion exchange capacity of the soil. The magnitude of the surface charge density on amphoteric surfaces is a function of pH and ionic strength in the soil solution that encompasses both the effects of background electrolyte concentration and ionic composition of the soil solution.

It is a well-known fact that an important proportion of the surface electric charge of many minerals does not depend on the solution composition, but is caused by isomorphic substitution within their crystal structures, so that it has a definite constant value. This charge is known as 'permanent charge', to distinguish it from that due to ion adsorption, which is known as 'variable' or 'pH-dependent' charge.

The objective of this study was to determine the charge characteristics in some soils of West Bengal.

Materials and Methods

Four soil samples were collected from Jalpaiguri, Baruipur and Diamond Harbour; and Mahisadal in the districts of Jalpaiguri, South 24 Parganas and East Midnapur respectively where annual rainfall of about 1250mm and mean temperature of approximately 24.8ÚC (Metrological Department, 2018).

The sampling sites and classification of the soils in this study are given in Table 1. The soil samples were air dried, crushed and then passed through 2mm sieve for laboratory analysis.

Physico-chemical analysis

Soil pH was measured in 1:2 soil solutions in

TABLE 1. Details of experimental soils

Sl. No.	Location	Soil order	Vegetation type
1.	Baruipur, 22.3597° N, 88.4318° E, West Bengal, India	Fluvaquent	Rice-rice-rice
2.	Jalpaiguri 26.5435° N, 88.7205° E West Bengal, India	Haplaquept	Tropical forest
3.	Mahisadal 22.1814° N, 87.9898° E West Bengal, India	Fluvaquent	Rice-rice-rice
4.	Diamond Harbour 22.1987° N, 88.2023° E West Bengal, India	Endoaquepts	Rice-rice-rice

H_2O and 1M KCl (National Soil Survey Centre, 1996), organic carbon (OC) was measured by the Walkley-Black method (Nelson and Somers, 1996) and used to calculate the amount on organic matter (OM) (OM = OC X 1.732). Cation exchange capacity was determined by NH_4OAC at pH 7.0 and is defined by the some of the exchangeable cations that a soil can absorb (Chapman, 1965). Anion exchange capacity is determined by colorimetric methods (Frank E. Clarke, 1950). Particle size distribution was analysed by the pipette method (Gee and Bauder, 1986). The ΔpH index was calculated from the difference between pH_{KCl} and pH_{water} (Mekaru and Uehara, 1972). Exchangeable Al (Bertsch and Bloom, 1996) and exchangeable Fe (Sparks, 1996). The Fe and Al contents associated with secondary minerals were determined in extracts obtained after boiling both 1g of soil for 30minutes in 20ml 9M H_2SO_4. The acid extract were analysed for Al and Fe and soil fused with alkali and total Fe and Al estimated by Atomic Absorption Spectrometry (AAS) (Sparks, 1996).

Surface charge analysis

Ion adsorption method

An estimate of the CEC (Cation exchange capacity) and AEC (Anion exchange capacity) as a function of pH was determined by measuring the amount of K^+ and Cl^- retained by the soils at different pH using a modification of Schofields method (Schofield, 1949). Based upon the unknown mineralogy of these soils, it was assumed that the clays contained essentially no sites capable of specifically absorbing K^+; and therefore that KCl could be treated as an indifferent electrolyte. Triplicate 2g samples of soil were weighed in centrifuge tubes and washed with 0.1 M KCl to minimize soluble Al; after discarding the supernatants, 20ml of the same solution were added and the pH adjusted with KOH or HCl to give a pH range between 2 and 8. The samples were equilibrated at room temperature (24+/-2R□C) by shaking intermittently on a reciprocal shaker for 12 hr. Then the samples were centrifuged, the supernatants discarded, and 20ml 0.01 M KCl added; this 0.01M KCl wash was repeated two more times. After the final washing, the supernatant pH was measured as well as the Cl^-, K^+ and Al concentrations. Next, the adsorbed K^+ and Cl^- ions were displaced by washing the soil with 0.5 M NH_4NO_3. The amounts of K^+ and Cl^- displaced, after correction for the entrained KCl with in the soil volume, were used as estimates of the negative and positive charges, respectively. Chloride was measured using a specific ion electrode with a double junction reference electrode filled with 100g Kg^{-1} KNO_3 solution in the outer chamber, and K^+ by flame photometer.

Statistical analysis

Each experiment was treated as a completely randomized design. Because the experiments were performed individually on each soil, comparisons of surface charge of the soils as a function of pH were accomplished by the use of correlation coefficient, were used to determine statistical significance of any differences in the surface charge measurements.

Results and Discussion

Important soil chemical and physical properties of the soil used in this study are given in Table 2.

Clay content in Jalpaiguri soil is much higher compared to Baruipur, Diamond Harbour and Mahisadal soil, and this is reflected in the corresponding cation exchange capacity values of these soils. Relatively higher cation exchange capacity of Jalpaiguri soil indicates presence of higher amount of organic matter and the presence of smectite types of clay mineral. Whereas comparatively lower cation exchange capacity of Diamond Harbour and Mahisadal soil are dominated with Kaolinite clay and comparatively lower amount of organic matter.

Whereas it can be seen that Jalpaiguri soil is more acidic (4.6) compare to Baruipur (6.1), Mahisadal (7.6) and Diamond Harbour soil (7.8). All these experimental soils had ÄpH less than zero, which indicate they present net negative surface charge (Meakru and Uehara, 1972). Cation exchange capacity of Jalpaiguri soil is higher than the Baruipur, Mahisadal and Diamond Harbour soil probably an effect of organic matter content (Morais *et al.*, 1976).

