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Research Article

Exploitation of hybrid vigour in sesame (*Sesamum indicum* L.)

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Abstract
Nature and magnitude of gene action and extent of heterosis were studied in a set of 21 hybrids and their parents developed by diallel mating design without reciprocals in sesame. The parent G.Til-3 was found to be the best general combiner for seed yield per plant, number of capsules per plant, number of seeds per capsule and number of branches per plant, whereas KMR-74 was good combiner for number of branches per plant and seed yield per plant. The crosses, KMR-74 x Patan-64, KMR-24 x G.Til- 3, KMR-74 x KMR-77 and G.Til-3 x G.Til-10 exhibited high *sca* effect and showed highly significant positive standard heterosis for seed yield per plant. The SCA variance was more than GCA variance for the traits capsule length, number of seeds per capsule and seed yield per plant indicating the role of non-additive gene action for the inheritance of these traits. Hence, it is suggested that yield can be improved by exploitation of hybrid vigour through heterosis breeding.

Key words:
Sesame, heterosis, gene action

Introduction

Sesame is one of the oldest oilseed crop of India and cultivated in an area of 18.2 lakh ha with a production of 6.1 lakh tons. Sesame seed has high nutritive value and unsaturated fatty acids (linoleic and tocopherol) which makes sesame the ideal oilseed for edible purpose. Average productivity of sesame in India is only 453 kg/ha which is far below the average productivity of China (1127 kg/ha) and Egypt (1211 kg/ha) (Banerjee and Kole 2009). This indicates the scope for enhancing the productivity of this crop by developing high yielding varieties. The combining ability studies of parents and hybrids provide useful information for the selection of better parents for effective breeding and also to elucidate the nature and magnitude of gene action, involved in the inheritance of various characters. The extent of heterosis depends upon the extent of diversity among the parental lines. The objective of this study was to estimate the magnitude of gene action, variances through combining ability studies and also the extent of heterosis present in the hybrids.

Material and Methods

The experimental material for the present study comprised of seven parents *viz*., KMR-24, KMR-74, KMR-77, G.Til-3, G.Til-10, G-20 and Patan-64. Crosses were made among the parents in diallel design without reciprocals during, *Rabi*, 2010. The resulting 21 F_1s, their parents and standard check Patan-64 were sown with a spacing of 30 cm between rows and 20 cm between plants during *kharif*, 2011 at Seed Research and Technology Centre, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design with three replications. Recommended agronomic practices and plant protection measures were followed to raise the healthy crop. Five plants were selected randomly from each replication and observations were recorded for various quantitative traits *viz*., plant height (cm), number of branches per plant, number of capsules per plant, capsule length (cm), number of seeds per capsule, test weight (g) and seed yield per plant (g). The mean data was analysed by following the method given by Griffings (1956).

Results and Discussion

Analysis of variance for combining ability indicated significant differences among genotypes for plant height, number of capsules per plant, number of seeds per capsule and seed yield per plant (Table-1). The estimates of components of variance revealed different types of gene action for the characters studied. Dominant gene action was found to be more pronounced for expression of traits like capsule length, number of seeds per capsule and seed yield per plant. Seed yield forms the major objective in any plant breeding programme and the SCA variance was more than GCA variance exhibiting the role of non-additive gene action for the inheritance of this trait. The character seed yield per plant is governed by both additive and non-additive gene action. Non-additive gene action was preponderant over additive in the inheritance of seed yield per plant. Manivannan and Ganesan (2001), Krishnaiah *et al*. (2002), Mothilal and Manoharan (2004) and Vidhyavathi *et* *al*. (2005) also reported the role of non-additive gene action for seed yield. However, importance of both additive and non-additive gene action was recorded by Kadu *et al*.(1992) and Thakare *et al*. (1999). The ratio of additive : dominance variance was closer to unity for plant height and number of capsules per plant suggesting the equal importance of both additive and dominance gene action in the expression of these traits. The GCA variance was more than SCA variance for test weight, number of branches per plant which reveals the predominance of additive gene action. Vidhyavathi *et al*.(2005) also concluded that additive gene action plays an important role in controlling test weight. When additive effects are predominant, use of pedigree method could be desirable.

The results of *gca* effects indicated that the parents G.Til-3 and Patan-64 were proved as good general combiners for seed yield per plant, number of capsules per plant and number of seeds per capsule (Table-2). The parents G.Til-3 and KMR-74 were found to be good general combiners for number of branches per plant and seed yield per plant. Significant and positive *gca* effect for capsule length, number of seeds per capsule and test weight were found in G.Til-10, but it has negative *gca* effect for seed yield per plant. Crosses involving these parents might produce heterotic hybrids with high mean performance for the respective traits.

