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Estimation of economic heterosis for seed and oil yield in sunflower (*Helianthus annuus* L.) hybrids for coastal saline belt

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Abstract
Present investigation was carried out to identify the best hybrid combinations giving high degree of useful heterosis for economic traits like seed and oil yield in sunflower under high saline soil in coastal saline belts of West Bengal. The standard heterosis for seed yield ranged from -12.7 to 17.9, -3.4 to 30.5 and -10.5 to 20.8 per cent over LFSH -171, DRSH-1 and KBSH-44, respectively. The maximum hybrid vigor for seed yield was reported in the CMS-234A x EC-273009, followed by CMS-853A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 and CMS-852A x EC-601751. The range of economic heterosis for oil yield varied from 0.3 to 27.2 per cent over LSFH-171, from -10.2 to 13.9 per cent over DRSH-1 and from 5.2 to 33.4 per cent over KBSH-44. The maximum hybrid vigor for oil yield was reported in the CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-850 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A X CSFI-99, CMS-234A X RHA-1-1 and PET-2-7-1A x R-138-2 . The study revealed that out of 32 new sunflower hybrids, only hybrids *viz.,* CMS-234 A x EC-273009, CMS-853 A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 CMS-850 A x EC-601978 and CMS-207 A X CSFI-99 manifested significant economic heterosis for seed and oil yield over national checks LSFH-171, DRSH-1 and KBSH-44. From the study it may be concluded that the sunflower hybrids *viz.* CMS-234 A x EC-273009, CMS-853 A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725, CMS-207 A X CSFI-99 and CMS-850 A x EC-601978 might be promoted for further evaluation and commercialization.

Key word
Economic heterosis, Sunflower, Seed Yield, Oil Yield.

INTRODUCTION

Sunflower (*Helianthus annus* L.) is the fourth important oilseed crop in the world. It belongs to the genus *Helianthus*, family Asteraceae. Sunflower seeds contain 38 to 42 per cent edible oil which is used for culinary purposes. Sunflower oil is considered as premium Oil as compared to other vegetable oils because of its light yellow colour, flavour, high smoke point and high level of linoleic acid (55 – 60 %).

In India, sunflower is cultivated over an area of 5.2 lakh hectares with a production and productivity of 3.35 lakh tonnes and 0.64 t/ha, respectively (Anonymous, 2016). Sunflower is being grown over 70 per cent of area across Karnataka, Maharashtra and Andhra Pradesh. It occupies an area of about 3.6 lakh hectare with a production of 2.1 lakh tonnes and productivity of 0.57 t/ha in Karnataka (Anonymous, 2018). Exploitation of heterosis on commercial for a particular locally requires isolation of suitable inbred and development of hybrids. To accomplish this task, one has to know the genetic diversity of the available germplasm and the combining ability of the parents. For improving the yield potential of

varieties and hybrids, the decision should be made on the choice of the right parent for hybridization.

Increasing seed and oil yields is the top priority of most sunflower breeding programs. Exploitation of heterosis is the main purpose in sunflower hybrid breeding programme (Putt,1966; Fick, 1978, Miller and Hammond, 1991;Limbore *et.al.,*1997). The main objective of sunflower breeding program is the development of productive F_1 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 seeds (Fick, 1976). Therefore, consideration of both the factors is important when breeding for a high oil yield. National sunflower 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 (1969) and restorer genes by Kinman (1970). Economic/Standard heterosis is the measure of heterosis in terms of superiority over the standard check(s)/ hybrid(s). The presence of high heterosis in certain crosses and low in others suggested that the nature of gene action varied with genetic architecture of the parents (Reddy and Madhavilatha, 2005; Vishwanath and Goud, 2006).

Present research programme was carried out with the objectives of (i) to evaluate the performance of the sunflower hybrids for yield and yield component under high saline soil and (ii) to identify the Economic/standard heterotic cross combinations/sunflower hybrids suitable for growing in the *rabi-summer* season in in coastal saline belts.