Organic matter is an important source of cation exchange capacity in these soils (Carvalho et al., 2009). With increasing percent of organic matter, surface charge increases that increment is very high even in small increments of organic matter. In this study it appears that organic matter has an increasing effect on surface charge. The evidence presented is based on comparison of the surface charge characteristics of samples which contain different amounts of organic matter, but which are almost similar in other respects.

Surface charge of the soil is estimated by substracting the cation exchange capacity value at a give pH from the corresponding anion exchange capacity value; these values are shown in Table 2 with the calculated surface charge values. Jalpaiguri soil possesses higher surface charge than Baruipur and Mahisadal soil. This has been attributed to the negative charge arising from the greater organic matter content. Presence of dissociated organic functional groups and unblocked exchange sites and amount of iron and aluminium oxide are responsible for surface charge. Amount of clay and their composition is an important factor for surface charge formation (Table 2).

Total Fe and Al as well as Al and Fe oxide also contribute surface charge characters that are reflected in Table 2 with simultaneous contribution of soil organic matter. In all this samples pH in water was greater than the measured in KCl.

Variability in the magnitude of this charge was attributed to the effect of consideration from various organic functional groups or Al/ Fe blocked exchange sites of clay. Organic matter and sesquioxide/ allophone are responsible for charge variation.

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TABLE 2. Chemical and Physical characteristics of soils

Soil Sample	pH_{water}	pH in 1(N) KCl	Δ pH	%O.C	%O.M	Fe_2O_3 g/Kg	Ex. Fe g/Kg	Al_2O_3 g/Kg	Ex. Al g/Kg	Ex.Ca (g/Kg)	CaO (g/Kg)	Ex.Mg (g/Kg)	MgO (g/Kg)	% sand,silt, clay
Baruipur	6.1	5.7	-0.4	1.25	2.16	0.39	0.28	0.27	0.14	3.0	4.17	0.60	0.99	28, 30, 42
Jalpaiguri	4.6	4.4	-0.2	2.82	4.88	1.26	0.89	1.11	0.58	2.1	2.91	0.06	0.09	34, 24, 42
Mahisadal	7.6	6.4	-1.2	1.13	1.95	0.26	0.19	0.21	0.11	2.9	4.03	0.80	1.32	31, 38, 31
Diamond Harbour	7.8	5.9	-1.9	1.11	1.92	0.22	0.16	0.17	0.09	2.4	3.33	0.77	1.27	30, 33, 37

Δ pH= pH_{KCl}-pH_{water}, EC= electrical conductivity, OC= organic carbon, OM= organic matter, Ex= Exchangeable

TABLE 3. Cation exchange capacity, anion exchange capacity, surface charge and their relationships with various chemical characters of soils

Soil Sample	AEC ($Cmol_cKg^{-1}$)	CEC ($Cmol_cKg^{-1}$)	Surface Charge	Correlation between	Regression value (clay & OM) (r*<0.05)	Correlation between Surface charge & Ex. Fe	Correlation between Surface charge & Ex. Al
Baruipur	22.5	28.0	5.5				
Jalpaiguri	28.7	43.5	14.8	0.689581	0.557837	0.658056	0.696652
Mahisadal	21.2	33.7	12.5				
Diamond Harbour	18.5	26.5	8.0				

AEC= Anion Exchange Capacity, CEC= Cation Exchange Capacity.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 69-73, 2018

Present Farming and Agriculture Market Scenario in the District of Uttar Dinajpur, India

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Received : 04.06.2018 **Accepted : 04.07.2018** **Published : 18.07.2018**

Abstract

The Uttar Dinajpur district is bounded around Darjeeling district in the North, Purnea district of Bihar State in the West, Malda and Dakshin Dinajpur district in the South and Bangladesh in the east. This district consists of 9 blocks i.e. Chopra, Islampur, Kaliaganj, Hemtabad, Raiganj, Goalpokhar-I, Goalpokhar-II, Karandighi, and Itahar. The crop cultivation is monocropping system. The crops are cultivated into Sandy soils, Sandy Loam soils, Loamy soils, Clay Loam soils and Clay soils. The pollution, deforestation, natural calamities, extinct of useful trees or pollinators and industrialization are totally transformed cropping pattern of uttar dinajpur district. The present production of Rice, Maize, Mustard, Potato, Chilli, Brinjal, Jute, Tea and Pineapple are highest in the land. The modern agricultural tools like rotavator, single wheel hoe weeder and Multicrop thresher are currently used into agricultural land. These agricultural inputs like seeds, fertilizers, pesticides, and farm machines or tools are provided by government corporation and private companies to supply chain like dealers or retailers. The private companies and the supply chain are affect villages farmer for input prices. The government agriculture department and the media are not highlighting a schemes and projects to villages farmer. Further, this will decline a lifestyle and income of villages farmer.

Keywords : agriculture input, communication, cropping pattern

Introduction

Uttar Dinajpur district was formed on Ist April, 1992 by division of the West Dinajpur district. It was included in the Jalpaiguri Division of the State. The geographical areas of Uttar Dinajpur district is 3140 km^2. It is located between 26Ú35'15" N and 25Ú10'25" N latitude and 89Ú0'30" E and 87Ú48'37" longitude. This is bounded around Darjeeling district in the North, Purnea district of Bihar State in the West, Malda and Dakshin Dinajpur district in the South and Bangladesh in the east. The government administration has been constituted with 2 Sub-Divisions, 9 blocks, 9 police stations, 9 panchayat samities, 99 gram panchayats, 1422 inhabited villages, 1504 mouzas and 4 municipalities. The Headquarters of the district is located at Karnajora near Raiganj. The total population is 2638662 in which Male and Female gender are 1550219 or 1450630 (Census, 2011).