Among the crosses studied, KMR-74 x Patan-64, KMR-24 x G.Til- 3, KMR-74 x KMR-77 and G.Til-3 x G.Til-10 were identified as the potential specific combiners for seed yield per plant and other yield contributing traits (Table-3). The cross KMR-74 x Patan-64 had registered significant and positive *sca* effect for all the characters studied except for test weight Highly significant *sca* effect for number of capsules per plant was exhibited in the crosses KMR-24 x Patan-64 (18.74), KMR-77 x Patan-64 (16.19) and G.Til-3 x G-20 (15.97). The hybrids KMR-74 x KMR-77, KMR-24 x G.Til-3 and KMR-74 x Patan-64 were found to be good specific combiners for number of seeds per capsule. The crosses KMR-77 x G.Til-10, KMR-77 x G-20 and KMR-74 x G.Til-10 showed highly significant positive *sca* effect for test weight. Good specific combiners for number of branches per plant were KMR-24 x Patan-64, G.Til-3 x G.Til-10 and KMR-74 x KMR-77. Study of the relationships of *sca* effects of crosses and *gca* effects of parents indicated that good specific combinations for seed yield per plant *viz*., KMR-74 x Patan-64, KMR-24 x G.Til-3, KMR-74 x KMR-77 and G.Til-3 x G.Til-10 involved either high x high or high x average combiners as parents. The parents with positive significant *gca* values are grouped as high combiners. The superiority of such crosses might be due to the accumulation and interaction of favourable genes contributed by the parents.

The crosses KMR-74 x Patan-64, KMR-24 x G.Til-3, G.Til-3 x G.Til-10, KMR-74 x KMR-77 and KMR-77 x G.Til-3 recorded highly significant and positive standard heterosis for seed yield per plant (Table-4). The variety Patan-64 used as check to estimate the standard heterosis. The hybrids, KMR-77 x G.Til-3, KMR-24 x KMR-74, KMR-24 x Patan-64, G.Til-3 x G.Til-10, KMR-74 x Patan-64 and KMR-24 x G.Til-3 showed highly significant standard heterosis for number of capsules per plant. The hybrids KMR-24 x G.Til-3, KMR-74 x Patan-64, KMR-74 x KMR-77, G.Til-3 x G.Til-10 and KMR-77 x G.Til-3 were found to have high heterosis for number of seeds per capsule. None of the crosses exhibited significant positive standard heterosis for number of branches per plant and capsule length. The cross KMR-77 x G.Til-10 had shown highly significant and positive standard heterosis for test weight. Among the crosses studied, two crosses exhibited significant positive heterosis for plant height (KMR-77 x G-20 and KMR-77 x G.Til-3).

Component of variation due to additive (D) and dominant (H_1) effect of genes were significant for plant height, number of capsules per plant, number of seeds per capsules and seed yield per plant (Table-5) indicating the importance of both additive and dominant genes for the expression of these traits. This was further confirmed by the significance of both GCA and SCA variances. Significant and greater magnitude of H_1 and H_2 than D for plant height, number of capsules per plant, number of seeds per capsule, test weight and seed yield per plant indicated the preponderance of non-additive factors involved for these traits. Significant and positive value of 'F' indicated high proportion of dominant alleles for the traits *viz*., number of capsules per plant, number of seeds per capsule and seed yield per plant. The h^2 value was significant for plant height, number of capsules per plant and number of seeds per capsule indicating dominance at heterozygous level.

The mean degree of dominance $(H_1/D)^{1/2}$ was more than unity, indicating the presence of over dominance in the inheritance of all the traits except test weight. The ratio of $H_2/4H_1$ was less than 0.25 for all the traits studied revealing the asymmetrical distribution of positive and negative genes in the parents. The ratio h^2/H_2 was less than one for all the seven traits indicating that these traits were under the control of atleast single group of genes. The heritability estimates were classified as low (0-30%), medium (30-60%) and high (>60%). In the present study, heritability was low to medium (6.0 to 31.0 %) showed importance of non-additive genetic variance in the inheritance of all these traits. Hence, simple selection based on phenotypic evaluation will not be effective and heterosis or recombination breeding with selection at later generations will be effective.

From this study, it was concluded that both additive and non-additive gene actions were observed in expression of the traits studied. Among the parents G.Til-3 was found to be good general combiner for number of branches per plant, number of capsules per plant, number of seeds per capsule and seed yield per plant. The best combiners G.Til-3, Patan-64 and KMR-74 could be utilized in future breeding programmes. The crosses KMR-74 x Patan-64, KMR-74 x KMR-77, KMR-24 x G.Til-3 and G.Til-3 x G.Til-10 showed highly significant *sca* effect and heterosis for seed yield. These crosses could be utilised for exploitation of heterosis for yield improvement.