MATERIAS AND METHODS

Thirty-two promising sunflower hybrids along with three National checks (LSFH-171, KBSH-44 and DRSH-1) were evaluated at AICRP-Sunflower, Nimpith Centre, West Bengal during R*abi,* 2017-18 and 2018-19 in Randomized Complete Bock Design with three replications under medium to high spoil salinity (EC 2.0-3.0dS/m) throughout the crop growth period. Each hybrids were sown in three rows of three meter length with a spacing of 60 x 30 cm.

Observations were recorded on ten randomly selected plants from each plot of all replications on the characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed yield/ head (g), 100-seed weight (g), hull content (%), volume weight (g/100cc). The seed yield (kg/ha), and oil yield (kg/ha) were estimated on plot basis. The mean values were subjected to statistical analysis. Heterosis, heterobeltiosis and economic heterosis was estimated as per the methods suggested by Fonesca and Patterson (1968) and Meredith and Bridge (1972) for individual as well as over the environments.

RESULTS AND DISCUSSION

Pooled analysis of data for seed yield and oil yield indicated that F_1s from the crosses CMS-234 A x EC-273009 (1276), CMS-853 A x EC 623023(1240), CMS-234A X RHA-1-1(1208), CMS-234 X RHA-1-1(1178), CMS-852 A x EC-601725(1176), CMS-852 A x EC-601751(1175), CMS-850A x EC-601751(1162) and CMS-853A x EC623021(1136) exhibited the higher seed yield/ plant over the national check hybrids, LSFH-171(NC-1), DRSH-1(NC-2), KBSH-53(NC-3) which recorded 1082 kg/ ha, 978 kg/ha and 1058 kg/ha of seed yield, respectively **(Table 1 & 2)**

The sunflower hybrids were evaluated on the basis of economic/standard heterosis for seed yield and yield contributing traits. The standard heterosis or seed yield varied from -12.7 to 17.9 per cent over LSFH-171, from -3.4 to 30.5 per cent over DRSH-1 and from -10.5 to 20.8 per cent over KBSH-44. Hybrid vigor for seed yield was the highest in case of CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 and CMS-852A x EC-601751 (**Table 3**). The range of economic heterosis for oil yield varied from 0.3 to 27.2 per cent over LSFH-171, -10.2 to 13.9 per cent over DRSH-1 and 5.2 to 33.4 per cent over KBSH-4. The maximum hybrid vigor for oil yield was reported in CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-850 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A X CSFI-99, CMS-234A X RHA-1-1 and PET-2-7-1A x R-138-2(**Table 3**).

Parameshwarappa *et al.* (2008) and Mohanasundaram *et al.* (2010) noticed standard heterosis for seed yield and for oil content. Significant standard heterosis for seed yield was also reported by Manivannan *et al.* (2015) and Thakare *et al.* (2015). High value of standard heterosis for seed yield in the experimental hybrids using CMS lines/tester lines had also been reported by Lakshman et al. (2019) in combining ability study, Meena *et al.* (2013), Chandra *et al*.(2015) Supriya *et al.* (2017) and Nandini *et al*.(2017). Existence of significant standard heterosis for seed yield had also been reported by Sahane *et al.*(2017).

The study revealed that for standard/ economic heterosis for seed yield, sunflower hybrid CMS-234 A x EC-273009 (1276 kg/ha) recorded 17.9, 30.5 and 20.8 per cent higher over that of three national checks *i.e.* LFSH-171,DRSH-1 and KBSH-44, respectively. Economic/standard heterosis for seed yield was also significant in experimental sunflower hybrid CMS-853 A x EC-623023, (1240kg/ha) which recorded 14.6 per cent higher than LSFH-171, 26.8 per cent higher than DRSH-1 and 17.4 per cent higher than that of KBSH-44. Seed yield of CMS-234 A x R-1-1 (1208 kg/ha) recorded 11.6, 23.5 and 14.4 higher than that of LSFH-171, DRSH-1 and KBSH-44, respectively. The hybrid CMS-852 A x EC-601725 (1175kg/ha) was recorded 8.7 per cent higher than LSFH-171, 20.2 per cent higher than DRSH-1 and KBSH-44, respectively (**Table 4**).