Materials and Methods

Most of the people of district are dependent directly or indirectly on agriculture. The agriculture land is used Gross cropped area 505.8 ha, Net sown area 241.3 ha and Area sown more than once 264.5 ha for farming. The field crops are cultivated into Sandy soils, Sandy Loam soils, Loamy soils, Clay Loam soils and Clay soils. The agro-climatic zone of district is Lower Gangetic Plain Region (III) that bounds New Alluvial Region and Old Alluvial Region (NARP). The agro ecological subzones are Assam or Bengal Plain, Hot Sub humid to Humid (Inclusion of Per humid) Eco-Region, Eastern Plain and Hot Sub humid (moist) Eco-

Region (ICAR). The district annual rainfall is 1857 mm. The SW monsoon and NW monsoon are entered late into the environment that affects crop ecology. The district farmers are irrigate land with Tanks, Ponds, Canal and Bore wells to overcome crop impact. The irrigated land maintains production and productivity of field crops.

The pattern of crop production is monocropping in district. This district consists of 9 blocks i.e. Chopra, Islampur, Kaliaganj, Hemtabad, Raiganj, Goalpokhar-I, Goalpokhar-II, Karandighi, and Itahar which cultivates cereal crops Rice, Wheat, Maize; oilseed crop Mustard; cash crops Tea, Jute; vegetable crops Potato, Chilli, Brinjal and fruit crops Pineapple, Banana, Mango. Chopra block grows Rice, Potato, Tea, Pineapple; Islampur block cultivates Maize, Potato and Mustard; Hemtabad block grows Rice, Maize, Mustard and Vegetables; Kaliaganj block sown Rice, Mustard and Vegetables; Raiganj block grows Rice, Maize, Jute and Vegetables; Goalpokhar block cultivates Rice, Maize and Potato and Karandighi block grows Rice or Mustard and Itahar block practices Paddy, Mustard or Jute. Since change of ambient weather of block, the current production of Rice, Maize, Mustard, Potato, Chilli, Brinjal, Jute, Tea and Pineapple are highest in the block. When disaster is stopped into the district then the upland farmers are practice Maize, Potato, Mustard, vegetables and the lowland farmers are cultivate Rice. Since innovations of farm machines or tools into area of agricultural engineering and farmers are used Rotavator, Single wheel hoe weeder or Multicrop thresher, weeding and harvesting in present trend.

Results and Discussion

Effect of agricultural input

The government sector has own agriculture input corporation in each state that provides certified input to supply chain. The government has licensed 3000 farmer producing companies that provide all kinds of agricultural inputs to supply chain. The supply chain provides input to farmers. The supply chain is never provided agricultural inputs of private company without schemes to farmer. The private companies are provide special voucher, gift and tour to supply chain for selling agricultural inputs. The supply chain aggressively sales input to farmer for special voucher, gift, and tour. The farmer purchases agricultural input without aware of feature and benefit. The harmful accident happens into input then private company is not assist to the farmer, according to private company guidelines and supply chain is also follow company guidelines. The private company and the government corporations are provide feature or function of agricultural input to farmer through programme but supply chain is provide improper information of input. The supply chain is keep agriculture inputs of one or more than company, they provides input of one or more than private company to farmers for earn income and advantages. The ultimate aim of private company and the supply chain is to generate income or profit with exploitation of farmers. The government of India and the state government are not put step to private agriculture company and supply chain for exploitation of farmer to agriculture inputs.

The farmers brought raw materials into the market and sell raw materials to market through broker and agent. The farmers are received less income from broker and agent. An Indian business group ITC was started e-programme call e-choupals that will be returned right income of farmers for agriculture inputs. The renowned TATA company was initiated TATA Kisan Kendra that offers agricultural inputs like seeds, fertilizers, pesticides and farm equipments with affordable prices. Shriram consolidated Ltd. was started Hariyali Kisan Bazar project to farmers that aims to provide agri-inputs, financial services, market linkages, warehousing or commodity exchanges, household goods, dedicated scientists and experts.

Effect of agricultural input price

Farm inputs are required to be available, affordable, accessible, and good quality. Seeds, fertilizers, and agro-chemicals, are essential for improving the productivity and incomes of smallholder farmers in developing countries (World Bank, 2007, 2013; FAO, 2013). Most of farm inputs are available in peri-urban areas where dealer shops are common. The economic activity and overall development is usually more advanced there than remote areas. The policy maker and the donor raises a farm input prices that focus predominantly on peri-urban areas will not reach the majority of those in the poorest and remotest rural areas (Belt *et al*., 2015).

The government sector and the private sector are prepare the price of agricultural inputs. They sell inputs to supply chain. The supply chain sales agricultural inputs with high cost to farmer. So that, they could get more profit from farmer. The private company provides gift, voucher and tour to supply chain for selling more agricultural inputs. The supply chain sells inputs to farmers with stress. When demand of agriculture input rises among farmer then the private company is increase the rate of inputs that affects the farmer budget. The farmer sells raw material into gilt market then they are not receive accurate government minimum support price (MSP). The government is not taken action on private company and supply chain to exploitation of framer for input prices.

Irregular distribution of Government agriculture subsidy, scheme and project

Agricultural subsidies are of two kinds: investment subsidies and input subsidies. Investment subsidies aim to improve the farm productivity on sustainable level by encouraging farmers to develop infrastructural facilities like installation of drip irrigation system, construction of rain water harvesting system, and acquiring farm implements. The input subsidies are provided primarily through subsidizing fertilizers, irrigation water, and power (electricity) used for irrigation and other agricultural purposes. From time to time, input subsidies have also been provided on seeds, as well as on herbicides and pesticides. Subsidies are among the most powerful instrument for manipulating or balancing the growth rate of production and trade in various sectors for an equitable distribution of income for protection of weaker sections of the society. The biggest problem in agricultural subsidy is its targeting to the deserving beneficiaries. Only 30 percent subsidies go to marginal, small, and medium farmers. The overall rate of agricultural production is decreasing and production cost is increasing. (Rajwinder and Manisha, 2012; Arora, 2013).

