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Research Note

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

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Abstract
The main objective related to heterosis breeding is to improve the oil content and seed yield of newly developed hybrids of sunflower (*Helianthus annuus* L.) using selected parental lines. The present experiment involved of four CMS lines and six testers which were crossed in line x tester fashion to estimate the heterosis for seed yield and yield contributing traits in sunflower. The resulting 24 hybrids were evaluated in two replications of randomized block design over two commercial checks LSFH-171 and LSFH-35 during *Kharif* 2018 at Oilseed Research Station, Latur. The morphological observations on ten quantitative characters were recorded. Range of standard heterosis in 24 hybrids over check, LSFH-171 ranged from -6.42 to 31.74, whereas the other check, LSFH-35 showed range from -13.56 to 13.56 for oil content while the extent of heterosis for seed yield in hybrid over LSFH-171 ranged from -20.51 to 37.18 while over the other check, LSFH-35 ranged from -6.06 to 62.12. Hybrid PET 89-1 x EC-601951 R exhibited a significant negative heterosis for early flowering and days to maturity over both checks. The hybrids *viz*., CMS 17 A X EC-601951 R, PET 89-1 x RHA-1-1 recorded a high significant heterosis in desirable direction over both standard checks, LSFH-171 and LSFH-35 for yield and yield contributing traits. These better performing hybrids can be used for exploiting hybrid vigour and needs to be evaluated in future sunflower breeding programme.

Key word
Sunflower, Lx T analysis, heterosis, yield.

Sunflower (*Helianthus annuus* L. 2n=34), is an important oilseed crop in the world, belonging to the genus *Helianthus* and family 'Asteraceae' (compositae). Sunflower is the second most important oilseed crop in the world after soybean on account of its wide range of adaptability and high oil content of 40-50 % and 23 % protein. Sunflower is highly cross pollinated crop and the main objective of sunflower breeding is to develop high yielding hybrid cultivars with stable and high yield through exploitation of heterosis. Sunflower hybrids are highly self-fertile with better yielding capacity and more uniform in days to maturity (Seetharam, 1977, Kaya and Atakisi, 2004). Heterosis or hybrid vigour, describes the superiority performance in terms of vigour, size, yield, speed of development, fertility and resistance to disease and to insect pests, of an F_1 hybrid over its homozygous parental inbred line (Shull *et al.*,1914). In sunflower, heterosis breeding evolved successfully with the detection of cytoplasmic male sterility source (Lecklereq, 1969) and fertility restoration (Kinman, 1970) that gave the required vigour to commercial hybrid seed production. The present investigation revealed the heterosis observed within the available genetic variability of crosses for various characters studied in sunflower.

The experiment was conducted at the experimental fields of Oilseed Research Station, Latur during 2017-18. by adopting line x tester mating design (Kempthorne, 1957) consisting of four lines (CMS-17 A, CMS-234 A, CMS-243 A and CMS- PET-89-1 A) and six testers (EC-623008, EC-601951, EC-601957, EC- 279309, 99 RT and RHA-1-1).The resultant 24 hybrids along with their 10 parents and two checks *viz*. LSFH-35 and LSFH-171 were evaluated in randomized block design with two replications at Oilseed Research Station, Latur during *Kharif* 2018. Each plot consisted of two rows of 3.0 meter length with a spacing of 60 cm between rows and 30 cm between plants. Observations were recorded in each entry on randomly selected three plants for ten characters *viz*. days to 50 per cent flowering, days to maturity, plant height (cm), head diameter (cm), seed filling(%), seed yield per plant (g), 100 seed weight, volume weight (g/100 ml), hull content (%) and oil content (%).

The mean sum of squares from analysis of variance for ten characters in sunflower is presented in **Table 1**. The mean sum of squares due to treatments was highly significant for all the characters. This indicates the existence of sufficient variability for yield and yield contributing characters in the material under study. The present estimation of heterosis for different characters under study is given in **Table 2**. Early flowering is desirable attributes in sunflower crop. Negative heterosis was considered as desirable for this characters. The hybrid, PET 891 A x EC601951 R (11.30%, 4.67%) had high significant negative heterosis over both the checks, LSFH 171 and LSFH 35.