Table 1. Performance *per se* of the sunflower hybrids for yield contributing traits

Hybrid combination	Seed yield (kg/ha) 2017-18	Seed yield (kg/ha) 2018-19	Oil yield (kg/ha) 2017-18	Oil yield (kg/ha) 2018-19
CMS-234 A x EC-273009	1346	1206	428	394
CMS-853 A x EC 623023	1308	1172	425	389
CMS-234A X RHA-1-1	1274	1142	411	375
CMS-103 A x EC-601978	1220	1092	418	382
CMS-207 A X CSFI-99	1194	1070	411	375
CMS-852 A x EC-601725	1241	1111	412	376
PET-89-1A x EC-601978	1102	988	381	349
CMS-850 A x EC-601978	1190	1066	416	380
PET-2-7-1A x R-138-2	1187	1063	410	374
P-2-7-1A x EC-601978	1225	1097	404	370
CMS-234 X RHA-1-1	1243	1113	394	360
CMS-853A x EC623021	1198	1074	400	366
CMS-852A x EC-601751	1240	1110	402	368
CMS-850A x EC-601751	1226	1098	402	368
CMS-10A x EC-601725	1167	1045	391	357
CMS-207A x SCG-2R	1194	1070	381	349
PET-89-1A x EC-601751	1169	1047	388	354
PET-2-7-1A x EC-601751	1124	1006	376	344
CMS-853A x EC-601725	1215	1089	381	349
CMS-10 A x EC-601978	1102	988	375	343
CMS-207A x R-272	1142	1022	382	350
CMS-103A x EC-623023	1146	1026	380	348
CMS-10A x EC-623023	1139	1021	370	338
PET-2-7-1A x EC-623016	1004	900	339	309
P-2-7-1A x EC-601751	1134	1016	356	326
CMS -207A x EC-623023	1072	960	348	318
CMS-207A x EC-623016	997	893	343	313
CMS -10A x EC-623021	1074	962	350	320
CMS-207A x EC-601725	1142	1022	374	342
CMS-207A x EC-623021	1085	971	363	331
CMS-207A x EC-623027	1047	937	364	332
CMS-10 A x EC-623023	1114	998	382	350
LSFH-171 (NC-1)	1142	1022	338	308
DRSH-1 (NC-2)	1021	915	377	345
KBSH-44 (NC-3)	1116	1000	322	294
G. Mean	**1159.5**	**1038.6**	**384.5**	**351.5**
S. E m(±)	**33.1**	**28.6**	**11.6**	**8.2**
C.D.(P=0.005)	**97.2**	**85.8**	**35.2**	**25.6**
C.V. (%)	**9.6**	**9.2**	**9.1**	**8.8**

Table 2. Mean Seed yield and yield contributing traits of sunflower hybrids under high saline soil (EC 3.0 to 4.0 dS/m) (2017-18 &2018-19 Pooled)

