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COMBINING ABILITY OF HIGH OLEIC ACID IN SUNFLOWER

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SUMMARY

Six CMS (CMS-342, CMS-343, CMS-349, CMS-351, CMS-352 and CMS-353) and five testers (RHA -344, RHA-345, RHA-346, RHA-348 and RHA-354) with high oleic acid were crossed for combining ability analysis. It was carried out at GKVK, University of Agricultural Sciences, Bangalore, India. Non-additive gene action was observed for days to 50 percent flowering, plant height, head diameter, stem girth, seed yield per plant, oil content and oleic acid whereas additive gene action was noticed for 100 seed weight. Among females HA-351 was the best general combiner for oleic acid, HA-342 for seed yield per plant and HA-349 for earliness and oil content. The male tester RHA-344 was the best combiner for seed yield per plant and RHA-348 for oleic acid, oil content and plant height. The crosses CMS-349 x RHA-346, CMS-353 x RHA-348 and CMS-343 x RHA-346 were the best cross combinations for oleic acid, oil content and seed yield plant respectively.

Key words: Oleic acid, combining ability, CMS, restorers.

INTRODUCTION

Sunflower is cultivated in an area of 18.35 m.ha with an annual production of 22.21 m.tons and productivity of 1212 kg/ha in the world. In India, sunflower is grown over an area of 2.7 m.ha with a production of 1.8 m.tons (Anonymous, 1996) and having moderate productivity (666 kg/ha). Although the seed oil of standard cultivated sunflower (*Helianthus annuus* L.) is considered to be of good quality for edible purposes, the development of hybrids with high oleic acid is currently an important breeding objective for this crop.

One of the advantages of this type of oil is higher degree of oxidative stability than the oil with low oleic acid content (Fuller *et al.*, 1967), which is desirable for frying purposes, refining and storage. Therefore, oil with high oleic acid content has greater shelf life than sunflower oil with high linoleic acid in both processed oil and

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Table 1: Analysis of variance for eight character in sunflower

Source	df	Days to 50% flowering	Plant height	Head diameter (cm)	Stem girth (cm)	Seed yield per plant (g)	100 seed weight (g)	Oil content (%)	Oleic acid content (%)
Replication	3	2.646**	498.728**	3.645*	0.800*	8.777*	0.836**	12.677**	34.233**
Crosses	29	35.321**	380.480**	3.648**	0.156**	16.000**	1.404**	18.022**	1309.758**
Lines	5	165.825**	950.799**	10.396**	0.589**	257.649**	5.537**	75.971**	4.109**
Tester	4	12.140	973.437**	4.291	0.079	178.168**	2.627**	18.292**	4.188**
LXT	20	7.331*	113.090**	1.848	0.063*	10.154*	0.126	3.480**	695.788**
Eror	120	0.603	43.330	1.140	0.028	5.820	0.169	1.418	0.558
GCA		0.460	4.401	0.029	0.001	1.082	0.021	0.239	5.934
SCA		1.682	17.465	0.176	0.008	1.083	0.010	0.515	102.200
SCA / GCA		3.655	3.968	5.978	5.765	1.000	0.504	2.156	17.219

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

Table 2: General combining ability effects for lines and testers for eight characters in sunflower

Parent	Days to 50% flowering	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Seed yield / plant (g)	100 seed weight (g)	Oil content (%)	Oleic acid content (%)
Lines								
HA-342	3.600**	6.932**	0.002	0.115**	3.720**	-0.580**	1.474**	- 4.179**
HA-343	3.800**	10.028**	0.392	0.226**	2.920**	-0.598**	0.541*	-12.644**
HA-349	-2.150**	-6.168**	-0.478*	-0.105**	-6.120**	-0.122	1.929**	6.371**
HA-351	-2.000**	-1.108	0.712**	0.015	0.815	0.618**	0.121	12.841**
HA-352	-1.900**	-2.718	0.557*	0.018	0.565	0.514**	-0.528*	- 0.484**
HA-353	-1.350**	- 6.958**	-1.183**	-0.268**	-1.900**	0.169	-3.538**	- 1.904**
Testers								
RHA-344	0.316*	0.193	0.420	-0.017	2.235**	-0.181*	0.036	6.943**
RHA-345	-0.600**	2.984*	0.216	0.012	1.593**	-0.099	0.281	- 1.735**
RHA-346	0.150	3.234*	0.112	0.031	0.985*	-0.204*	0.367	-11.548**
RHA-348	0.941**	4.634**	-0.070	0.062	-0.215	-0.100	0.802**	8.772**
RHA-354	-0.808**	-11.048**	-0.679**	-0.088**	-4.598**	0.585**	-1.481**	- 2.431**