Table 1. Analysis of variance for different traits in sunflower

Source of variations	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling (%)	Hull content (%)	100-Seed weight (g)	Oil content (%))	Seed yield / plant (g)	Volume weight (g/100ml)
Replicates	1	2.520	4.687	30.130	0.106	11.701	1.687	0.016	0.035	4.083	45.747
Crosses	23	10.368**	21.629**	2033.848**	9.717**	42.009**	34.857**	0.698**	13.108**	60.000**	25.449**
Line	3	21.576	23.743	6175.830*	12.846	52.892	17.451	0.800	45.990*	22.222	26.167
Tester	5	11.320	4.270	1345.489	8.037	23.659	50.420	0.295	6.378	29.450	7.530
Line x Tester	15	7.809**	26.993**	1434.904**	9.651**	45.949*	33.151**	0.812**	8.776**	77.738**	31.279**
Error	23	1.042	3.296	45.756	2.216	20.576	1.763	0.103	0.272	3.865	3.469

Table 2. Heterosis (%) for ten characters in sunflower.

Sr.No.	Hybrid	Days to 50% flowering		Days to maturity		Plant height (cm)		Head diameter (cm)	
		LSFH-171	LSFH-35	LSFH-171	LSFH-35	LSFH-171	LSFH-35	LSFH-171	LSFH-35
1	CMS 17A x EC0623008	-5.22 **	1.87	4.60 *	5.20 *	31.74 **	21.05 **	14.64	9.28
2	CMS 17A x EC- 601951	-2.61	4.67 *	1.15	1.73	-26.47 **	-32.44 **	-39.60 **	-42.43 **
3	CMS 17 A x EC- 601957	-0.87	6.54 **	2.30	2.89	32.47 **	21.73 **	0.00	-4.68
4	CMS 17 A x EC-279309	0.00	7.48 **	0.57	1.16	26.22 **	15.99 **	6.15	1.19
5	CMS 17 A x 99 RT	0.00	7.48 **	1.72	2.31	-36.52 **	-41.67 **	-7.54	-11.86
6	CMS 17 A x RHA-1-1	3.48	11.21 **	-4.02	-3.47	0.24	-7.89	6.11	1.15
7	CMS 234 A x EC-623008	-1.74	5.61 **	-1.15	-0.58	24.39 **	14.30 **	9.81	4.68
8	CMS 234 A x EC-601951	-3.48	3.74	-5.75 *	-5.20 *	-21.57 **	-27.93 **	-32.94 **	-36.08 **
9	CMS 234 A x EC-601957	-3.48	3.74	2.30	2.89	29.90 **	19.37 **	8.57	3.49
10	CMS 234 A x EC-279309	0.00	7.48 **	2.87	3.47	11.27 *	2.22	9.77	4.64
11	CMS 234 A x 99 RT	0.00	7.48 **	2.87	3.47	36.03 **	25.00 **	17.13	11.65
12	CMS 234 A x RHA-1-1	0.00	7.48 **	1.72	2.31	2.57	-5.74	-12.19	-16.29
13	CMS 243 A x EC-623008	6.96 **	14.95 **	-0.57	0.00	18.87 **	9.23	0.04	-4.64
14	CMS 243 A x EC- 601951	5.22 **	13.08 **	4.60 *	5.20 *	36.03 **	25.00 **	13.43	8.13
15	CMS 243 A x EC- 601957	1.74	9.35 **	-3.45	-2.89	30.51 **	19.93 **	14.64	9.28
16	CMS 243 A x EC-279309	-1.74	5.61 **	-2.87	-2.31	35.42 **	24.44 **	-3.62	-8.13
17	CMS 243 A x 99RT	5.22 **	13.08 **	-6.90 **	-6.36 **	50.37 **	38.18 **	20.75	15.11
18	CMS 243 A x RHA-1-1	1.74	9.35 **	-0.57	0.00	37.62 **	26.46 **	8.57	3.49
19	PET 89-1A X EC- 623008	-3.48	3.74	-6.90 **	-6.36 **	3.92	-4.51	3.66	-1.19
20	PET 89-1 A x EC- 601951	-11.30 **	-4.67 *	-0.57	0.00	-2.94	-10.81 *	0.00	-4.68
21	PET 89-1 A x EC- 601957	-1.74	5.61 **	-9.20 **	-8.67 **	-5.88	-13.51 **	-14.60	-18.60
22	PET 89-1 A x EC- 279309	-1.74	5.61 **	0.57	1.16	-1.35	-9.35	-8.53	-12.81
23	PET 89-1 A x 99RT	1.74	9.35 **	-0.57	0.00	-15.44 **	-22.30 **	-32.91 **	-36.04 **
24	PET 89- 1 A x RHA-1-1	5.22 **	13.08 **	2.87	3.47	-2.57	-10.47 *	-2.42	-6.98