Hybrid combination	Plant height (cm)	Head diameter (cm)	Days to 50% flowering	Seed yield (kg/ha)	100-seed weight (g)	Oil content (%)	Oil yield (kg/ha)
CMS-234 A x EC-273009	132	11.5	65.5	1276	5.6	32.2	411
CMS-853 A x EC 623023	128	11.0	65.5	1240	4.5	32.8	407
CMS-234A X RHA-1-1	120	12.0	66.5	1208	4.1	32.5	393
CMS-103 A x EC-601978	116	11.2	63.8	1156	5.3	34.6	400
CMS-207 A X CSFI-99	116	10.6	68.2	1132	4.8	34.7	393
CMS-852 A x EC-601725	117	11.7	62.0	1176	5.0	33.5	394
PET-89-1A x EC-601978	110	10.2	66.3	1045	4.5	34.9	365
CMS-850 A x EC-601978	98	9.6	63.3	1128	4.5	35.3	398
PET-2-7-1A x R-138-2	112	9.8	65.8	1125	4.1	34.8	392
P-2-7-1A x EC-601978	127	11.5	68.5	1161	4.7	33.3	387
CMS-234 X RHA-1-1	135	11.2	66.5	1178	5.4	32.0	377
CMS-853A x EC623021	121	10.9	64.0	1136	5.0	33.7	383
CMS-852A x EC-601751	119	11.1	65.5	1175	4.3	32.8	385
CMS-850A x EC-601751	93	10.6	62.5	1162	4.6	33.1	385
CMS-10A x EC-601725	120	12.2	66.5	1106	4.7	33.8	374
CMS-207A x SCG-2R	131	10.8	67.5	1132	4.5	32.2	365
PET-89-1A x EC-601751	108	11.3	68.8	1108	4.7	33.5	371
PET-2-7-1A x EC-601751	114	11.0	66.0	1065	5.0	33.8	360
CMS-853A x EC-601725	135	12.8	66.5	1152	4.3	31.7	365
CMS-10 A x EC-601978	124	10.8	63.8	1045	4.5	34.4	359
CMS-207A x R-272	112	10.1	66.1	1082	4.6	33.8	366
CMS-103A x EC-623023	122	10.4	63.1	1086	4.3	33.5	364
CMS-10A x EC-623023	125	11.8	65.0	1080	4.0	32.8	354
PET-2-7-1A x EC-623016	109	10.4	67.7	952	6.2	34.0	324
P-2-7-1A x EC-601751	124	11.1	68.5	1075	5.0	31.7	341
CMS -207A x EC-623023	132	10.3	66.5	1016	4.0	32.8	333
CMS-207A x EC-623016	112	9.8	64.9	945	3.9	34.7	328
CMS -10A x EC-623021	128	10.4	68.0	1018	5.0	32.9	335
CMS-207A x EC-601725	121	10.1	68.0	1082	4.3	33.1	358
CMS-207A x EC-623021	128	10.4	67.0	1028	4.5	33.8	347
CMS-207A x EC-623027	122	9.5	66.1	992	4.2	35.1	348
CMS-10 A x EC-623023	132	10.3	65.5	1056	4.3	34.7	366
LSFH-171 (NC-1)	127	11.0	70.5	1082	4.6	29.9	323
DRSH-1 (NC-2)	123	10.6	68.5	968	5.0	37.0	361
KBSH-44 (NC-3)	130	10.9	70.5	1058	4.6	29.2	308
G. Mean	**120.1**	**10.7**	**66.2**	**1098.2**	**4.6**	**33.2**	**366.2**
S. E m(±)	**2.3**	**0.34**	**1.1**	**30.1**	**0.2**	**0.7**	**10.2**
C.D.(P=0.005)	**6.8**	**1.0**	**3.1**	**90.2**	**0.6**	**2.1**	**31.6**
C.V. (%)	**9.2**	**5.1**	**6.8**	**9.6**	**5.8**	**8.2**	**9.4**

