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Study of Combining ability and Gene Action in Sunflower (*Helianthus annuus* L.)

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ABSTRACT: The present investigation entitled, "Study of Combining ability and Gene action in Sunflower (*Helianthus annuus* L.)" was undertaken to study the combining ability and gene action in parents and hybrids for seed yield and components traits in sunflower in which six female lines were crossed with four male lines so as to obtained 24 F_1s.
The crosses and parents with two checks, were evaluated in a randomized block design with two replications during *Kharif* 2017 at Experimental farm at Oilseeds research station, Latur. Data were recorded on 10 characters *viz*., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed filling (%), 100-seed weight (g), volume weight (g100/ml), hull content (%), seed yield per plant (g) and oil content (%). Among the female parents CMS 10A was good general combiner for days to 50 % flowering, days to maturity, plant height (cm), seed filling (%) and 100 seed weight (g). CMS 2A is found to be good general combiner for), seed filling (%), 100 seed weight (g), oil content (%), Seed yield per plant and volume weight (g/100ml). The CMS 127A was good general combiner for days to maturity and CMS 243A was good combiner for seed yield per plant (g). Among the male parents, Ak-345-2 identified as best general combiner for seed yield per plant (g) and volume weight (g/100 ml). RHA-1-1 is good combiner for plant height (cm) and 100 seed weight (g). The sca effect of hybrids *viz*., CMS 10A x AK-345-2 and CMS 2A x 99 RT were highly significant for seed yield/plant (g) and other component traits in desirable direction. There is predominance of non- additive gene action for all the studied characters except Days to 50% flowering and plant height (cm).

Keywords: combing ability, gene action, sunflower.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the fourth important oilseed crop in the world. It belongs to the genus *Helianthus* and family Asteraceae. Sunflower seeds contain 38% to 42% edible oil, which is used by many customers for confectionary purposes. Sunflower oil is considered as premium edible oil as compared to other vegetable oils because of its light-yellow colour, high smoke point and high level of linoleic acid (55% – 60%) as well as a most important thing is that it is a neutral flavored oil. So, while cooking it does not leave its flavor in the food. Sunflower was introduced in India in 1969 from Russia for its distinct advantages like photo-insensitivity, wider adaptability over large geographical area, short duration, better oil quality in terms of cooking with high polyunsaturated fatty acid content (PUFA) and most importantly high seed multiplication ratio. However, largescale cultivation of sunflower in India was started from 1972 onwards with the introduction of Russian varieties. In India, sunflower was cultivated over an area of 0.7 million hectares in 2014-15 (Padmaiah *et al.*, 2015), and at present sunflower was cultivated over an area of 550,000 hectares with a production and productivity of 335,000 tons and 0.64 ton per hectare, respectively (Anonymous, 2018). It occupies an area of about 360,000 hectares with a production of 210,000 tones and productivity of 0.57 tons per ha in Karnataka (Anonymous, 2017). Sunflower has a huge scope of being grown in West Bengal, Maharashtra and Madhya Pradesh (Dutta, 2011). Sunflower is fifth most important oilseed crops in India after soybean, mustard, groundnut and sesame as source of edible oil. In Maharashtra sunflower is cultivated on 25.7-thousand-hectare area with the production of 16.6 thousand tones with a productivity of 646 kg/ha (2016-17). The oscillation moments in the area of cultivation, production and productivity of sunflower are directly regulated and convinced by market prices as well as biotic and abiotic stresses. (Anonymous, 2017-2018).

MATERIAL AND METHODS

The present research investigation was carried out at Oilseed Research Station, Latur, Maharashtra, during *Kharif* 2016-2018. The experimental material consists of four lines and six restorers. And these were crossed in Line x Tester fashion and produced 24 hybrids. The complete set of experimental material comprised of 36 genotypes i.e., 4 CMS lines, 6 restorers, 24 hybrids and 2 standard checks were sown in Randomized Block Design with two replications during *Kharif* 2018 at Oilseeds Research Station, Latur. Each plot consisted of one row of 4.5-meter length with spacing of 60 cm between rows and 30 cm within row i.e., within plants. Border rows on all sides of experimental plot were grown to avoid the border effect. All the recommended agronomic cultural practices including plant protection measures, application of recommended dose of fertilizer, weeding and irrigation were practiced on the right time and on the whole plots at the same time to raise the healthy plants. The morphological observations on 10 quantitative characters *viz*., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed filling (%), 100-seed weight (g), volume weight (g100/ml), hull content (%), seed yield per plant (g) and oil content (%) were recorded by randomly selecting 3 plants in each plot and in each replication. Results are based on the procedure given by Sprague and Tatum (1942) for combining ability analysis and the testing of significance of different genotypes.