The state government and the central government are agricultural scheme to farmers. This scheme is not reach to block villages. Most of the village farmers are not aware about government scheme. The farmers are about scheme then they do not understand the proper procedure of scheme. The state government is not provide campaign and hand bill to farmers into the villages. When disaster like drought, flood, crop falling and improper fruiting of field crops are incur into the block villages. The state government and the central government are allocate contingency to farmers but the subsidy is not distributed properly among farmer. The government department is grant subsidy to selected framers who can provide commission to department employees. The faith of farmers is diminishing from agriculture department and the agitation is increasing to the agriculture department.

The private agriculture company provides crop meeting, campaign, harvesting meeting and crop demonstration but the agriculture department do not offer crop meeting, campaign, harvesting meeting and crop demonstration. The agriculture department is never collaborate with private company for agriculture programme. The department provides irregular report to block villages and the state government and the central government does not take action sincerely of block report.

Loss of cropping patterns among village farmer

Cropping patterns based on climate and land capability are sustainable. Climate change will likely to cause further problems in our crop production and is likely to become the most important environmental issue in the 21st century. The climate change is increasing a loss of genetic diversity that are forcing farmer to change crop patterns. The farmers are cultivate High Yielding Varieties (HYV) and Hybrids instead of traditional varieties or cultivars (Shetty *et al*., 2007; Shekara *et al*., 2016).

The farmers were cultivate rice, wheat, jute, sugarcane, cabbage, cauliflower, mustard, chilli, tomato etc into block villages at well weather and climate conditions. The private agriculture company was provide all kinds of seed to supply chain. The village industrialization and pollution are transformed agriculture patterns of block villages or the natural calamities like flood and drought are totally transit crop pattern. The natural calamities and pollution are bring massive transformation into climate or weather conditions. The reservoirs like lake, river and pond are decline in block villages and the underground water is mitigating slowly in uttar dinajpur district. Deforestation provides irregularity into SW monsoon and NW monsoon. This district has lost beneficial trees like mango, jackfruit, and eucalyptus that indicate rainfall. The loss of animal habitat and the pollinator habitat that transforms plant physical factors, adaptation and cropping pattern of block villages. The villages farmer are cultivate mostly paddy, mustard, maize, okra, jute and tomato in present period. The government seed corporation and the private company have restricted a supply of seeds into the market. Massive transformation of cropping patterns has observed in block of uttar dinajpur district.

Effect of Mass communication

The success of agricultural development programmes in developing countries largely depends on the nature and extent of use of mass media in mobilization of people for development. The planners in developing countries realize that the development of agriculture could be hastened with the effective use of mass media. It transfers modern agricultural technology to literate and illiterate farmers alike even in interior areas, within short time. Radios, Television have been acclaimed to be the most effective media for diffusing the scientific knowledge to the masses. Farm magazine are commonly used. It offers agricultural information among the literate farmers (Purushothaman *et al.*, 2003).

The crop diversity had been seen in block villages during past period. The production and the productivity were high in past years. The scientists, subject matter specialist (SMS) and media were communicate with village farmers. The scientists, subject matter specialist (SMS) and private company were conduct farmers meeting, fertilizer and pesticide application programme, crop demonstration and crop harvest meeting. The media was highlight a kharif and rabi crops of farmer into several states. The scientists, SMS and Krishi Vigyana Kendra (KVK) were advice about Integrated Pest Management (IPM), Integrated Nutrient Management (INM), agronomic practices and implements. The media was highlight the farmers programme into the nation.

The mankind thinking is changed towards farmer in Modern period. The Indian people are follow modern lifestyle but they are not implement tangible agriculture projects for farmer. So that, the farmer revenue will be double into upcoming period. The scientists, the KVK, the agriculture department and the media are not organized programmes to farmer welfare. The scientists, the KVK, the agriculture department, the private companies are never implement tangible projects to the farmer welfare. The media is not highlight the present livelihood of farmers to government. The media is never debate on crop methods, natural disasters, irrigation mechanism, fertilizer or pesticide doses application, post harvest methods, crops CACP (Commission of agriculture costs and prices), global and Indian agriculture market. The media is never highlight the tangible project of the scientists, the KVK, the agriculture department and the private companies. The media is never interact with village farmers into good condition. They always interact with farmers into casual and disaster conditions. The media is lesser focus into rural area than urban area. This will decline agriculture development of block villages.

The present farming is differ than past farming. The transition of weather, climate and natural calamities is totally changed the farming of uttar dinajpur district. The farmers are affected with the policy of government department and private company. This policy is affected the income and lifestyle of farmers which makes farmer helpless. The media is never participate into highlighting a lifestyle and income of farmer. It highlights an event of natural calamities of farmers. The strategy of government department, private companies and media are declining the block farmers.