*Significant at 5% level **Significant at 1% level the seed. From the nutrition point of view, monounsaturated high oleic acid sunflower oil is similar to olive oil; superior to other types of seed oils that have been questioned in the past due to polyunsaturated fats (Doty, 1978). More recent studies in this field, (Grundy, 1986) suggested that a diet rich in monounsaturated fatty acids reduces cholesterol in blood plasma and therefore, the risk of coronary heart disease. Development of hybrids with high levels of monounsaturated oleic acid is an important goal among sunflower breeders (Fernandez - Martinez *et al.*, 1993). For the development of hybrids, selection of suitable parents is a prerequisite. Although the lines and testers with high oleic acid content are available, the past experience in sunflower as well as in other crops has proved that per se performance is not always a good indicator of their combining ability. Hence, the present study was initiated to estimate the combining ability of six lines and five testers for high oleic acid using line x tester analysis.

MATERIAL AND METHODS

Six cytoplasmic male sterile lines (CMS-342, CMS-343, CMS-349, CMS-351, CMS-352 and CMS-353) were crossed with five restorers (RHA-344, RHA-345, RHA-346, RHA-348 and RHA-354) in a line x tester combination to synthesize 30 hybrids. The seeds were collected from the Project coordinating unit (Sunflower) which were earlier received from USDA-ARS, Fargo North Dakota. These female and male lines are reported to have high oleic acid content. The 30 F_1's along with their parents so synthesized were grown in a randomized block design with four replications during June 1995-96 at GKVK, University of Agricultural Sciences, Bangalore, India. All recommended cultural practices and plant protection measures were followed for raising a good crop. Observations were recorded on five randomly selected plants from each entry in each replication for eight quantitative characters viz., days to 50 percent flowering, plant height, head diameter, stem girth, seed yield per plant, 100 seed weight, oil content and oleic acid percentage. The mean values of the five observations were subjected to line x tester analysis (Kempthorne, 1957) to estimate combining ability effects.

RESULTS AND DISCUSSION

Analysis of variance for combining ability and estimates of variance due to GCA and SCA are presented in Table 1. The variance due to lines were significant for days to 50 percent flowering, plant height, head diameter, stem girth, seed yield per plant, 100 seeds weight, oil content and oleic acid content. Testers were also found to be significantly different for all the traits except days to 50 percent flowering, head diameter and stem girth, thus justifying the selection of parents for combining ability analysis. The crosses between these lines and testers were significantly different from each other for all the characters. The variance due to the interaction

Table 3: Specific combining ability effects for eight characters in sunflower

Cross	Days to 50% flowering	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Seed yield / plant (g)	100 seed weight (g)	Oil content (%)	Oleic acid content (%)
CMS 342 X RHA 344	1.733**	-3.773	0.844	0.028	1.455	0.134	0.215	- 0.533**
CMS 342 X RHA 345	0.650	5.685	-0.627	-0.010	-1.353	-0.221	0.664	5.946**
CMS 342 X RHA 346	0.400	6.335	0.953	0.176*	1.155	0.189	-0.078	- 1.542**
CMS 342 X RHA 348	0.108	-1.015	-0.489	-0.020	-0.145	-0.115	0.191	- 5.013**
CMS 342 X RHA 354	-2.892**	-7.232*	-0.681	-0.174*	-1.112	0.014	-0.993	1.142**
CMS 343 X RHA 344	-0.217	-1.913	-0.096	-0.021	-1.120	0.072	0.167	14.832**
CMS 343 X RHA 345	-0.050	6.245	1.033	0.199	1.272	0.002	0.727	-10.989**
CMS 343 X RHA 346	0.700	-1.655	-0.263	-0.075	2.155	0.160	0.665	-20.352**
CMS 343 X RHA 348	2.158**	5.595	0.171	0.144	-0.895	-0.147	-2.434**	14.103**
CMS 343 X RHA 354	-2.592**	-8.272*	-0.846	-0.248**	-1.412	-0.086	0.875	2.407**
CMS 349 X RHA 344	-0.267	1.677	-0.701	-0.015	-1.880	-0.292	-0.180	2.317**
CMS 349 X RHA 345	0.150	-2.365	0.228	-0.105	0.612	0.126	-0.603	- 2.204**
CMS 349 X RHA 346	-0.600	-0.565	-0.443	0.041	-1.130	0.056	-0.023	16.508**
CMS 349 X RHA 348	-0.392	-4.315	0.491	-0.086	0.920	-0.076	0.136	- 4.313
CMS 349 X RHA 354	1.108**	5.568	0.424	0.165	1.478	0.186	0.670	-12.308**