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Table 1. Anova for combining ability variances in sesame

Source	d.f	Plant height (cm)	No. of branches / plant	No. of capsules / plant	Capsule length (cm)	No. of seeds / capsule	Test weight (g)	Seed yield / plant(g)
Replications	2	46.85	0.46	41.19	0.03	0.953	0.10	5.58
Genotypes	27	279.09**	1.23	1025.46**	0.09	174.13**	0.15	102.72**
Error	54	727.50	0.29	52.10	0.01	10.62	0.03	1.77
$\sigma^2 g$	6	109.07	0.70	392.16	0.02	33.53	0.09	23.81
$\sigma^2 s$	21	88.45	0.33	327.44	0.03	65.05	0.04	37.22
$\sigma^2 g : \sigma^2 s$		1.23	2.12	1.19	0.67	0.52	2.23	0.64

** significant at 1% level

Table 2. General combining ability (gca) effects of parents for different traits in sesame

Parents	Plant height (cm)	No. of branches / plant	No. of capsules / plant	Capsule length (cm)	No. of seeds / capsule	Test weight (g)	Seed yield / plant (g)
KMR-24	-1.53*	0.18	1.01	0.01	-2.09**	-0.01	-1.08**
KMR-74	0.39	0.26**	1.85	-0.03*	-0.94	-0.11**	0.74**
KMR-77	6.88**	0.03	2.04	0.03	-1.02	-0.02	-1.51**
G.Til-3	-2.03**	0.36**	12.00**	-0.02	1.84**	0.04	2.41**
G.Til-10	-.043	-0.32**	-4.74**	0.08**	1.69**	0.10**	-0.53*
G-20	1.03	-0.22*	-8.56**	-0.01	-1.94**	-0.13**	-1.72**
Patan-64	-4.05**	-0.29**	3.61**	-0.05**	2.047**	0.13**	1.68**

* significant at 5% level, ** significant at 1% level

Table 3. Specific combining ability effects for different traits in sesame

Crosses	Plant height (cm)	No. of branches / plant	No. of capsules / plant	Capsule length (cm)	No. of seeds / capsule	Test weight (g)	Seed yield / plant (g)
KMR-24 x KMR-74	-6.06**	-0.17	15.27**	0.22**	-3.36**	0.03	-3.02**
KMR-24 x KMR-77	0.29	0.06	-1.92	-0.00	-3.95**	0.04	-2.34**
KMR-24 x G.Til-3	-10.58**	0.37**	6.93**	0.05*	12.53**	-0.02	7.90**
KMR-24 x G.Til-10	2.33**	-0.60**	-5.92**	-0.42**	-3.66**	-0.08	3.92**
KMR-24 x G-20	-1.83*	0.14	4.69**	-0.09**	2.31**	0.15**	1.67**
KMR-24 x Patan-64	2.88**	0.71**	18.74**	-0.06**	-2.10**	-0.31**	-3.17**
KMR-74 x KMR-77	-9.06**	0.42**	5.24**	-0.09**	13.23**	-0.23**	7.11**
KMR-74 x G.Til-3	-12.63**	-1.36**	-35.89**	0.03	-7.29**	0.15**	-8.67**
KMR-74 x G.Til-10	-0.89	-0.68**	-19.98**	-0.24**	-7.81**	0.29**	-6.92**
KMR-74 x G-20	2.88**	-0.11	15.18**	-0.05*	1.16	-0.02	0.49
KMR-74 x Patan-64	9.82**	0.28*	13.11**	0.12**	9.75**	-0.28**	13.61**
KMR-77 x G.Til-3	9.10**	-0.13	6.42**	0.17**	5.12**	-0.08	3.49**
KMR-77 x G.Til-10	2.82**	-0.18	6.82**	-0.03	-3.40**	0.30**	0.39
KMR-77 x G-20	7.46**	0.12	-2.02	0.03	3.90**	0.29**	-0.27
KMR-77 x Patan-64	12.97**	-0.03	16.19**	-0.10**	-6.84**	0.20**	-4.97**
G.Til-3 x G.Til-10	4.02**	0.44**	8.89**	0.05*	2.75**	0.19**	5.33**
G.Til-3 x G-20	-11.31**	0.28*	15.97**	-0.06**	-2.29**	-0.17**	2.98**
G.Til-3 x Patan-64	-5.21**	-0.37**	-31.92**	0.04*	-4.03**	0.17**	-8.88**
G.Til-10 x G-20	0.27	0.13	-0.04	0.04*	1.53*	-0.09*	0.56
G.Til-10 x Patan-64	-11.78**	0.21	-11.41**	-0.22**	-11.21**	0.05	-6.82**
G-20 x Patan-64	-12.89**	-0.62**	-12.36**	-.013**	-8.92**	-0.09*	-6.24**