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Indian Agriculturist, Vol. 62, No. 1 & 2, pp. 75-82, 2018

Attitude of Agriculture Graduates for Agriculture Entrepreneurship

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Received : 29.06.2018 **Accepted : 06.07.2018** **Published : 18.07.2018**

Abstract

The present study was conducted in Rajasthan. The investigation concerned with Students, College of Agriculture, Jobner, which is the oldest post graduate college in Rajasthan and majority of the agriculture graduate students of this college are successful and reputed entrepreneurs and serving on many important posts in different states of India and abroad. India, predominantly an agro based country with about 67% population living in more than five lakh villages. It has vast potential for giant leap into agri-business. India has one of the world's largest agricultural education systems. In addition to this, there are large numbers of private colleges both affiliated and non-affiliated to SAU's which also annually admit larger number of students. There is corresponding lack of employment opportunities for agricultural professionals in public sector. Rising unemployment among agricultural graduates and market forces unleashed by the phenomenon of globalization and opening of world economics has necessitated that agricultural graduates should not be mere degree holders but must be professional who can measure the employment issues and concerns. Hence, an investigation entitled "Attitude of Agriculture Graduates of S.K.N. College of Agriculture, Jobner towards Agriculture Entrepreneurship" was conducted on proportionate randomly selected randomly by proportional allocation method 100 students comprising 50 male students and 50 female students from M.Sc. and Ph.D. From the S.K.N. College of Agriculture, Jobner. Attitude was found to be positive.

Key words **:** Attitude, Agriculture Graduates and Entrepreneurship

Introduction

India, predominantly an agro based country with about 67% population living in more than five lakh villages. It has vast potential for giant leap into agri-business. India has one of the world's largest agricultural education system with 61 State Agricultural Universities (SAUs), two Central Agricultural University (CAU), 5 Deemed Universities (DUs) and 4 general Central Universities with Agriculture faculty. These institutions enroll on annual basis about 15,000 students at UG level in as many as 11 disciplines and over 7,000 students at PG and 1700 students at PhD level. At any point, there are over 80,000 students studying in SAUs. In addition to this, there are large numbers of private colleges both affiliated and non-affiliated to SAUs which also annually admit larger number of students. Many general universities also offer agricultural education either themselves or through affiliated colleges. Agricultural education is a broad term which includes disciplines of Agriculture Agronomy, Veterinary Science, Forestry, Fisheries, Horticulture and Home Science.

There is corresponding lack of employment opportunities for agricultural professionals in public sector. Rising unemployment among agricultural graduates and market forces unleashed by the phenomenon of globalization and opening of world economics has necessitated that agricultural graduates should not be mere degree holders but must be professional who can measure the employment issues and concerns (Katyal, 2004).

There is a tremendous scope for empowerment of agricultural graduates through establishment of Dairy, Poultry, Fishery, Food Processing and Value

Addition, Floriculture, Green house, Poly house enterprises etc; and thus they can even become employment generator. But, it has been many a times reported that, only few students want to become entrepreneurs. Recent experiences indicate that the economic progress of few countries, particularly developed countries is due to the contribution of large number of small entrepreneurs employing up in their establishment. So, large numbers of such entrepreneurs for developing and transforming village clusters into sustainable economic units needed (Kalam, 2007).

As opposed to the increasing demand for higher education, unemployment of university graduates has been rapidly increasing. Even though accurate data on unemployment is not available, it is believed that over 28 per cent of agricultural and natural resource college graduates need to find job (Jalali, 2003). This is why many universities offer entrepreneurial courses, activities and stimulate students to involve in entrepreneurial activities. Actually, universities are playing an increasingly important role in entrepreneurship development (Menzies, 2000).

Accelerating changes of current world in scientific and technical eras and subsequent challenges of economic- social system, decreasing of ground water reserves and increasing of poverty and unemployment due to more attention of policy makers and scholars to entrepreneurship concept, as far as they consider the last model of development for development based on entrepreneurship (Ahmad pourdariani, 2007).Hesrich & Piters (2002) known entrepreneurship as something beyond efforts worth and the time that consumed for it. Although entrepreneur, received personal and financial satisfaction (internal) as rewards resulting from his/her efforts of it (entrepreneurship). Simultaneously, by unfolding of role and effect of entrepreneurship on employment trends and economic growth in developed countries, effort for education and generalizing of knowledge and entrepreneurial spirit among the managers, merchants, students and potential entrepreneurs was strongly advocated-(Ahmadpourdariani, 2007).

Despite the higher production, the per capita availability of food has not increased significantly. These facts show that the future growth of agriculture would have to necessarily come largely from increased productivity from a shrinking natural resource base through efficient as well as scientific management. We can make it possible through the proper deployment and utilization of specially trained manpower of our agricultural graduates. The quality of the agricultural graduates and their efficiency depend on the type and method of education imparted to them. Field oriented practical programmes greatly influence their performance in the actual field conditions. Agricultural education enables them in the scientific utilization of the available natural resources to the maximum extent to enhance the national development.

Globalization of trade, explosion of few technologies, rapidly changing role of Governments and intense competitive pressures have brought many new challenges to the Indian food and agri-business sector. The various institutes had designed programme to develop young men and woman into competent professional managers for the agriculture, food and food processing, agri-business, rural and allied sector. Increasing the number of startups and business successions and improving the support for young entrepreneurs is internationally of high importance for economy and labour markets. Occupation plays an important role in the life of an individual and plays a broader psychological importance that has been generally recognized.

Entrepreneurship is important for modernization, improvement, development and assets establishment. To create self-employment opportunities for unemployed agriculture graduates, entrepreneurship is widely regarded as an integral player in business culture and engine. Entrepreneurship is the practice of starting new organizations, particularly new businesses generally in response to identified opportunities. Entrepreneurship ranges in scale from solo projects (even involving the entrepreneur only part-time) to major undertakings creating many job opportunities.