** and* indicates significant at 1% and 5%, respectively

Table 2. Continued…

Sr.No.	Hybrid	Seed filling (%)		Hull content (%)		100-Seed weight (g)		Oil content (%)	
		LSFH-171	LSFH-35	LSFH-171	LSFH-35	LSFH-171	LSFH-35	LSFH-171	LSFH-35
1	CMS 17A x EC0623008	3.57	12.31 *	-0.31	-10.56 *	-32.25 **	-14.42	-3.67	-11.02 **
2	CMS 17A x EC- 601951	-4.08	4.02	-2.67	-12.68 *	-20.00 **	1.05	-6.42 **	-13.56 **
3	CMS 17 A x EC- 601957	-1.42	6.90	31.08 **	17.61 **	-27.83 **	-8.84	4.59 *	-3.39
4	CMS 17 A x EC-279309	1.10	9.63	16.95 **	4.93	-32.25 **	-14.42	13.03 **	4.41 *
5	CMS 17 A x 99 RT	-2.07	6.20	24.02 **	11.27 *	-28.67 **	-9.89	12.84 **	4.24 *
6	CMS 17 A x RHA-1-1	-9.09	-1.41	24.02 **	11.27 *	-20.83 **	0.00	12.84 **	4.24 *
7	CMS 234 A x EC-623008	-5.76	2.20	12.24 *	0.70	-28.08 **	-9.16	22.94 **	13.56 **
8	CMS 234 A x EC-601951	-1.31	7.02	4.40	-6.34	2.75	29.79 **	31.74 **	21.69 **
9	CMS 234 A x EC-601957	2.49	11.14 *	16.17 **	4.23	-27.50 **	-8.42	32.11 **	22.03 **
10	CMS 234 A x EC-279309	-0.32	8.10	12.24 *	0.70	-30.83 **	-12.63	17.25 **	8.31 **
11	CMS 234 A x 99 RT	-6.02	1.91	-10.52 *	-19.72 **	-29.17 **	-10.53	13.94 **	5.25 **
12	CMS 234 A x RHA-1-1	-15.09 **	-7.92	5.18	-5.63	-37.00 **	-20.42 *	19.27 **	10.17 **
13	CMS 243 A x EC-623008	-7.32	0.50	31.08 **	17.61 **	-15.83 *	6.32	13.21 **	4.58 *
14	CMS 243 A x EC- 601951	-12.27 *	-4.87	-8.95	-18.31 **	-34.50 **	-17.26 *	15.60 **	6.78 **
15	CMS 243 A x EC- 601957	-9.25	-1.59	-1.88	-11.97 *	-32.00 **	-14.11	22.94 **	13.56 **
16	CMS 243 A x EC-279309	-3.99	4.11	11.46 *	0.00	-19.58 **	1.58	9.72 **	1.36
17	CMS 243 A x 99RT	-0.20	8.22	11.46 *	0.00	-25.33 **	-5.68	20.92 **	11.69 **
18	CMS 243 A x RHA-1-1	-9.29	-1.63	36.58 **	22.54 **	-19.17 **	2.11	16.88 **	7.97 **
19	PET 89-1A X EC- 623008	-4.69	3.36	-0.31	-10.56 *	-20.83 **	0.00	8.26 **	0.00
20	PET 89-1 A x EC- 601951	-4.69	3.36	-0.31	-10.56 *	-23.08 **	-2.84	22.94 **	13.56 **
21	PET 89-1 A x EC- 601957	-15.11 **	-7.94	11.46 *	0.00	-2.67	22.95 **	19.27 **	10.17 **
22	PET 89-1 A x EC- 279309	-8.99	-1.31	11.46 *	0.00	-13.33 *	9.47	22.94 **	13.56 **
23	PET 89-1 A x 99RT	-7.53	0.28	27.16 **	14.08 **	-30.83 **	-12.63	4.59 *	-3.39
24	PET 89- 1 A x RHA-1-1	0.29	8.76	24.02 **	11.27 *	-12.00	11.16	18.35 **	9.32 **