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

Table 3: Specific combining ability effects for eight characters in sunflower (continued)

Cross	Days to 50% flowering	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Seed yield / plant (g)	100 seed weight (g)	Oil content (%)	Oleic acid content (%)
CMS 351 X RHA 344	-0.917*	-1.883	-0.391	0.017	-0.965	-0.110	-0.263	- 8.528**
CMS 351 X RHA 345	0.000	-4.875	0.438	0.005	0.977	-0.007	-0.248	0.526
CMS 351X RHA 346	-0.250	0.524	-0.008	0.006	-0.090	-0.177	0.124	11.938**
CMS 351 X RHA 348	-0.292	-1.725	-0.824	-0.071	-1.815	0.204	0.444	- 6.558**
CMS 351 X RHA 354	1.458**	7.958*	0.784	0.043	1.895	0.090	-0.058	2.622**
CMS 352 X RHA 344	-0.767*	6.877*	0.214	0.077	0.985	0.137	-1.134	- 1.778**
CMS 352 X RHA 345	-0.350	-1.815	-0.357	0.012	0.777	0.200	-0.394	10.951**
CMS 352 X RHA 346	0.150	-6.915*	-0.677	-0.127	-2.290	-0.317	-0.041	- 7.637**
CMS 352 X RHA 348	-1.142**	-1.015	0.656	-0.023	1.235	0.031	0.775	- 0.083
CMS 352 X RHA 354	2.108	2.868	0.164	0.060	-0.707	-0.050	0.794	- 1.453**
CMS 353 X RHA 344	0.433	-0.983	0.129	-0.087	1.525	0.059	1.194	- 6.308**
CMS 353 X RHA 345	-0.400	-2.875	-0.717	-0.102	-2.285	-0.098	-0.144	- 4.229**
CMS 353 X RHA 346	-0.400	2.275	0.438	-0.021	0.200	0.090	-0.649	1.083**
CMS 353 X RHA 348	-0.442	2.475	-0.004	0.057	0.700	0.103	0.888	1.862**
CMS 353 X RHA 354	0.808*	-0.892	0.154	0.153	-0.142	-0.153	-1.289	7.952**

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

between lines and testers was found to be significant for all characters except head diameter suggesting the significant contribution of the SCA effects towards the variation among the crosses. Further, the ratio of GCA : SCA variances showed that SCA variances were greater than GCA variances for all characters except 100 seed weight, indicating the predominance of non-additive effects for seed yield and most of the yield components and additive gene action for 100 seed weight. These results are comparable with earlier reports by Alba *et al.* (1985), Giriraj *et al.* (1987), Bindhu Madhava (1990), and Harini (1992). The estimates of general combining ability effects for eleven parents are presented in Table 2. It is evident that no single line or tester was a good general combiner for all the characters studied. Among six females studied, HA-351 and HA-349 were the best general combiner for oleic acid content and earliness. HA-351 and HA-352 were good combiners for head diameter and 100 seed weight. HA-342 was the best general combiner for seed yield per plant, but was a poor combiner for 100 seed weight and oleic acid content. HA-349 was the best combiner for oil content, but a poor combiner for head diameter and stem girth. HA-353 was a poor combiner for head diameter and stem girth. Of the five male testers studied, RHA-348 was the best general combiner for oleic acid content, oil content and plant height. RHA-344 was a good combiner for seed yield per plant. RHA-354 was a good general combiner for earliness but it was a poor combiner for yield and majority of its components. Although, none of the testers showed significant GCA effects for stem girth and head diameter, the testers RHA-344 and RHA-348 exhibited higher magnitude of GCA effects. In general, there was no correspondence between *per se* performance and GCA effects of lines and testers for all the characters. However, the few parents which exhibited high significant GCA effects also exhibited high *per se* performance. Among female lines, HA-342 and HA-343 had high GCA effects and high *per se* performance for seed yield per plant. HA-351 had a high GCA effect and high *per se* performance for oleic acid content. Hence, the *per se* performance of lines could be used as indicator for their GCA effects. Among the testers, RHA-348 had high *per se* performance and high GCA effects for plant height, oil content and oleic acid content, whereas RHA-344 and RHA-354 had high *per se* performance and high GCA effect for seed yield per plant and 100 seed weight, respectively. Although the female line, CMS 351 and the male tester RHA 348 had good general combining ability for high oleic acid content, the cross between these parents had a very low SCA effect for the trait. Interestingly, perusal of the SCA effects (Table 3) of various traits indicated that the crosses which had high SCA effect (>10.00) were high x low types, that is, one parent had high GCA and other parent had low GCA effect for oleic acid content. Therefore, to obtain crosses with high oleic acid content, it is desirable to select the parent such that one parent should have high GCA and other low GCA effects. Such results are not surprising, because, in several crops it is proved that crossing diverse parents usually results in crosses with high heterosis. The estimates of specific combining ability effects for 30 crosses are presented in Table 3. The crosses CMS 342 x RHA