The relative proportion of agricultural graduates finding employment in the public sector in India is also shrinking gradually. More jobs should, therefore, be created in the private sector, besides increasing avenues for self employment (George and Bhaskaran, 2004). This, however, necessitates fine-tuning the entrepreneurial skills of the agricultural graduates. With this objective, the Ministry of Agriculture, Government of India, in association with the National Bank for Agriculture and Rural Development (NABARD), Small Farmers Agribusiness Consortium (SFAC) and the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, launched a programme called "Agriclinics and Agribusiness Centers Scheme". The objectives are to supplement the efforts of the government extension system in making available inputs and services to the farmers and to provide gainful employment to the agricultural graduates. The training of agricultural graduates to instill the spirit of entrepreneurship is an integral part of this. Government of India on 9th April, 2002 launched Agri-clinic and agri-business centers scheme to give the way to the agriculture graduates who are deprived from unemployment. It aims to develop the entrepreneurship skill among the unemployed agriculture youth to start their own business *viz*. Soil Testing Lab., Seed Production and Marketing, landscaping and Nursery, Fish Fingerlings Production, Seed Processing ,Vermi-compost, Veterinary Clinic, Crop Protection Centre, Floriculture, Food Processing and Horticulture Unit, Mushroom cultivation, Biofertilizer, Production and Marketing of Poultry. It also helps to tap the expertise available in the large pool of graduates in agriculture and allied sectors. The scheme's main objectives are to create the job producers not job seekers. It is expected that the setting up of agri-clinic (AC) and agri-business centers (ABC) by agricultural graduates under the scheme will strengthen transfer of technology and extension services. It is also believed that it will help youth to improve their income and give a better position in the society. Thus these centers are supposed to bring in both social and economic transformation in the county.

Materials and Methods

Presented study was conducted in S.K.N. College of Agriculture Jobner, which is under the administrative control of Sri Karan Narendra Agriculture University, Jobner, Jaipur, because this is the oldest post graduate college in Rajasthan and majority of the agriculture graduate students of this college are successful and reputed entrepreneurs and serving on many important posts in different states of India and abroad.

From the S.K.N. College of Agriculture, Jobner, a list of all male and female students admitted in M.Sc. and Ph. D. courses and registered in session 2014-15 was prepared with the help of the student section of the college. Out of these a total of 100 students comprising 50 male students and 50 female students from M.Sc. and Ph.D. courses were selected randomly by proportional allocation method for the study purpose.

Results and Discussion

For finding out the levels of attitude of agriculture graduates towards agriculture entrepreneurship, the attitude of respondents was classified into three levels "Most favorable", "Favorable " and "Less Favorable" on the basis of mean (104.49) and standard deviation (7.52) as follows: (1.)The respondents who obtained the attitude score below 96.97 were classified as having "Less favorable" attitude towards agriculture entrepreneurship. (2.) The respondents who obtained the attitude score from 96.97 to 112.01 were categorized into having "Favorable" attitude towards agriculture entrepreneurship. (3.) The respondents who obtained the attitude score more than 112.01 were classified as having "Most favorable" attitude towards agriculture entrepreneurship.

Distribution of agriculture graduates into different levels of attitudes

It is evident from the table-1 that majority of agriculture graduates 66.00 per cent had "Favorable" attitude towards agriculture entrepreneurship, whereas 22.00 per cent agriculture graduates had "Less favorable" attitude and only 12.00 per cent agriculture graduates had "Most favorable" attitude towards agriculture entrepreneurship.

It is also observed from the table-1 that majority of the male (72.00%) and female 60.00 per cent agriculture graduates had "Favorable" attitude towards

Table 1. Distribution of agriculture graduates into different levels of attitudes towards agriculture entrepreneurship

(n=100)

S. No.	Level of attitude towards Agriculture Entrepreneurship	Male agriculture graduates (n=50)		Female agriculture graduates (n=50)		Total agriculture graduates (n=100)	
		F	Percent	F	Percent	F	Percent
1	Less favorable (below 96.97 scores)	11	22.00	11	22.00	22	22.00
2	Favorable (from 96.97 to 112.01 scores)	36	72.00	30	60.00	66	66.00
3	Most favorable(above 112.01 scores)	3	6.00	9	18.00	12	12.00
Total		**50**	**100.00**	**50**	**100.00**	**100**	**100.00**

X=104.49 $\sigma = 7.52$ $X^2 = 3.54$ (Non-significant)

Tabulated value of X^2 at 5 per cent level of significance with 2 degrees of freedom= 5.991

agriculture entrepreneurship, whereas only 3.00 per cent male agriculture graduates and 9.00 per cent female agriculture graduates had "Most favorable" attitude and equal percentage of male and female agriculture graduates (22.00%) had "Less favorable" attitude towards agriculture entrepreneurship.

The calculated value of chi-square (χ^2) was found to be 3.54, which is less than its tabulated value (5.99) at 5 per cent level of significance. Hence, the null hypothesis was accepted and alternate hypothesis was rejected. This leads to the conclusion that there is a non-significant agreement between the male and female agriculture graduates with regard their level of attitude towards agriculture entrepreneurship.

The results show that majority of male and female agriculture graduates had favorable attitude towards agriculture entrepreneurship, which might be due to the reason that most of the agriculture graduates were from the families having moderate literacy level, medium economic condition and average occupational status. All these would have created a medium condition for higher education. Their parents being educated might have inquired about the different services and jobs offered after graduation and reached to a conclusion and might have given more value to agricultural entrepreneurship. Agriculture graduates being residents of rural areas would have developed contact with local agriculture personnel and get aware about the importance of agricultural entrepreneurship. After having been admitted to post graduation, they might came to know the importance of agricultural entrepreneurship and its role in development of the country and on other hand and might also aware about the vast area of agriculture businesses to develop a positive attitude towards agricultural entrepreneurship, which might have resulted in their favorable attitude towards agricultural entrepreneurship. The findings are in support with the findings of Dahake, 2009.