** and* indicates significant at 1% and 5%, respectively

Table 2: Continued…

Sr. No	Hybrid	Seed yield / plant (g)		Volume weight (g/100ml)	
		LSFH-171	LSFH-35	LSFH-171	LSFH-35
1	CMS 17 A x EC- 623008	-12.82*	3.03	4.61	13.24
2	CMS 17 A x EC- 601951	37.18**	62.12**	-19.77*	-13.15
3	CMS 17 A x EC-601957	-6.41	10.61	6.43	15.21
4	CMS 17 A x EC- 279309	3.85	22.73**	8.82	17.80*
5	CMS 17 A x 99RT	-20.51**	-6.06	-1.07	7.09
6	CMS 17 A x RHA-1-1	-5.13	12.12	0.29	8.57
7	CMS 234 A x EC- 623008	0.00	18.18**	8.48	17.43*
8	CMS 234 A x EC- 601951	-15.38**	0.00	17.48*	27.18**
9	CMS 234 A x EC-601957	-7.69	9.09	-32.12**	-26.51**
10	CMS 234 A x EC -279309	-16.67 **	-1.52	-12.09	-4.84
11	CMS 234 A x 99RT	10.26	30.30**	7.28	16.14*
12	CMS 234 A x RHA-1-1	-20.51**	-6.06	6.77	15.58
13	CMS 243 A x EC- 623008	-12.82*	3.03	-15.86*	-8.92
14	CMS 243 A x EC- 601951	-3.85	13.64*	-6.31	1.42
15	CMS 243 A x EC- 601957	-5.13	12.12	0.97	9.31
16	CMS 243 A x EC- 279309	-2.56	15.15*	-1.42	6.72
17	CMS 243 A x 99RT	0.00	18.18**	-0.70	7.50
18	CMS 243 A x RHA-1-1	-20.51**	-6.06	-20.01**	-13.40
19	PET 89-1 A x EC-623008	7.69	27.27**	-9.36	-1.88
20	PET 89-1 A x EC-601951	-3.85	13.64*	-0.60	7.61
21	PET 89-1 A x EC- 601957	-20.51**	-6.06	10.28	19.39*
22	PET 89-1 A x EC-279309	-12.82*	3.03	9.50	18.54*
23	PET 89-1 A x 99RT	-25.64**	-12.12	14.84*	24.32**
24	PET 89-1 A x RHA-1-1	15.38**	36.36**	5.75	14.4

** and* indicates significant at 1% and 5%, respectively

In sunflower early to medium duration hybrids are present in the study as the checks LSFH 171 and LSFH 35 was of late maturity. The cross combinations *viz*., PET 89-1A x EC-601957 R (-9.20%, -8.67 %), CMS 243A x 99 RT (- 6.90%, -6.36 %), CMS 234A x EC-601951 R (-5.75%, -5.20 %), and PET 89-1 A x EC 623008 R (6.90,-6.36%) showed a highly significant and negative standard heterosis over both checks for days to maturity. For plant height dwarf to medium tall plant are required because tall plants are prone to lodging therefore negative heterosis in this case is also desirable. The crosses *viz.,* CMS 17A x 99 RT (-36.52 %, -41.67%), CMS 17A x EC-601951R (-26.47 %, -32.44 %), PET 89 1A x 99 RT (-15.44 %,-22.20 %). CMS 234 A x EC 601951 R (-21.57, -27.93%) exhibited highest negative heterosis over both the standard checks for plant height. Similar result were also reported by Vikas *et al.,* (2015) for plant height. The percentage of filled seed is important for getting higher seed yield per head. Maximum significant positive heterosis was recorded in three crosses viz., CMS 17 A x EC-623008 R (3.57%, 12.31%), CMS 234 A x EC-601957 R (2.49%, 11.14 %) and PET 89-1 A x RHA1-1 (0.29 %, 8.76 %) over both the checks. Desirable positive heterosis result were in accordance with the research work of Ingle *et al*., (2015).

Low hull content seed has direct relation to increased oil content. Only one cross CMS 234A x 99 RT (-10.52%, -19.72 %), recorded significant negative heterosis over both the checks. Thombare *et al.,* (2007) reported desirable negative heterosis for hull content in sunflower. For 100-seed weight the cross CMS 234A x EC-601951 R (2.75 %, 29.89 %) registered high positive heterosis for 100 seed weight over both checks LSHF-171 and LSFH-35. Almost identical result has been shown by Patil *et al.,* (2012) for 100 seed weight. Oil content is the important criteria in sunflower which depends on the genotype. The crosses viz., CMS 234A x EC-601951 R(31.74 %, 21.69 %), CMS 234A x EC-601957 R (32.11 %, 22.03 %) and 234 x EC 623008 R (22.94 %,13.56 %) recorded highest significant positive heterosis over both checks. These results are in confirmation with the findings of Kulkarni *et al.,* (2017). Increased seed yield per plant is the ultimate objective in crop breeding hence high heterosis for seed yield is always looked for two crosses viz., CMS 17A x EC- 601951 R (37.18 %, 62.12 %), and PET 89-1 A x RHA 1-1 (15.38 %, 36.36 %) exhibited significant positive high heterosis over both the standard checks. Similar result was also reported by Patil *et al*., (2012), Patil *et al.,* (2017) and Thombare *et al.,* (2007). High volume weight is having direct relation to increase the weight of seed. The two crosses *viz.,* CMS 234A x EC- 601951 R (17.48 %, 27.18 %) followed by PET 89-1A x 99 RT (14.84 %, 24.32 %) recorded highly significant positive heterosis over both checks. Result reported by Patil *et al*., (2017).

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