Table 3. Economic Heterosis for seed and oil yield in sunflower hybrids

Hybrid combination	2017-18 & 2018-19 (Pooled)							
	Seed yield (kg/ha)	h2 (%) for seed yield over N.Ch-1	h2 (%) for seed yield over N.Ch-2	h2(%) for seed yield over N.Ch-3	Oil yield (kg/ha)	h2 (%) for oil yield over N.Ch-1	h2 (%) for oil yield over N.Ch-2	h2(%) for oil yield over N.Ch-3
CMS-234 A x EC-273009	1276	17.9	30.5	20.8	411	27.2	13.9	33.4
CMS-853 A x EC 623023	1240	14.6	26.8	17.4	407	26.0	12.7	32.1
CMS-234A X RHA-1-1	1208	11.6	23.5	14.4	393	21.7	8.9	27.6
CMS-103 A x EC-601978	1156	6.8	18.2	9.5	400	23.8	10.8	29.9
CMS-207 A X CSFI-99	1132	4.6	15.7	7.2	393	21.7	8.9	27.6
CMS-852 A x EC-601725	1176	8.7	20.2	11.4	394	22.0	9.1	27.9
PET-89-1A x EC-601978	1045	-3.4	6.9	-1.0	365	13.0	1.1	18.5
CMS-850 A x EC-601978	1128	4.3	15.3	6.8	398	23.2	10.2	29.2
PET-2-7-1A x R-138-2	1125	4.0	15.0	6.5	392	21.4	8.6	27.3
P-2-7-1A x EC-601978	1161	7.3	18.7	9.9	387	19.8	7.2	25.6
CMS-853A x EC623021	1136	5.0	16.2	7.6	383	18.6	6.1	24.4
CMS-852A x EC-601751	1175	8.6	20.1	11.3	385	19.2	6.6	25.0
CMS-850A x EC-601751	1162	7.4	18.8	10.0	385	19.2	6.6	25.0
CMS-10A x EC-601725	1106	2.2	13.1	4.7	374	15.8	3.6	21.4
CMS-207A x SCG-2R	1132	4.6	15.7	7.2	365	13.0	1.1	18.5
PET-89-1A x EC-601751	1108	2.4	13.3	4.9	371	14.9	2.8	20.5
PET-2-7-1A x EC-601751	1065	-1.6	8.9	0.9	360	11.5	-0.3	16.9
CMS-853A x EC-601725	1152	6.5	17.8	9.1	365	13.0	1.1	18.5
CMS-10 A x EC-601978	1045	-3.4	6.9	-1.0	359	11.1	-0.6	16.6
CMS-207A x R-272	1082	0.0	10.6	2.5	366	13.3	1.4	18.8
CMS-103A x EC-623023	1086	0.4	11.0	2.8	364	12.7	0.8	18.2
CMS-10A x EC-623023	1080	-0.2	10.4	2.3	354	9.6	-1.9	14.9
PET-2-7-1A x EC-623016	952	-12.0	-2.7	-9.8	324	0.3	-10.2	5.2
P-2-7-1A x EC-601751	1075	-0.6	9.9	1.8	341	5.6	-5.5	10.7
CMS -207A x EC-623023	1016	-6.1	3.9	-3.8	333	3.1	-7.8	8.1
CMS-207A x EC-623016	945	-12.7	-3.4	-10.5	328	1.5	-9.1	6.5
CMS -10A x EC-623021	1018	-5.9	4.1	-3.6	335	3.7	-7.2	8.8
CMS-207A x EC-601725	1082	0.0	10.6	2.5	358	10.8	-0.8	16.2
CMS-207A x EC-623021	1028	-5.0	5.1	-2.7	347	7.4	-3.9	12.7
CMS-207A x EC-623027	992	-8.3	1.4	-6.1	348	7.7	-3.6	13.0
CMS-10 A x EC-623023	1056	-2.4	8.0	0.0	366	13.3	1.4	18.8
LSFH-171 (N.Ch-1)	1032	-	-	-	338	-	-	-
DRSH-1 (N.Ch-2)	978	-	-	-	361	-	-	-
KBSH-44 (N.Ch - 3)	1058	-	-	-	316	-	-	-
G. Mean	**1097.5**	-	-	-	**412.2**	-	-	-
S. E m(±)	**30.1**	--	--	--	**23.2**	-	-	-
C.D.(P=0.005)	**90.2**	-	-	-	**68.6**	-	-	-
C.V. (%)	**9.6**	-	-	-	**9.4**	-	-	-