Attitude of agriculture graduates about agriculture entrepreneurship

A perusal of the table-2 depicts that the statement no.3 "Agricultural entrepreneurship creates positive attitude towards starting an agri-clinic or agri-business center at village level" had secured the first rank by both male (MS 4.74) and female (MS 4.66) agriculture graduates as it was strongly agreed by 37.00 per cent male and 33.00 per cent female agriculture graduates, agreed by the 13.00 per cent male and 17.00 per cent female agriculture graduates. Thus the most of the agriculture graduates had favorable attitude towards this statement.

The probable reason behind such findings might be that they are interested in doing business in

Table 2. Attitude of agriculture graduates towards different statements about agriculture entrepreneurship

(n=100)

S.No.	Attitudinal statements	Male agriculture graduates (N=50) SA 5	A 4	U 3	DA 2	SDA 1	MS	Rank	Female agriculture graduates (N=50) SA 5	A 4	U 3	DA 2	SDA 1	MS	RANK
1	Agricultural education develops confidence in student to accept agriculture entrepreneurship as a profession	27 (54.00)	18 (36.00)	1 (2.00)	4 (8.00)	0 (0.00)	4.36	VIII	31 (62.00)	16 (32.00)	0 (0.00)	3 (6.00)	0 (0.00)	4.5	VII
2	Agricultural entrepreneurship doesn't provide good employment opportunity	0 (0.00)	8 (16.00)	2 (4.00)	28 (54.00)	12 (24.00)	3.88	XVII	0 (0.00)	4 (8.00)	1 (2.00)	21 (42.00)	24 (48.00)	4.30	X
3	Agricultural entrepreneurship creates positive attitude towards starting an agriclinic or agri-business center at village level	37 (74.00)	13 (26.00)	0 (0.00)	0 (0.00)	0 (0.00)	4.74	I	33 (66.00)	17 (34.00)	0 (0.00)	0 (0.00)	0 (0.00)	4.66	I
4	An agriclinic or agri-business training can create confidence to accept agriculture entrepreneurship as a profession	37 (74.00)	12 (24.00)	0 (0.00)	1 (1.00)	0 (0.00)	4.70	II	27 (54.00)	22 (44.00)	0 (0.00)	1 (2.00)	0 (0.00)	4.56	V
5	It provides me knowledge about various agencies involved in agriculture entrepreneurship	31 (62.00)	12 (24.00)	0 (0.00)	0 (0.00)	1 (2.00)	4.56	III	27 (54.00)	23 (46.00)	0 (0.00)	0 (0.00)	0 (0.00)	4.54	VI
6	An agriclinic or agri-business training may create Agricultural business anxiety	12 (24.00)	17 (34.00)	14 (28.00)	2 (4.00)	5 (10.00)	2.42	XXV	14 (28.00)	18 (36.00)	10 (20.00)	4 (8.00)	4 (8.00)	2.32	XXV
7	Agricultural entrepreneurship does not provide best subsidiary occupation opportunities	10 (20.00)	5 (10.00)	1 (2.00)	24 (48.00)	10 (20.00)	3.38	XXII	4 (8.00)	9 (18.00)	4 (8.00)	23 (46.00)	10 (20.00)	3.52	XXI
8	Agricultural entrepreneurship leads to employment generation	25 (50.00)	21 (42.00)	4 (8.00)	0 (0.00)	0 (0.00)	4.42	VII	31 (62.00)	17 (34.00)	2 (4.00)	0 (0.00)	0 (0.00)	4.60	III
9	Agricultural entrepreneurship does not provide maximum net profit and income	2 (4.00)	4 (8.00)	9 (18.00)	31 (62.00)	4 (8.00)	3.62	XXI	0 (0.00)	10 (20.00)	8 (16.00)	22 (44.00)	10 (20.00)	3.64	XX
10	Agricultural enterprises are more suitable to small and marginal farmers	24 (48.00)	16 (32.00)	8 (16.00)	2 (4.00)	0 (0.00)	4.24	XIV	19 (38.00)	15 (30.00)	10 (20.00)	6 (12.00)	0 (0.00)	3.94	XIX
11	Agricultural entrepreneurship develops favorable attitude towards rural living	22 (44.00)	22 (44.00)	6 (12.00)	0 (0.00)	0 (0.00)	4.32	X	16 (32.00)	34 (68.00)	0 (0.00)	0 (0.00)	0 (0.00)	4.32	IX
12	Agricultural entrepreneurship provides help to improve the farmer's economy	30 (60.00)	18 (26.00)	0 (0.00)	2 (4.00)	0 (0.00)	4.52	IV	33 (66.00)	15 (30.00)	0 (0.00)	2 (4.00)	0 (0.00)	4.62	II
13	Agricultural entrepreneurship provides effective skill of agriculture communication	27 (54.00)	20 (40.00)	3 (6.00)	0 (0.00)	0 (0.00)	4.48	V	29 (58.00)	21 (42.00)	0 (0.00)	0 (0.00)	0 (0.00)	4.58	IV
14	Agricultural graduate can not earn less than professional graduate	6 (12.00)	16 (32.00)	18 (36.00)	2 (4.00)	8 (16.00)	2.80	XXIII	18 (36.00)	14 (28.00)	10 (20.00)	7 (14.00)	1 (2.00)	2.18	XXVI
15	Agricultural girls mainly prefer jobs in government sector	10 (20.00)	21 (42.00)	11 (22.00)	8 (16.00)	0 (0.00)	2.34	XXVI	9 (18.00)	23 (46.00)	4 (8.00)	13 (26.00)	1 (2.00)	2.48	XXIV