345, CMS 343 x RHA 344, CMS 343 x RHA 348, CMS 349 x RHA 346, CMS 351 x RHA 346, CMS 352 x RHA 345 and CMS 343 x RHA 354 were the best specific combiners for oleic acid content. Interestingly these crosses also had high *per se* performance for oleic acid content. The crosses CMS-342 x RHA-354 and CMS-343 x RHA-354 were best specific combiners for earliness. As regards plant height, CMS-351xRHA-354 exhibited high SCA effect. The best specific cross for oil content was CMS-353 x RHA-344. None of the crosses showed significant SCA effect for head diameter, seed yield per plant, 100 seed weight and oil content. This is expected because the parents were selected for the study based on their oleic acid content. This suggested that there was no interaction between female and male parents. The crosses which have high GCA effect and high *per se* performance for these yield components could be utilized in a heterosis breeding programme of sunflower. The parents HA-351 and RHA-348 which have good general combining ability for oleic acid could be used as one of the parents to obtain crosses with high oleic acid content. The parents HA-349 and RHA-348 which have good general combining ability for oil content could be used as one of the parents to obtain crosses with high oil content. Similarly the parents HA-342 and RHA-344 which have high GCA could be used as one of the parents to evolve hybrids with higher yield.

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APTITUD COMBINATORIA DE LINEAS DE ALTO CONTENIDO DE ÁCIDO OLÉICO EN EL GIRASOL

RESUMEN

Se cruzaron seis CMS (CMS-342, CMS-343, CMS-349, CMS-351, CMS-352 y CMS-353) y cinco testigos (RHA-344, RHA-345, RHA-346, RHA-348 y RHA-354) con un alto contenido de ácido oléico para un análisis de su capacidad de combinación. Esta investigación se llevó a cabo en GKVK, Universidad de Ciencias Agrícolas, Bangalore, India. No se observaron efectos no aditivos para los días hasta 50% de floración, la altura de la planta, diámetro del capítulo, la circunferencia del tallo, la producción de semillas por planta, el contenido oléico y de ácido oléico mientras que se observaron efectos aditivos para el peso de 100o semillas. Entre las hembras, HA-351 fué la mejor combinadora para el ácido oléico, HA-342 para la producción de semillas por planta, HA-349 para la precocidad y el contenido oléico. El testigo RHA-344 fué el mejor combinador para la producción de semillas por planta y RHA-348 para el ácido oléico, el contenido oléico y la altura de la planta. Los cruzamientos CMS-349 x RHA-346, CMS-353 x RHA-348 y CMS-343 x RHA-346 fueron las mejores combinaciones para el ácido oléico, el contenido oléico y la producción de semillas por planta, respectivamente.

VALEUR EN COMBINAISON DE LIGNÉS RICHES EN ACIDE OLÉIQUE CHEZ LE TOURNESOL

RÉSUMÉ

Six lignées CMS (CMS-342, CMS-343, CMS-349, CMS-351, CMS-352, et CMS-353) et cinq testeurs (RHA-344, RHA-354, RHA-346, RHA-348 et RHA-354) à teneur élevée en acide oléique ont été croisées pour l'analyse de la valeur en combinaison. L'essai a été réalisé à GKVK, Université des Sciences Agricoles, Bangalore, Inde. Un effet génétique non additif est observé pour le nombre de jours à 50 pour cent de floraison, la taille, le diamètre du capitule, la circonférence de la tige, la production en grains par plante, la teneur en huile et en acide oléique tandis que un effet génétique additif est noté pour le poids de 1000 grains. C'est la femelle HA-351 qui présente la meilleure aptitude générale à la combinaison pour l'acide oléique, HA-342 pour la production de grains par plante et HA-349 pour la précocité et la teneur en huile. Le testeur RHA-344 combine le mieux pour le rendement en grains par plante et RHA-348 pour l'acide oléique, la teneur en huile et la taille. Les croisements CMS-349 x RHA-346, CMS-353 x RHA-348 et CMS-343 x RHA-346 furent respectivement les meilleures combinaisons hybrides pour l'acide oléique, la teneur en huile et le rendement en grains par plante.