Table 4. Economic Heterosis for seed and oil yield of Superior sunflower hybrids

Hybrid combination	2017-18 & 2018-19 (Pooled)							
	Seed yield (kg/ha)	h2 (%) for seed yield over N.Ch-1	h2 (%) for seed yield over N.Ch-2	h2(%) for seed yield over N.Ch-3	Oil yield (kg/ha)	h2 (%) for oil yield over N.Ch-1	h2 (%) for oil yield over N.Ch-2	h2(%) for oil yield over N.Ch-3
CMS-234 A x EC-273009	1276	17.9	30.5	20.8	411	27.2	13.9	33.4
CMS-853 A x EC 623023	1240	14.6	26.8	17.4	407	26.0	12.7	32.1
CMS-234A X RHA-1-1	1208	11.6	23.5	14.4	393	21.7	8.9	27.6
CMS-852 A x EC-601725	1176	8.7	20.2	11.4	394	22.0	9.1	27.9
CMS-103 A x EC-601978	1156	6.8	18.2	9.5	400	23.8	10.8	29.9
CMS-207 A X CSFI-99	1132	4.6	15.7	7.2	393	21.7	8.9	27.6
CMS-850 A x EC-601978	1128	4.3	15.3	6.8	398	23.2	10.2	29.2
PET-2-7-1A x R-138-2	1125	4.0	15.0	6.5	392	21.4	8.6	27.3
LSFH-171 (N.Ch-1)	1032	-	-	-	309	-	-	-
DRSH-1 (N.Ch-2)	928	-	-	-	346	-	-	-
KBSH-44 (N.Ch - 3)	972	-	-	-	276	-	-	-

Analysis on pooled data for oil yield revealed that standard heterosis for oil yield the sunflower hybrid, CMS-234 A x EC-273009 (411kg/ha) was the highest and manifested 27.2, 13.9 and 33.4 per cent increased standard heterosis over that of LSFH-171, DRSH-1 and KBSH-44, respectively. Higher standard heterosis for seed yield and most of the yield contributing traits in the experimental hybrids with the use of diverse CMS lines were also reported by Manivannan *et al.* (2015). Standard heterosis over best check *i.e.* DRSH-1 for seed yield and oil content was also recorded by Rathi *et al.* (2016) The magnitude and direction of standard heterosis of diverse CMS based hybrids were different for all the traits under study. The result was further attested by Tyagi *et.al*. (2013) and Lakshman *et.al*. (2018).

The significant economic heterosis for oil yield were also observed in experimental sunflower hybrids *viz.,* CMS-853 A x EC-623023(407), which recorded 26.0 per cent over LSFH-171, 12.8 per cent over DRSH-1 and 32.1 per cent over KBSH-44. Oil yield of CMS-103A x EC-601978 (400kg /ha) showed 23.8, 10.85 and 29.9 per cent economic heterosis over LSFH-171, DRSH-1 and KBSH-44, respectively, CMS-850 A x EC-601978 (398) was recorded 23.2 per cent economic heterosis over LSFH-171, 10.2 per cent over DRSH-1 and 29.2 per cent over KBSH-44 with respect to oil yield. CMS-852 A x EC-601725(394 kg/ha), CMS-207 A X CSFI-99(393), CMS-234A X RHA-1-1(393 kg/ha) and PET-2-7-1A x R-138-2 (393 kg/ha) rerecorded 22.0, 9.0 and 27.2 per cent increased standard heterosis over LSFH-171, DRSH-1 KBSH-44, respectively.

The study revealed that out of 32 sunflower hybrids evaluated, hybrids *viz.,* CMS-234 A x EC-273009, CMS-234 X RHA-1-1, CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A X CSFI-99 and CMS-850 A x EC-601978 manifested significantly a higher seed and oil yield over national checks LSFH-171, DRSH-1 and KBSH-44. These hybrids could be exploited further and commercialized.

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