RESULTS AND DISCUSSION

The investigation of combining ability helps in pointing out superior parents for future hybridization programme and specific cross combinations i.e., identification of superior crosses for improving yield and yield contributing traits thus, can be exploited for different breeding purposes. In the present study 4 cytoplasmic male sterile (CMS) lines and 6 fertility restorer lines were used as a female and male parent respectively for synthesis of 24 hybrids.

Analysis of variance (ANOVA) for combining ability revealed that the average performance of hybrids was different from that of parents as conspicuous for significance of parents vs. crosses which specify that the mean performance of the parents was different from that of the hybrids, suggesting that the presence of heterosis (Table 1). (Parmeswari *et al.,* 2004; Jeena and Sheikh 2004; Rahman *et al.,* 2006; Halaswamy *et al.,* 2004; and Ravi Rana *et al.,* 2004)

In any hybridization programme indispensable part is selection of parents. Selection of phenotypically diverse parents, is the first and foremost part of hybridization programme. In quantitatively inherited characters, prediction of ability of the parents to combine well, generate more variability and transmit desired gene combination to the progeny is rather difficult through parental phenotypes. Recent developments in biometrical genetics have made it possible to make such predictions ease. Multivariate analysis (Murty and Arunachalam, 1966) and combining ability analysis (Sprague and Tatum, 1942, Jinks and Hayman, 1953) are some of the widely used biometrical methods for selection of right parents.

Table 1: Analysis of variance for line x tester for different characters including parents 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	1.333	0.750	2.013	0.130	3.905	0.101	0.028	0.521	99.908	9.559
Crosses	23	27.464**	20.736**	617.209**	6.675**	154.651**	32.134**	1.139**	13.329**	179.622**	37.931**
Line Effect	3	84.722**	49.139*	3128.746**	1.782	222.360	50.388	0.999	15.245	38.730	39.416
Tester Effect	5	40.533*	25.383	271.748	12.782	29.747	26.092	0.653	19.473	295.245	70.540
Line * Tester Eff.	15	11.656*	13.506**	230.056**	5.618**	182.744**	30.497**	1.329**	10.898**	169.259**	26.765**
Error	23	4.333	1.663	9.727	1.370	20.329	6.106	0.072	0.434	10.240	1.864

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

The variance component due to general combining ability (gca) was smaller in magnitude than that of specific combining ability (sca) for all the characters (Table 2) which indicated that non-additive gene action except for days to 50 % flowering and plant height played important role for the inheritance of these traits. The ratio of (δ^2gca/δ^2sca) was less than unity for all characters except days to 50 % flowering (1.2671) and Plant height (1.3277) indicating additive type of gene action and predominance of non-additive gene action for other studied traits. (Bindu Madhava, 1990; Nehru, 1993; Shekar, 1996; and Radhika *et al*., 2001). The contribution of lines (female) was higher in magnitude compared to testers (male) (Table 3) for the character *viz.,* Days to flowering (40.2375 %), Days to maturity (30.9104 %), Plant height (66.1198 %), Seed filling per cent (18.7541 %), Hull content per cent (20.4531 %). The contribution of tester (male) was higher in magnitude compared to line (female) for the character *viz*., head diameter (41.6275 %), 100 seed weight (g) (12.4646 %), oil content (%) (31.7600 %), Seed yield/plant (35.7327 %) and volume weight (g/100ml) (40.4279 %). (Ortis *et al.,* 2000; Bajaj *et al.,* 1997; and Ashoka *et al.,* 2000).

Table 2: Estimation of gene action (var. gca and var. sca) for 10 characters in sunflower.

Sr. No.	Character	Variance gca	Variance sca	Ratio var.gca/var.sca	Gene action
1.	**Days to 50% flowering**	5.0972**	4.0227**	1.2671	Additive
2.	**Days to maturity**	2.3756**	5.7073**	0.8325	Non-additive
3.	**Plant Height (cm)**	147.0191**	102.7957*	1.3277	Additive
4.	**Head diameter (cm)**	0.1664**	2.2117**	0.0752	Non-additive
5.	**Seed filling (%)**	-5.6690	83.5106**	-0.0679	Non-additive
6.	**Hull content (%)**	0.7743	12.6934**	0.0610	Non-additive
7.	**100-seed weight (g)**	-0.0503	0.6221**	-0.0808	Non-additive
8.	**Oil content (%)**	0.6461*	5.0735**	0.1273	Non-additive
9.	**Seed yield / plant (g)**	-0.2271	79.7920**	-0.0028	Non-additive
10.	**Volume weight (g/100ml)**	2.8214**	11.3654**	0.2482	Non-additive

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

Table 3: Per cent contributions of lines, testers and their interactions (L X T) to hybrid sum of squares in sunflower.