16	Agricultural entrepreneurship also provides the graduate with a positive attitude towards the adoption of modern technology.	23 (46.00)	27 (54.0)	0 (0.00)	0 (0.00)	0 (0.00)	4.46	VI	26 (52.00)	23 (46.00)	1 (2.00)	0 (0.00)	0 (0.00)	4.50	VII
17	Agricultural entrepreneurship does not help in developing good personality.	0 (0.00)	5 (10.00)	9 (18.00)	24 (48.00)	12 (24.00)	3.86	XVIII	0 (0.00)	4 (8.00)	9 (18.00)	15 (30.00)	22 (44.00)	4.10	XV
18	Agricultural entrepreneurship does not help in promoting cooperative efforts.	0 (0.00)	0 (0.00)	19 (38.00)	24 (48.00)	7 (14.00)	3.76	XIX	0 (0.00)	1 (2.00)	8 (16.00)	17 (34.00)	24 (48.00)	4.28	XI
19	Agricultural entrepreneurship does not provide required management skill for profitable and better management of Agricultural / horticultural farm.	0 (0.00)	3 (6.00)	3 (6.00)	38 (76.00)	6 (12.00)	3.94	XVI	0 (0.00)	4 (8.00)	1 (2.00)	25 (50.00)	20 (40.00)	4.22	XII
20	Agricultural entrepreneurship kindles love towards nature.	11 (22.00)	21 (42.00)	12 (24.00)	2 (4.00)	4 (8.00)	3.66	XX	13 (26.00)	14 (28.00)	14 (28.00)	2 (4.00)	7 (14.00)	3.48	XXII
21	Agricultural entrepreneurship is the hope for growing population in India	27 (54.00)	11 (22.00)	12 (24.00)	0 (0.00)	0 (0.00)	4.30	XII	18 (36.00)	22 (44.00)	9 (18.00)	1 (2.00)	0 (0.00)	4.14	XIV
22	Agricultural entrepreneurship should be given top priority for development	17 (34.00)	32 (64.00)	0 (0.00)	0 (0.00)	1 (2.00)	4.28	XIII	8 (16.00)	40 (80.00)	1 (2.00)	1 (2.00)	0 (0.00)	4.10	XV
23	Agricultural entrepreneurship help to safeguard our cultural heritage keeping agrarian society	26 (52.00)	16 (32.00)	8 (16.00)	0 (0.00)	0 (0.00)	4.36	VIII	15 (30.00)	21 (21.00)	14 (28.00)	0 (0.00)	0 (0.00)	4.02	XVII
24	Agricultural entrepreneurship is meant for uneducated and poor people	11 (22.00)	12 (24.00)	15 (30.00)	10 (20.00)	2 (4.00)	2.60	XXIV	3 (6.00)	15 (30.00)	15 (30.00)	9 (18.00)	8 (16.00)	3.08	XXIII
25	I will take to Agricultural entrepreneurship and prosper	24 (48.00)	18 (26.00)	8 (16.00)	1 (2.00)	0 (0.00)	4.32	X	17 (34.00)	26 (52.00)	6 (12.00)	1 (2.00)	0 (0.00)	4.18	XIII
26	Today's need is to promote Agricultural y entrepreneurship than industry	23 (46.00)	11 (22.00)	16 (32.00)	0 (0.00)	0 (0.00)	4.14	XV	18 (36.00)	13 (26.00)	19 (38.00)	0 (0.00)	0 (0.00)	3.98	XVIII
27	I have very low future aspirations in agricultural field.	25 (50.00)	18 (36.00)	7 (14.00)	0 (0.00)	0 (0.00)	1.64	XXVII	19 (38.00)	14 (28.00)	12 (24.00)	3 (6.00)	2 (4.00)	2.10	XXVII

SA = Strongly agree A = Agree N = Neutral DA = Disagree SDA = Strongly disagree

Rank correlation coefficient (r_s) = 0.8995 t = 10.29**

** Significant at 1 percent level of significance

Tabulated value of t at 1 percent level of significance with 25 degrees of freedom = 2.787

agriculture sector and most of the students were belonged to the medium to high academic achievement category, medium to high family income, medium to high family education, medium to high occupational status of family, due to which they might also be motivated by their family for taking up agriculture entrepreneurship.

In the similar way the statement no-4 "An agriclinic or agri-business training can create confidence to accept agriculture entrepreneurship as a profession" had been awarded second rank in order of preference by the male (MS 4.7) and fifth rank of the preference by female agriculture graduates (MS 4.56).

The statement no-5 "It provides me knowledge about various agencies involved in agriculture entrepreneurship" had been awarded the third rank in order of preference by male agriculture graduates (MS 4.56) and sixth rank of the preference by female agriculture graduates. The statement no-12 "Agricultural entrepreneurship provides help to improve the farmer's economy" (MS 4.58) was ranked third in their preference by female agriculture graduates whereas in case of male agriculture graduates (MS 4.52) the same statement was ranked fourth in their preference.

On the other side, the statement no-27th "I have very low future aspiration in agricultural field" got the lowest mean score (MS 1.64) by both male and female (MS 2.1) agriculture graduates had been ranked 27th last, as it was strongly agreed by 50.00 per cent male and female (38.00%) agriculture graduates, agreed by the 36.00 per cent male and 28.00 per cent female agriculture graduates. Thus the most of the agriculture graduates had unfavorable attitude towards this statement.

The probable reason behind such findings might be that the new agriculture graduates are interested in order private or public sector of business because the risk in the agriculture business is higher than other sector and the agriculture is also season bounded and due to high changes in seasons there is very low income in agriculture.

The value of rank order correlation (r_s) was found to be 0.8995 for which the calculated value of 't' (10.29) was higher than its tabulated value (2.787) at 1 per cent level of significance. Hence, the null hypothesis was rejected and the alternate hypothesis was accepted. This leads to the conclusion that there is a highly significant correlation between the male and female agriculture graduates with regard to their attitude towards different statements about agriculture entrepreneurship.

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