* significant at 5% level, ** significant at 1% level

Table 4. Estimates of standard heterosis for yield and component traits in sesame

Crosses	Plant height (cm)	No. of branches / plant	No. of capsules / plant	Capsule length (cm)	No. of seeds / capsule	Test weight (g)	Seed yield / plant (g)
KMR-24 x KMR-74	-13.92**	-9.09	51.12**	1.27	-7.74	-6.17	14.15
KMR-24 x KMR-77	2.89	-9.09	22.47*	-5.06	-8.93	-2.47	-8.78
KMR-24 x G.Til-3	-23.37**	-18.18	38.39**	-5.06	25.60**	-2.47	188.54**
KMR-24 x G.Til-10	-4.01	-36.36**	4.31	-18.99**	-3.57	-2.47	88.44**
KMR-24 x G-20	-7.55	-13.64	15.73	-10.13**	0.60	-2.47	46.83**
KMR-24 x Patan-64	-8.03*	0.00	47.75**	-10.13**	-10.12*	-9.88	25.85
KMR-74 x KMR-77	-6.85	3.00	18.35	-10.13**	23.81**	-16.05**	156.01**
KMR-74 x G.Til-3	-23.55**	-36.36**	-16.57	-7.59**	-7.74	-0.00	-17.41
KMR-74 x G.Til-10	-5.71	-36.36**	-17.98	-13.92**	-8.93	7.41	-34.88
KMR-74 x G-20	1.14	-18.18	34.83**	-10.13**	0.60	-12.35*	56.10**
KMR-74 x Patan-64	3.58	-24.27*	39.70**	-5.06	23.81**	-12.35*	297.90**
KMR-77 x G.Til-3	13.42**	-9.09	55.06**	-0.00	14.29**	-4.94	127.66**
KMR-77 x G.Til-10	7.64	-29.09*	27.53**	-3.80	-1.19	11.11*	39.12*
KMR-77 x G-20	15.64**	-18.18	6.18	-5.06	5.36	2.47	12.20
KMR-77 x Patan-64	-17.74**	-24.27*	-9.37	-11.39**	-5.95	8.64	-6.88
G.Til-3 x G.Til-10	-2.80	-3.00	47.75**	-5.33*	14.88**	-4.94	168.93**
G.Til-3 x G-20	-20.98**	-4.55	-0.56	-10.13**	-0.60	-12.35*	117.07**
G.Til-3 x Patan-64	-19.64**	-24.27*	-19.10	-7.59**	4.17	9.88	-6.63
G.Til-10 x G-20	-3.35	-27.27*	-1.91	-2.53	5.95	-7.41	38.54*
G.Til-10 x Patan-64	-25.79**	-27.27*	-12.74	-13.92**	-8.93	3.70	-19.56
G-20 x Patan-64	-24.81**	-46.97**	-20.79*	-13.92**	-11.31*	-6.17	-28.54

* significant at 5% level, ** significant at 1% level

Table 5. Estimates of genetic components and ratios for seven characters in sesame

Character	$\hat{D}$	$\hat{F}$	$\hat{H}_1$	$\hat{H}_2$	$\hat{h}^2$	$(H_1/D)^{1/2}$	$H_2/4H_2$	h^2/H_2	Heritability (NS)%
Plant height	15.95**	-7.42	322.03**	280.38**	296.40**	4.493	0.207	0.241	31.0
No. of branches / plant	0.72	0.76	1.12	0.87	0.68	1.251	0.193	0.783	24.0
No. of capsules / plant	680.62**	887.46**	1237.21**	887.30**	242.92**	1.348	0.184	0.532	21.0
Capsule length	0.05	0.10	0.15	0.10	0.07	1.65	0.167	0.754	6.0
No. seeds /capsule	98.18**	176.55**	295.48**	207.98**	35.14**	1.73	0.176	0.169	8.0
Test weight	-2.45	-3.72	5.50**	5.85**	-1.09	-1.50	0.205	-0.045	10.0
Seed yield / plant	32.21**	44.84**	159.08**	137.52**	1.80	2.22	0.216	0.013	11.0

** significant at 1% level