Characters	Lines	Testers	Line x Testers
Days to 50% flowering	40.2375 %	32.0844 %	27.6781 %
Days to maturity	30.9104%	26.6119%	42.4777 %
Plant Height (cm)	66.1198%	9.5714%	24.3088 %
Head diameter (cm)	3.4819%	41.6275 %	54.8906 %
Seed filling (%)	18.7541 %	4.1816%	77.0643 %
Hull content (%)	20.4531 %	17.6513%	61.8955 %
100-seed weight (g)	11.4410%	12.4646 %	76.0944 %
Oil content (%)	14.9179%	31.7600 %	53.3221 %
Seed yield / plant (g)	2.8124%	35.7327 %	61.4549 %
Volume weight (g/100ml)	13.5541 %	40.4279 %	46.0181 %

The gca effect of line were related to *per se* performance. The line CMS 10A was good general combiner (Table 4) for days to 50 % flowering (-3.833), Days to maturity (-2.958), Plant Height (cm) (-22.476), seed filling (%) (3.419) and 100 seed weight (g) (0.299). CMS 2A is found to be good general combiner for Seed filling (%) (2.661), 100 seed weight (g) (0.187), Oil content (%) (1.145), Seed yield per plant (2.194) and Volume Weight (g/100ml) (1.434). The CMS 249A was good combiner for Oil content (%) (0.790).

Table 4: Estimates of general combining ability (GCA) effect of lines for ten characters in sunflower.

Characters	CMS 249A	CMS 207A	CMS 10A	CMS 2A
Days to 50% flowering	1.750**	1.833**	-3.833**	0.250
Days to maturity	0.375	1.458**	-2.958**	1.125*
Plant Height (cm)	13.349**	9.910**	-22.476*	-0.784
Head diameter (cm)	-0.040	0.351	-0.525	0.213
Seed filling (%)	-6.068**	-0.013	3.419**	2.661*
Hull content (%)	2.392	2.333**	0.875	-0.817
100-seed weight (g)	-0.303**	-0.184*	0.299**	0.187*
Oil content (%)	0.790**	-0.923**	-1.012**	1.145**
Seed yield / plant (g)	0.662	-2.042*	0.511	2.194*
Volume weight (g/100ml)	0.286	-2.626**	0.906	1.434*

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

Among the male parents, Ak-345-2 identified as best general combiner (Table 5) for seed yield per plant (g) (7.779) and volume weight (g/100ml) (4.268) followed by TSG-110 which is good combiner for hull content (%) (-2550) and oil content (%) (1.186), RHA-1-1 is good combiner for plant height (cm) (-7.559) and 100 seed weight (g) (0.365). (Mohanasundaram *et al.,* 2010; Chandra *et al.,* 2011; Patil *et al.,* 2012; Qumar *et al.,* 2015; and Faridi *et al.*,2015).

The crosses showing high desirable sca effect have involved either one of the parents of high gca effect and in turn had high *per se* performance (Table 6). The sca effect of hybrids *viz*., CMS 10A × AK-345-2 (12.995) and CMS 2A × 99RT (9.413) were highly significant for seed yield/plant (g) and other component traits in desirable direction indicating the high performance of these crosses is due to non-allelic gene action. (Patil *et al.* 2012; Binodh *et al.,* 2009; Karasu *et al.,* 2010; Chandra *et al.,* 2011; Jondhale *et al.,* 2012; Qamar *et al.,* 2015 and Aleem *et al.,* 2015).

Table 5: Estimates of general combining ability (GCA) effects of testers for ten characters in sunflower.

Characters	Ak-345-2 R	TSG-110	EC-640324	SCG-04	99RT	RHA-1-1
Days to 50% flowering	-0.542	0.708	-2.792	-1.417	0.208	3.833
Days to maturity	-0.083	0.917	-2.458	-1.333	0.292	2.667
Plant Height (cm)	-0.388	3.224**	-5.476**	1.924	8.274**	-7.559**
Head diameter (cm)	2.394	-0.357	0.039	-0.067	-0.776	-1.233
Seed filling (%)	2.126	-1.511	2.795	-1.329	-1.185	-0.897
Hull content (%)	0.375	-2.550**	-1.238	-0.088	0.750	2.750
100-seed weight (g)	-0.323**	-0.006	-0.273*	-0.066	0.304**	0.365**
Oil content (%)	-0.164	1.186**	0.681*	1.753**	-0.944**	-2.512**
Seed yield / plant (g)	7.779**	-10.525**	0.709	-1.539	3.199	0.376
Volume weight (g/100ml)	4.268**	-3.452	2.543	-1.472	0.386	-2.274

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

Table 6: Estimates of specific combining ability (SCA) effects for ten characters in sunflower.

Sr. No.	Characters	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)
	Crosses	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1.	**CMS 249A × AK-345-2R**	0.125	0.250	-1.262	1.498	16.008**	-2.608	0.628**	-0.112	10.254**	0.587
2.	**CMS 249A × TSG-110**	-0.625	-1.750	7.926**	-0.335	0.645	-3.433*	-0.549*	0.398	-2.508	-1.413
3.	**CMS 249A × EC-640324**	-3.125*	-1.875	-7.674**	-1.317	-8.291**	2.004	0.273	2.362**	-3.651	0.222
4.	**CMS 249A × SCG-04**	4.000**	0.500	-3.274	-0.630	-12.152**	1.254	0.266	2.250**	-1.069	-0.443
5.	**CMS 249A × 99RT**	-0.125	1.875	10.226**	1.663*	6.109*	-0.233	-0.574*	-0.882	-0.281	-2.561
6.	**CMS 249A × RHA-1-1-R**	-0.250	1.000	-5.941**	-0.879	-2.319	3.017	-0.045	-4.015**	-2.744	3.609*
7.	**CMS 207A × AK-345-2R**	0.042	-0.333	0.677	-2.143*	-7.847*	1.167	-0.066	-1.159	-15.056**	0.473
8.	**CMS 207A × TSG-110**	-1.708	-2.333*	-4.635*	0.774	1.590	5.092**	-0.368	-0.519	3.117	0.283
9.	**CMS 207A × EC-640324**	3.792**	4.542**	3.915	-0.123	9.489**	0.029	0.279	-0.654	1.504	-1.917
10.	**CMS 207A × SCG-04**	-2.083	-1.083	8.515**	2.319**	11.683**	-1.121	0.417	0.853	10.136**	2.448
11.	**CMS 207A × 99RT**	1.292	-1.208	-2.485	0.108	-9.161**	-1.958	-1.378**	-1.119	2.144	-3.029*
12.	**CMS 207A × RHA-1-1-R**	-1.333	0.417	-5.986**	-0.935	-5.754	-3.208	1.116**	2.598**	-1.844	1.741
13.	**CMS 10A × AK-345-2R**	-2.292	-2.417 *	12.213**	0.733	7.841*	-0.125	0.136	2.999**	12.995**	3.622*
14.	**CMS 10A × TSG-110**	1.458	0.583	9.951**	1.735*	-1.236	-4.950**	-0.030	1.049	9.299**	1.922
15.	**CMS 10A × EC- 640324**	1.458	0.958	0.801	-0.662	-4.183	-4.763**	-0.329	-0.496	-5.440*	1.792
16.	**CMS 10A × SCG-04**	-1.417	-0.667	-11.249**	-0.895	-2.534	-0.413	-0.185	-2.338**	-5.972*	-1.143
17.	**CMS 10A × 99RT**	-2.042	-0.792	-2.449	-2.352**	-3.338	5.750**	0.475*	-2.041**	-11.275**	-3.601*
18.	**CMS 10A × RHA-1-1-R**	2.833*	2.333*	-9.266**	1.441	3.450	4.500**	-0.066	0.827	0.393	-2.591
19.	**CMS 2A × AK-345-2R**	2.125	2.500*	-	-0.089	-16.001**	1.567	-0.697**	-	-8.192**	-4.682*

				11.629**					1.728**		
20.	**CMS 2A × TSG-110**	0.875	3.500**	- 13.241**	-2.173**	-0.999	3.292	0.946**	-0.927	-9.909**	-0.792
21.	**CMS 2A × EC-640324**	-2.125	-3.625**	2.959	2.101*	2.985	2.729	-0.222	-1.213	7.588**	-0.097
22.	**CMS 2A × SCG-04**	-0.500	1.250	6.009**	-0.793	3.004	0.279	-0.499*	-0.765	-3.095	-0.862
23.	**CMS 2A × 99RT**	0.875	0.125	-5.291 *	0.581	6.390*	-3.558*	1.476**	4.043**	9.413**	9.191**
24.	**CMS 2A × RHA-1-1-R**	-1.250	-3.750**	21.193**	0.373	4.622	-4.308*	-1.005**	0.590	4.195	-2.759

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